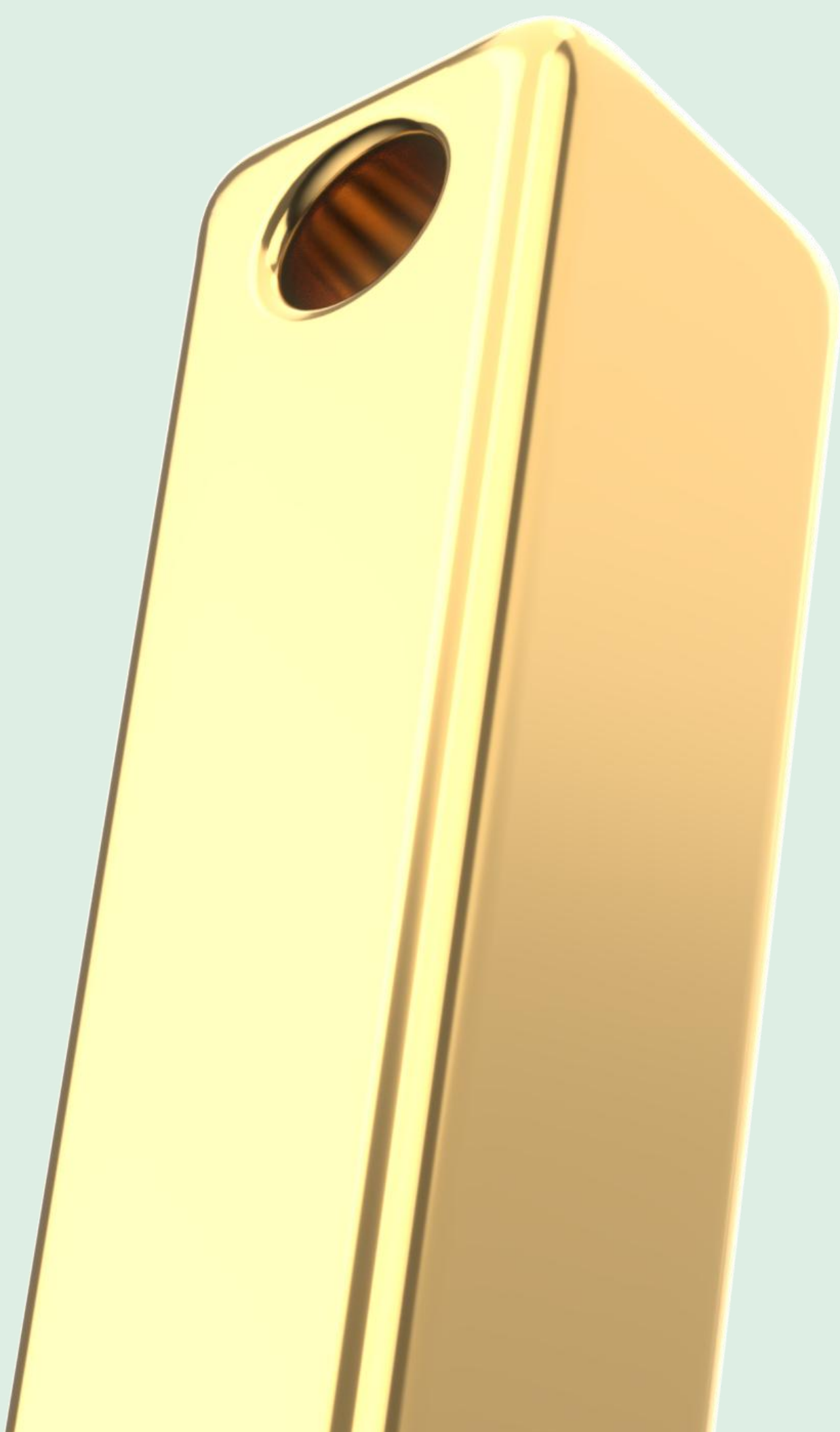




Lowering the Bar

A Salutogenic Design Approach to Healthy Ageing and the Promises We Keep

Master Thesis

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Executive Summary

Dutch healthcare will be short 266,000 workers by 2034 (Ministerie van Volksgezondheid, 2024), while the years people spend in ill health keep growing rather than shrinking (Crimmins, 2015). Compressing that period is argued to be the single most effective route to a sustainable health system (Scott et al., 2021). Prevention is therefore also a design problem.

Women between 55 and 70 sit at its centre. Around this age, bone density and muscle loss begin to decide how long independence lasts (Wright et al., 2024; Cruz-Jentoft et al., 2019). Yet they sit at the edge of attention: menopause entered Dutch health policy only in 2025, and the literature still calls it an issue needing urgent attention (Delanerolle et al., 2025; Rijksoverheid, 2025). Preventive routines carry unusual weight at this age, and they break easily. Several of the women in this study described giving their own health a lower priority after years of caring for others.

Almost every product aimed at that gap measures: it sets a target, judges her daily, and is abandoned for it (Attig & Franke, 2020; Kidman et al., 2024). The evidence runs the other way: benefit rises steeply at the low end of effort if it is done consistently (Lally et al., 2010; Lee et al., 2019). This thesis argues for lowering the bar, setting support at the smallest behaviour that can be kept.

This thesis presents a wearable product-service system that helps a woman act on a preventive health behaviour of her choosing, without measuring her body. It was developed with Silvie Health, a startup focused on women's health over 55. Through a mixed-methods approach and a salutogenic lens, it delivers three results.

Firstly, an evidence base. Desk research on eight sub-questions, nine interviews with women (55-75) and expert interviews established what drives adherence, trust, burden and motivation. The synthesis changed the brief: the constraint is the step from intention to action. Requirements followed, and a first concept: a bedside clock, built, tested and let go. What carried into the product-service system was its voice: “you have done enough”

Secondly, the system: the Silvie Pillar, a gold-coated titanium pendant wearable. She makes a promise to herself in the accompanying app, and the pendant vibrates softly on her breastbone to remind her at a time that follows her preferences. She squeezes the pendant to confirm she kept her promise. No score, no sensing of biometrics.

Thirdly, evidence that the system is desirable, feasible and viable, grounded in correspondence with thirteen suppliers and a jeweller, and sessions with the target group, covering the interaction, the inner workings, manufacturability, cost, the app and the service, each reported with what it does not yet prove.

What distinguishes this thesis is its position: a preventive health wearable can measure nothing, judge nothing, and still earn its place. It demonstrates a proof of concept, a viable counter-example to a wearable culture built on measurement and self-optimisation. In doing so, the author hopes to contribute to a kinder and more humane way of approaching healthy ageing, one that asks and judges less.

Keywords: healthy ageing; execution gap; promise; salutogenic design; wearable jewellery; haptic feedback; capacitive sensing; product-service system; reparability; women 55+

Figure 1. Participant wearing a pendant prototype around her neck, 3D printed in PLA.

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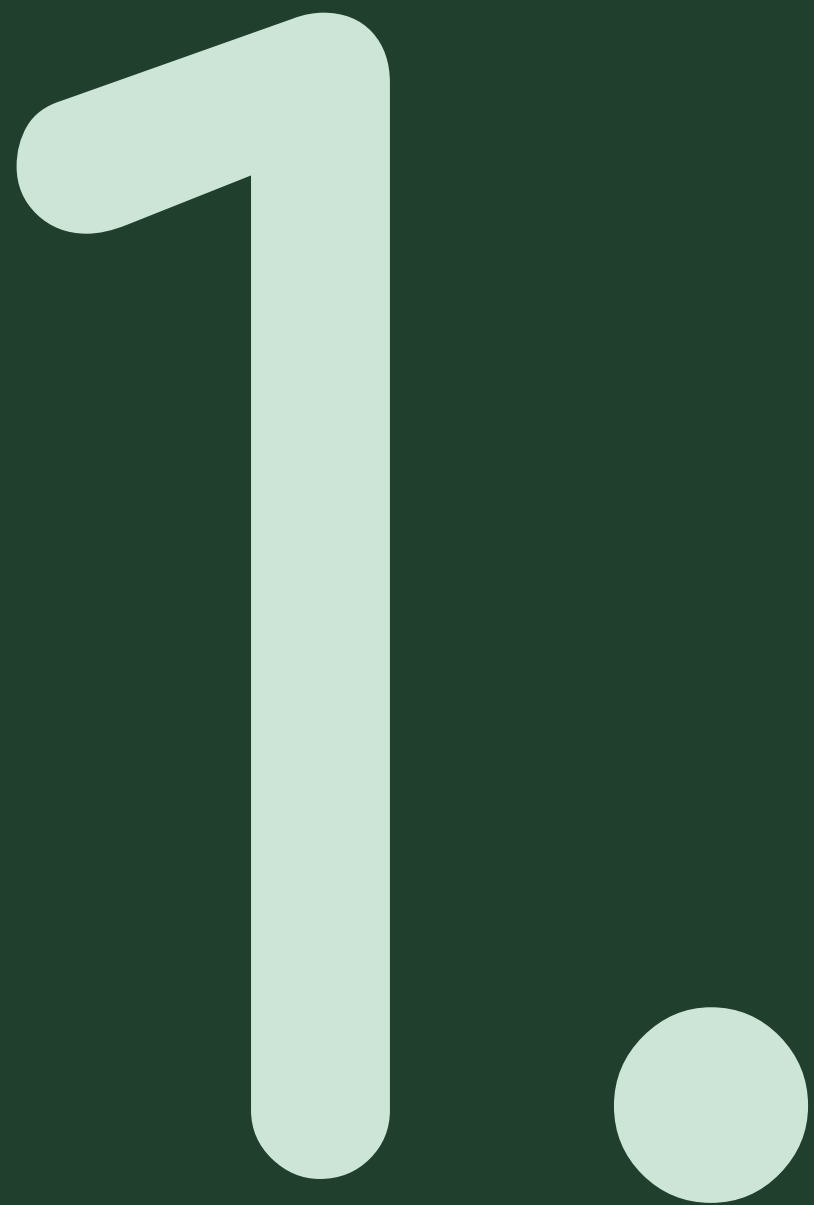
And finally, to myself

This might read a little strangely, but I want to thank myself too. For showing up every single day, going through the uncertainties of this process, and handling the responsibility managing this project. For staying curious, and for pushing hard.

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Introduction

This chapter sets out the background and why it matters (1.1), the project definition, stakeholders and scope (1.2), and the project approach (1.3).

1.1. Background, Motivation and Relevance

1.1.1. Background: From living longer to staying well longer

Scenario A: Expansion of Morbidity (the current trend)

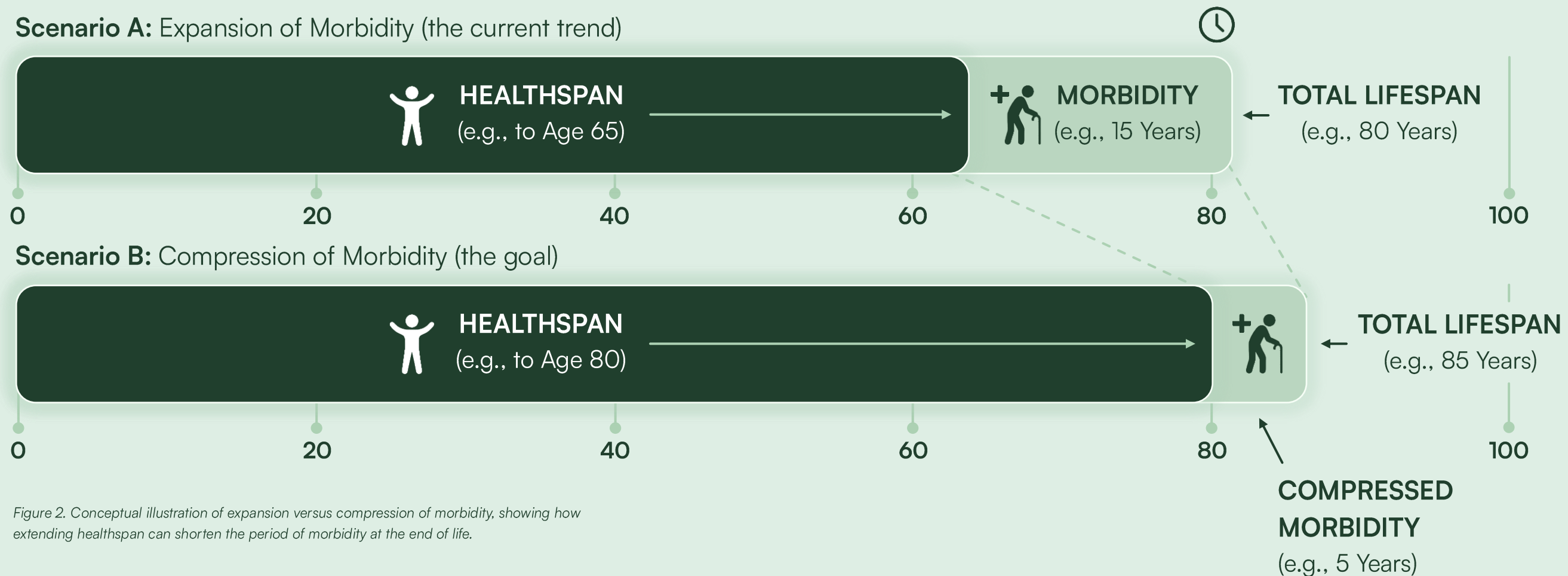


Figure 2. Conceptual illustration of expansion versus compression of morbidity, showing how extending healthspan can shorten the period of morbidity at the end of life.

For most of human history, the ambition was simple: survive. In the last century, public health and medicine made huge progress on that front, and “living longer” became the default expectation. The harder question today is what that longer life looks like. The World Health Organization frames healthy ageing as the ongoing process of developing and maintaining the functional ability that enables wellbeing in older age; meaning the ability to do the things people value, not just the absence of disease (WHO, 2020).

This shift in focus can be seen in *Figure 2*: the focus shifts from lifespan (the total length of the bar) to healthspan (the dark green section of the bar): not only how many years we live, but how many years we can live with strength, autonomy, and quality of life. Crimmins (2015) describes this as the core tension of modern ageing. As seen in **Scenario A (Expansion of Morbidity)**, many gains in longevity have come from reducing mortality and improving treatment, while the onset and accumulation of chronic conditions and functional limitations remain a major challenge. In this scenario, the period lived with morbidity (represented by the light green section) is not automatically “compressed” just because lifespan increases; instead, we simply spend more years in a state of diminished health.

The ultimate goal, however, is represented by **Scenario B (Compression of Morbidity)**. Here, the focus is on pushing the onset of disease further back into the later years of life. By extending healthspan relatively more than the total lifespan, we effectively “compress” the time spent in ill health at the end of life.

The incentive for pursuing Scenario B extends beyond individual wellbeing; it is an economic priority. Scott et al. (2021) suggests that the “Longevity Dividend” resulting from compressed morbidity could be the single most effective way to ensure the sustainability of healthcare systems. For instance, increasing healthy life expectancy by just one year is estimated to be worth US\$38 trillion to the global economy (Scott et al., 2021). Furthermore, the McKinsey Health Institute (2025) found that for every dollar invested in proven healthy ageing interventions, there is a US\$3 return to the broader economy through reduced healthcare costs.

In other words, the opportunity is not only biomedical; it is also behavioural, environmental and economical.

1.1.2. The Execution Gap in Preventive Health

If healthspan depends on thousands of small, repeated actions (sleep, movement, nutrition, preventive routines), then “healthy ageing” becomes partly a daily-life systems problem: are people supported by routines, environments, and services that make healthy behaviour realistic and maintainable (Crimmins, 2015; WHO, 2020).

A persistent barrier in preventive health is the gap between knowing/agreeing and doing. Even when people have good intentions, consistent execution is hard, especially when the behaviour is repetitive, low reward in the short term, and easy to postpone. Habit research helps explain why: automaticity is not a “3-week switch,” but a gradual learning curve. In a study by Lally et al. (2010), habit automaticity reached a plateau on average after about 66 days, with wide variation (roughly 18 to 254 days), and a single missed day did not meaningfully erase progress.

This “Execution Gap” is where design must intervene. If we want preventive routines to matter, we need to design systems that make them easy to execute and robust to normal life. Supplementation is a clear case of such a routine. Like other preventive habits, its success depends less on a single decision than on what happens daily: remembering, selecting the right items, fitting intake into real routines, managing supply, and recovering after disruptions. Much of this is not a persuasion problem but an execution one. Adjacent evidence from medication adherence shows how quickly routines fail when they become cognitively heavy, socially awkward, or practically inconvenient, and that non-adherence is often not “carelessness” but a rational response to everyday constraints and competing priorities (Harris et al., 2025).

Finally, there is strong motivation to treat this as a designable problem rather than a medical one. A randomized trial of a “pillbox app” for older adults showed that relatively grounded design moves like linking prompts to meals (instead of abstract clock-times) or using clear visual identification of medication can improve adherence and support perceived independence (Mira et al., 2014).

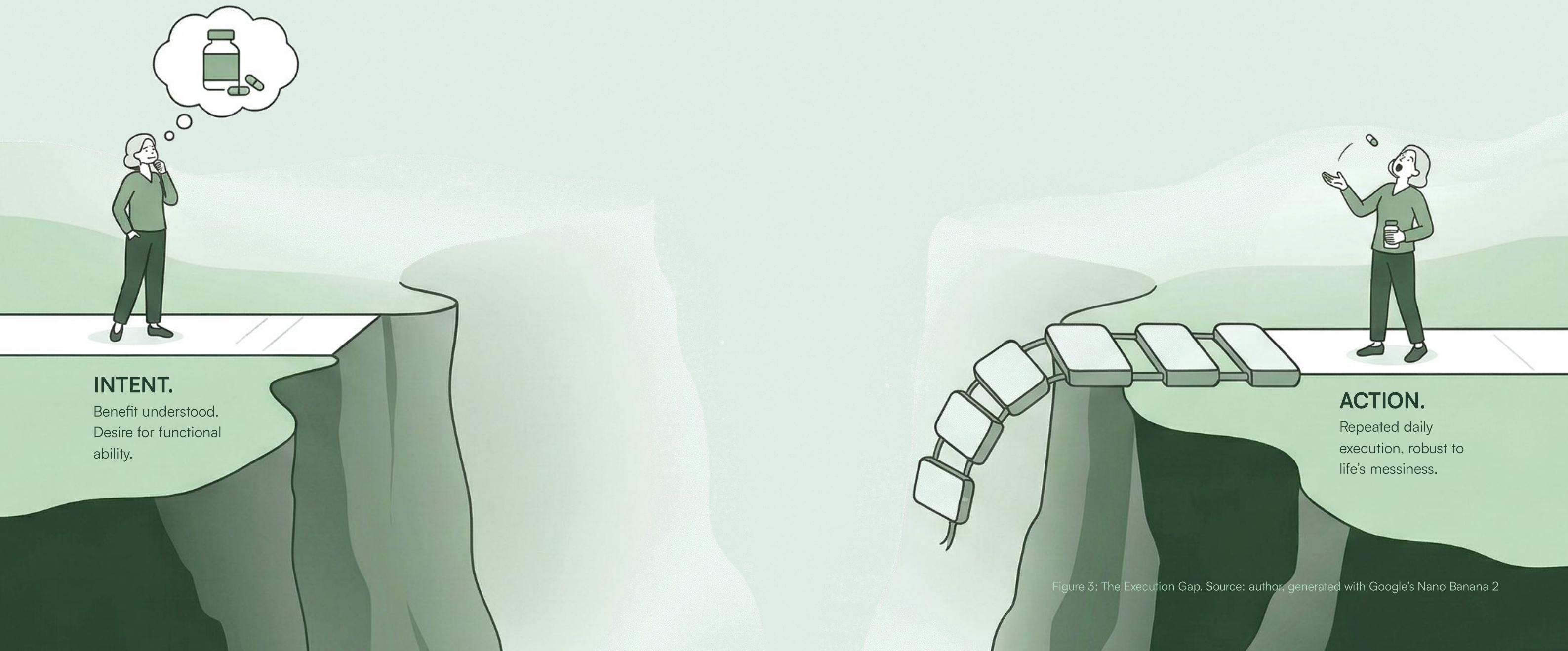


Figure 3: The Execution Gap. Source: author, generated with Google's Nano Banana 2

1.1.3. Relevance: Supplementation as a Design Case

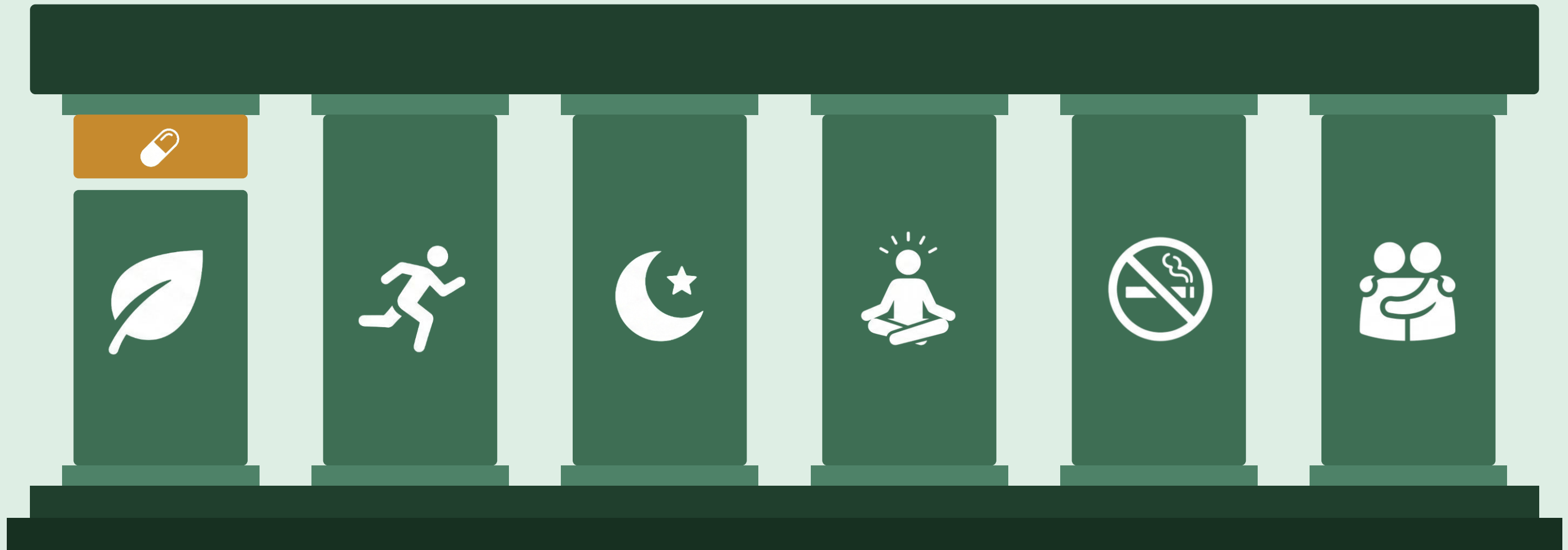


Figure 4: Supplementation as a small, optional part of the nutrition pillar, within the six pillars of health. Own illustration, based on Lippman et al. (2024)

To investigate this execution gap, this thesis focuses on supplementation. The theoretical value of supplements (and evidence informed nutrition more broadly) only translates into outcomes if a routine is executed correctly and repeated reliably. Supplements are not a substitute for a healthy diet. Still, they are a very common part of how people try to care for themselves as they get older. In Europe, supplement use differs strongly per country, but a consistent pattern is that use is higher among women than men (Skeie et al., 2009). This matters for design because "taking supplements" is often not one simple action. It can become a daily routine with multiple products, multiple moments, and repeated opportunities for friction, doubt, or mistakes, especially when people are busy, tired, or juggling other responsibilities.

At the same time, it is important to be honest about what supplementation can and cannot promise. Large cohort studies have not found that supplement use "in general" translates into living longer, and daily multivitamin use has not been associated with a mortality benefit (Chen et al., 2019; Loftfield et al., 2024). This thesis therefore does not frame supplementation as a shortcut to longevity, and it does not set out to settle whether supplements work; the evidence is compound-specific and mixed. Instead, it treats supplementation as a practical tool for functional health: the everyday outcomes people actually take supplements for, such as staying sharp, feeling energetic, and maintaining strength and mobility.

Where specific compounds and outcomes have been studied, the picture is in places encouraging. In older adults, a daily multivitamin-mineral has been linked to modestly better episodic memory over three years (Vyas et al., 2024); B vitamins to slowed brain atrophy (Smith et al., 2010); DHA to improved cognition (Yurko-Mauro et al., 2010); and protein combined with resistance training to greater gains in lean mass and leg strength than training alone (C.-D. Liao et al., 2017). Some compounds are also studied at doses that are hard to reach through food alone, even for people who already eat well (Buford et al., 2007). And in the Netherlands, national nutrition guidance explicitly advises vitamin D for women from age 50 (and men from age 70), partly because it reduces the risk of falls and fractures (Voedingscentrum, 2026).

What these cases share is a condition: the benefit, where it exists, is realised only when the supplement is taken correctly and consistently. The objective value may be modest or uncertain, but it is realised at all only through long term use, which makes that use a design problem in its own right.

Ultimately, supplementation is best understood not as a standalone solution but as one small part of nutrition: the part that tops up what food does not provide. Health is increasingly framed as a set of lifestyle pillars; lifestyle medicine identifies six, namely nutrition, physical activity, restorative sleep, stress management, avoidance of risky substances, and social connection, with strong evidence (including randomised trials and meta-analyses) that they are central to creating and maintaining health (Lippman et al., 2024). Supplementation is not one of these pillars. It sits inside the nutrition pillar as an optional, gap-filling component (Figure 4) that helps individuals reach functional peaks that their diet alone might not reach. Yet still, it is food first; supplements only earn their place when the diet is sound and when they are taken correctly and consistently in daily life.

1.1.4. Why focus on women 55+?

This project focuses on women aged 55-75 who live independently and for whom supplementation is already part of everyday self-care (or is intended to become so). Two selection criteria need justifying: the focus on women, and the choice of this age band. Both are argued below from three perspectives (behavioural, physiological, and design) which together explain why this is a life stage where preventive routines still have real leverage on long term functioning, yet are increasingly easy to disrupt.

From a behavioural perspective, the focus on women follows from consumption patterns: European population data show that dietary supplement use is consistently higher among women than men, making them a realistic starting point for studying supplement routines (Skeie et al., 2009). The age band, in turn, marks a life stage where many people are still independent in their daily routines while preventive health goals become more salient. Intentions around healthy ageing are often already present; the challenge shifts toward making daily execution reliable.

From a physiological perspective, the years around and after the menopausal transition come with risks such as bone density loss and muscle loss (Wright et al., 2024). Choosing 55+ also has a practical logic: by the mid-50s many women are in a more stable post-menopausal phase, which gives a clearer context for studying long term resilience rather than short term hormonal fluctuation. Muscle strength and function become increasingly central to independence in later life, as reflected in the European consensus definition of sarcopenia (Cruz-Jentoft et al., 2019). This is where the WHO's framing of healthy ageing becomes concrete: retaining the functional ability to do the things one values (see section 1.1.1). for many women in this group, the goal is staying strong and capable enough to keep doing the everyday activities that matter to them, from lifting a grandchild to opening a jar.

From a design perspective, this is a group where small failures in routine design can have outsized consequences. Normal cognitive ageing brings gradual declines in processing speed and aspects of memory that (while typically not severe enough to impair daily functioning) can create subtle difficulty with complex, easily postponed tasks such as the prospective memory needed to remember a daily intake (Harada et al., 2013). This stage also brings more routine disruption moments: travel, caregiving, retirement transitions. Here, even well intended habits become fragile. Adherence therefore depends less on motivation than on reducing friction and decision load at the moments routines break. The systems that do this must also be dignity preserving: older adults' sense of dignity can be undermined when they feel lost because of digital systems (Raja et al., 2022).

Taken together, these three perspectives explain the choice of population: women 55-75 are a group for whom preventive routines genuinely matter, yet for whom those routines are especially prone to quiet failure. That combination of high relevance and high fragility is what makes them a meaningful design focus.

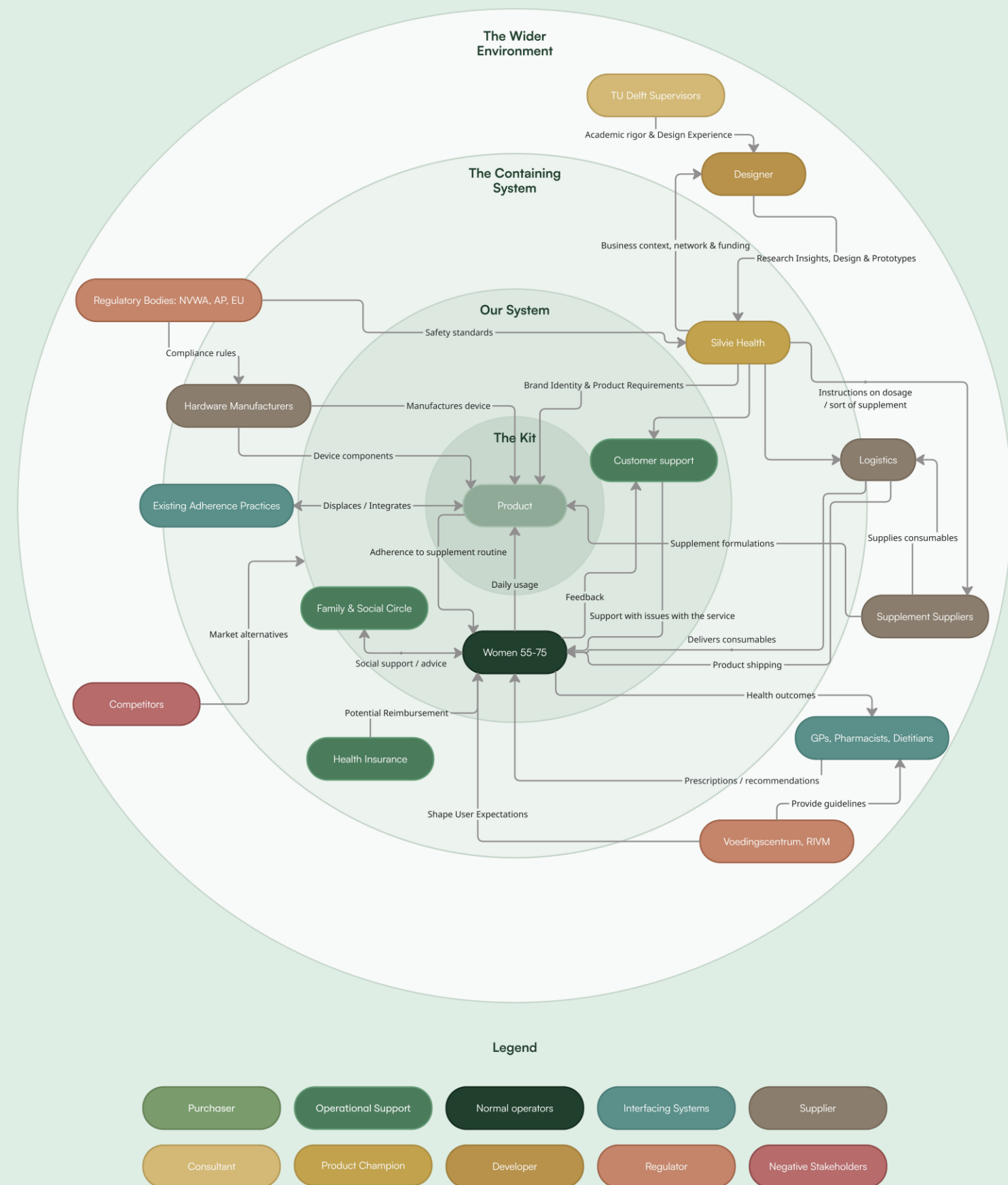


Figure 5. The Onion Model Stakeholder Map

1.2. Project definition

1.2.1. Problem definition

Many women aged 55-75 who live independently rely on supplements as part of how they care for their health, yet the value of those supplements depends entirely on a routine that is easy to let slip. As established in Section 1.1, the difficulty is rarely a lack of motivation; it is execution. What begins as "taking a vitamin" grows into multiple products and moments held together by memory and habit, and it is in that everyday complexity that adherence breaks down, through cognitive load, uncertainty about correct use, and a confidence that rests more on hope than on knowing.

The gap between evidence-informed supplementation and its reliable, dignified execution in everyday life is the problem this project sets out to address.

1.2.2. Context and stakeholders

This graduation project is conducted in collaboration with Silvie Health, a startup that develops evidence-informed nutrition and supplementation solutions for women aged 55 and older. Silvie's mission is grounded in supporting healthy ageing in a way that is practical in everyday life: helping women stay strong, sharp, and independent by making nutrition support accessible, trustworthy, and easy to sustain. Within this project, the focus is not on developing new supplements or making clinical claims, but on designing the experience layer around supplementation: how the routine fits into real lives, how it reduces friction and doubt, and how it supports autonomy and confidence over time.

The design problem sits in a broad ecosystem of stakeholders. To map this ecosystem systematically, this project adopts the onion model proposed by Alexander (2007), which organises stakeholders in concentric circles around the product being developed (see *Figure 5*). The model distinguishes four layers: The Kit (the product itself, containing no human stakeholders), Our System (the product plus its human operators and the standard operating procedures that determine use), The Containing System (Our System plus any human beneficiaries, purchasers, and interfacing systems, whether involved in operations or not), and The Wider Environment (all remaining stakeholders, including regulators, developers, suppliers, consultants, and competitors). Within each layer, Alexander defines generic stakeholder 'slots', such as Normal Operator, Functional Beneficiary, Interfacing System, and Negative Stakeholder, that serve as a checklist for identifying roles that might otherwise be overlooked.

The model was chosen because ordering stakeholders by proximity shows who shapes interaction requirements, who must trust the design for it to be adopted, and who sets its constraints. The closer a stakeholder sits to the centre, the more directly their needs have to be resolved in the product itself; outer ring stakeholders are usually addressed through service, communication or compliance.

Closest to the product are the primary users: women aged 55-75 living independently, for whom supplementation is already part of self-care or is intended to become so. In Alexander's terms, they are the Normal Operators: the people who interact with the product daily. The challenge for this group is often not motivation but consistency and clarity: knowing what to take, remembering to take it, and trusting that it matters. Around them, within the same system boundary, are the people who directly support the routine. Family members, partners, and adult children serve as Operational Support: they remind, motivate, and help with practical tasks like refilling. Customer Support also occupies an Operational Support role within this ring, advising users on how to use the product and troubleshooting issues that arise during daily operation.

The Containing System includes stakeholders who benefit from, interface with, or purchase the product without operating it themselves. Healthcare professionals, including general practitioners, pharmacists, and dietitians, function as Interfacing Systems: their prescriptions and recommendations shape what the product must support or integrate with. Silvie Health occupies the Product Champion slot: initiating development, providing funding, and protecting the project's scope and direction. Existing adherence practices (pillboxes, reminder apps, current supplement storage setups) also function as Interfacing Systems in an adapted sense: they represent the neighbouring routines and tools that the new product must either displace or integrate with, and understanding their limitations directly informs design requirements. Health insurance funds represent a potential Purchaser role within this ring: a stakeholder distinct from the end user who may fund or reimburse the product, and whose requirements around evidence and cost-effectiveness could shape the service model.

The Wider Environment contains all remaining stakeholders. Regulatory bodies (the NVWA, European Commission, and data protection authorities under the GDPR such as the AP in the Netherlands) act as Regulators whose compliance requirements define hard boundaries for any solution. Public health guidance bodies such as the Voedingscentrum and RIVM occupy a hybrid role between Regulator and Consultant: they do not enforce rules directly, but their guidelines shape public expectations and the credibility space within which the product must operate. Competitors represent Negative Stakeholders in Alexander's taxonomy: actors whose interests are opposed to the product's success and who offer alternative solutions that may pull users away. Also in this ring are the development roles: the Designer functions as a Developer in Alexander's terms, responsible for research, design, and prototyping but not involved in the product's daily operation. TU Delft Supervisors act as Consultants, providing academic guidance and methodological oversight from outside the development organisation. Hardware manufacturers, supplement suppliers, and logistics partners occupy Supplier roles: they provide the components and fulfilment infrastructure the product depends on, and their lead times, capabilities, and cost structures create practical constraints on what can be designed and scaled.

Beyond placement in the onion model, Alexander's framework highlights the concept of surrogacy, where one stakeholder represents another who is unavailable. This is particularly relevant here: Silvie Health partly acts as surrogate for end users during business and strategic decisions, and the designer acts as surrogate for users during the design process. Alexander warns that surrogate viewpoints may diverge from those they represent, which underscores the importance of direct user research throughout this project.

The map was built from the interviews reported in Chapter 2 and from conversations with the Silvie Health team, then cross-checked against Alexander's (2007) generic slots. That cross-check surfaced two roles the interviews did not: existing supplement routines as an Interfacing System, and data protection authorities as a distinct regulator.

Geographically, the project is grounded in the Netherlands and the wider European context. This shapes the routines, living situations, and cultural attitudes towards supplementation encountered, and it also sets practical constraints: the regulatory environment for supplements and health claims is European, and service feasibility (delivery, customer support, distribution) is shaped by local infrastructure. The analysis is therefore situated in the EU and may not transfer directly to other regulatory contexts, such as the United States, where supplement regulation and reimbursement differ substantially. 'Context' is also understood here in a broader design sense: not only where people live, but where the routine happens, across physical, social, and temporal environments. This is discussed more fully in Chapter 2.4.

1.2.3. Design assignment

If supplements only deliver value when the routine around them holds, and that routine is where things break down, the task is to design the system that carries it through daily life. This gives the project its design assignment:

Design and validate a scalable product-service solution to support consistent and correct supplementation routines for women aged 55-75.

1.2.4. Research question and sub-questions

Before such a system can be designed, several things have to be understood: why a routine holds for some women and quietly collapses for others, what "correct" use actually demands in everyday conditions, and what any solution must offer to be trusted, adopted, and kept. That turns the assignment into a central research question:

Main question

How can a product-service system help women 55+ adhere to a supplementation routine consistently and correctly in daily life?

The sub-questions open the two key words, consistently and correctly, in turn. The first two ask why routines succeed or fail and what correct use demands (SQ1, SQ2). The next two ask where a system could intervene and what low burden means (SQ3, SQ4). The following two ask what makes adoption hold, through trust and motivation (SQ5, SQ6). The last two ground the work in what already exists and in the limits that bound the solution space (SQ7, SQ8). Each becomes a line of enquiry in the research that follows.

Sub Questions

1. What are the main barriers affecting consistent supplementation routines among women 55+ and what strategies distinguish women who are consistently adherent?
2. What does "correct" supplementation mean in day-to-day use and where do misunderstandings or errors occur?
3. Which routine moments are most design relevant, and where in these moments could a product service system realistically support the user?
4. What does low-burden adherence mean for women 55+ and which factors most effectively reduce burden in real routines?
5. How do women 55+ form trust in a supplementation system and what design cues build trust?
6. What do women 55+ need to stay motivated and continue using a supplementation system over time?
7. Which existing solutions are used or known, and why do they work or fail for this target group?
8. What regulatory and technical feasibility constraints govern the design of a supplementation product-service system in the EU, and how do these constrain the solution space?

Figure 6. Illustration of the problem. Image generated with Google Gemini.



1.2.5. Scope and boundaries

This project focuses on the design of a device-based product-service system that helps people in active ageing manage their everyday health, and supplementation in particular, with greater clarity and confidence. The scope includes the development of a physical product concept, as well as the supporting service touchpoints needed to integrate it into daily life.

The project is positioned within the domain of preventive health and everyday wellbeing. It therefore addresses self-managed routines in non-clinical contexts, with a particular focus on usability, dignity, and integration into daily practice. The emphasis is on strengthening users' own understanding of and autonomy over their health, rather than on maximising compliance.

Medical and FSMP (Food for Special Medical Purposes) related contexts, such as dysphagia, are considered only to inform requirement setting, explore edge cases, and support the longer-term relevance of the concept. These contexts are not a primary focus. Accordingly, the project does not aim to develop a clinical solution, make therapeutic claims, or enter regulated medical territory.

1.2.6. Deliverables and definition of success

The outcome of this graduation project consists of an evaluated product-service concept supported by design research and development work. The main deliverables are:

- a functional prototype demonstrating the core interaction and key mechanisms of the concept
- a service blueprint and roadmap showing the supporting service structure and possible implementation pathway
- validation evidence demonstrating performance against the defined measurable requirements (desirability, feasibility, and viability)
- the final thesis and accompanying showcase deliverables (a poster)

Success is defined by the extent to which the final concept demonstrates a viable, desirable, and feasible way to help people in active ageing manage their everyday health, and supplementation in particular, with greater clarity, confidence, and autonomy, while remaining appropriately scoped within the domain of preventive health and wellbeing.

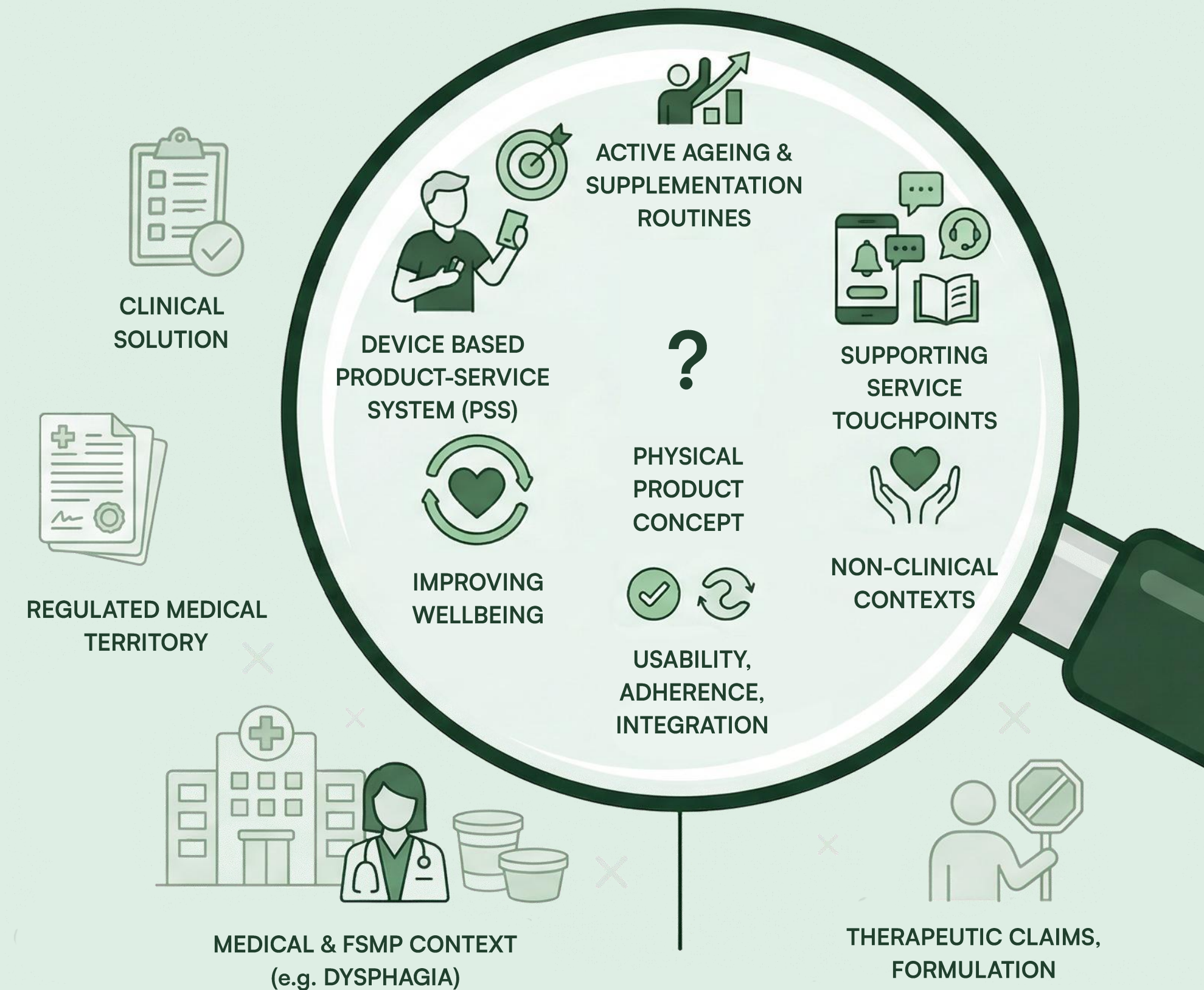


Figure 7. Scope and boundaries. Source: author, generated with Google's Nano Banana 2

How to read this report

This report follows one thread from start to finish: the gap between knowing what is good for you and actually doing it. Chapter 1 names that gap. Chapter 2 studies it in one concrete case, the supplement routines of women of 55 and older. Chapter 3 chooses a direction and sharpens the problem. Chapter 4 designs for it, tests the leading concept, and shows why that test forced a turn from a clock about supplements to a pendant about keeping promises to yourself. Chapters 5 and 6 work that pendant out and check whether it is desirable, feasible and viable. Whenever the report changes subject, it is this same thread that carries over.

1.3. Project approach

This project integrates three complementary perspectives: the Double Diamond framework as process scaffold, the Delft Design Guide as methodological toolbox, and salutogenic design as a guiding value lens.

1.3.1. The Double Diamond

The overarching design process is the Double Diamond (Design Council, 2026), which structures the project around two cycles of divergent and convergent thinking. The first diamond (Discover and Define) maps the problem space; the second (Develop and Deliver) generates and validates solutions.

The Design Council uses four guiding principles that apply across all phases: 1. put people first; 2. communicate visually and inclusively; 3. collaborate and co-create; and 4. iterate, iterate, iterate (Design Council, 2026). These principles are directly reflected in the methods chosen for this project: user interviews, as well as views integrated from the client, experts, manufacturers, and general practitioners, along with experts from the TU Delft on sensors and food design from different faculties. Moreover, visual tools such as journey maps, scenarios, and concept drawings make insights accessible to stakeholders; expert consultations and a co-creation approach bring in diverse perspectives; and multiple prototypes and tests are included in this project.

In this project the Double Diamond also accommodates the inherent complexity of designing for health behaviour: problems are rarely well defined at the outset, and early assumptions frequently shift once real users are involved. The model therefore functions less as a rigid roadmap and more as a framework for disciplined iteration in that it is making the current phase of the project visible while retaining the flexibility to revisit earlier decisions as the design develops.

1.3.2. The Delft Design Guide

Method selection within each phase is guided by the Delft Design Guide (Technische Universiteit Delft, 2021), a comprehensive methodological reference developed at TU Delft's Faculty of Industrial Design Engineering. Specific DDG methods are applied at the points where they add value. The rationale for each method, and how it has been adapted to this project, is introduced in-line in the chapter where it is applied.

1.3.3. A Salutogenic Design Lens

While the Double Diamond provides the process structure and the Delft Design Guide provides the methodological tools, the salutogenic design lens shapes the values and quality criteria applied throughout. Salutogenesis, a concept introduced by medical sociologist Antonovsky (1979) inverts the conventional focus of health science: rather than asking what causes disease (the pathogenic orientation), it asks what enables people to stay healthy, cope effectively, and move towards the positive end of an ease/dis-ease continuum.

Central to Antonovsky's model is the concept of the Sense of Coherence (SOC), a global orientation reflecting the degree to which a person experiences their world as comprehensible (structured and predictable), manageable (resources adequate to meet demands), and meaningful (demands worthy of investment). A strong SOC has been consistently associated with higher health and well-being outcomes across populations (Eriksson & Lindström, 2006). SOC can be supported or undermined by the environments and artefacts with which people interact. The shift within this lens is the transition of the user from a passive "patient" or "victim" of symptoms to an active agent in their own health generation. In pathogenic design, the focus is often on correcting a deficiency; in a salutogenic framework, design empowers users to maintain their own equilibrium. This nudges the solution from a utilitarian tool into a facilitator of self-tuning and self-efficacy.

Applied to product and service design, a salutogenic lens reorients design goals away from compliance or deficiency correction and towards strengthening capacity and confidence. For this project, it operationalises as a set of design values that run through all phases: interactions should be clear and legible (supporting comprehensibility), low in cognitive and physical burden (supporting manageability), and aligned with the user's own health goals and identity (supporting meaningfulness). This salutogenic orientation is consistent with the Design for Health and Wellbeing perspective articulated in the Delft Design Guide, and complements the Design for Behavioural Change perspective, which frames design as part of the choice architecture that shapes daily routines (Technische Universiteit Delft, 2021).

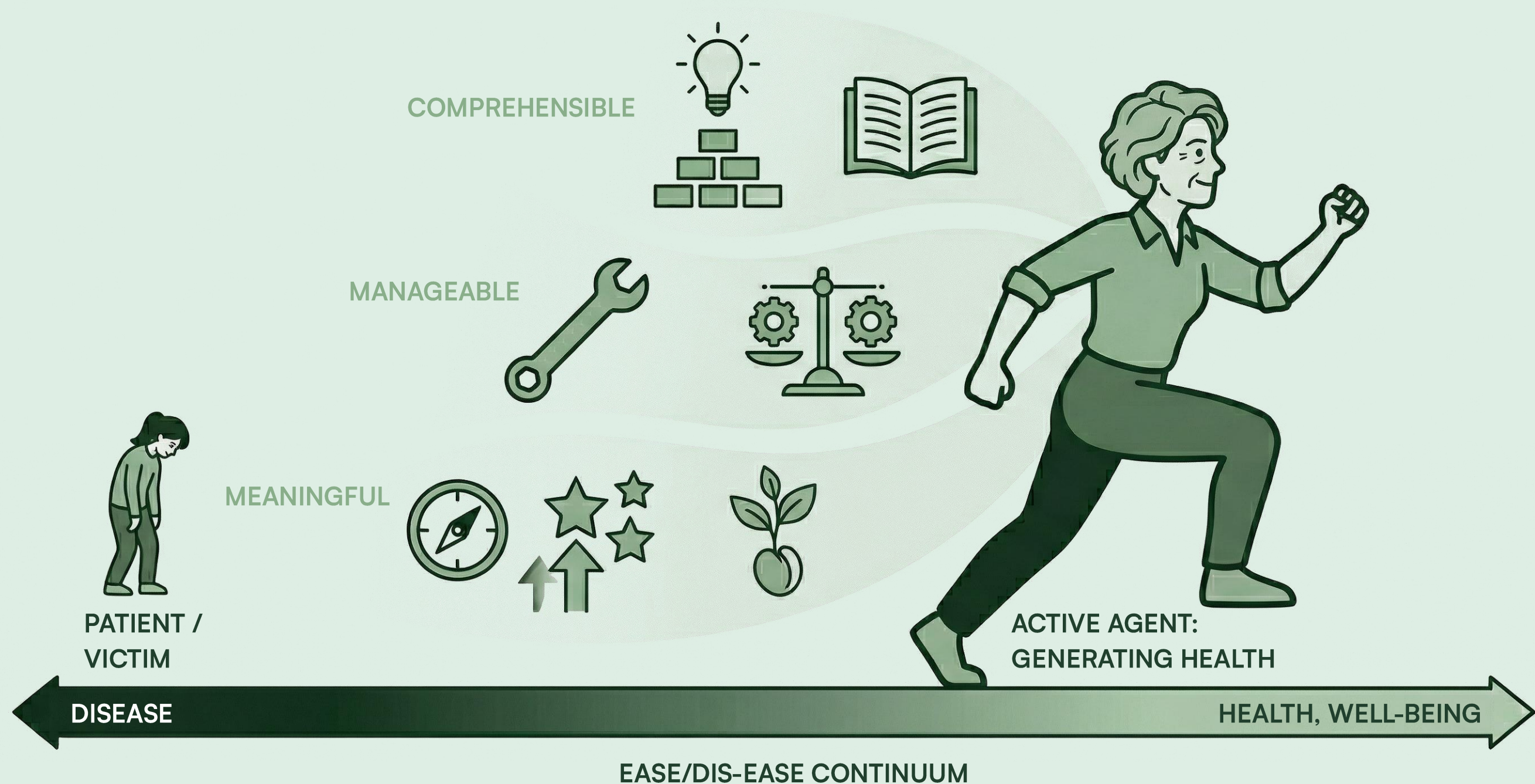


Figure 8 The Ease/ Dis-ease continuum. Generated with Google Gemini.

The 6C framework

To apply salutogenic principles as concrete design criteria, this project adapts Antonovsky’s sociological 6C framework (Antonovsky, 1993). Antonovsky viewed Complexity and Conflict as unavoidable parts of life that can be both harmful and helpful. He also recognized that Coercion can successfully create stability for some, even if it is morally questionable. This project, however, adapts these complex sociological concepts into a straightforward, practical tool for evaluating designs. The revised framework (Figure 9) measures design quality across six dimensions, which are split into two clear categories: three negative stressors to **minimise** and three positive outcomes to **maximise**.

The adapted 6C framework is applied throughout this thesis: in the Define phase, each desirability requirement is annotated with its primary 6C dimension, and in the Develop phase, concepts are evaluated against these dimensions. The framework does its work in the Define phase, where it annotates each desirability requirement. When the problem was reframed in Chapter 4 the requirements were rewritten and those annotations were not carried across, so the final design is evaluated against the revised requirements and against the three components of the sense of coherence rather than against the six dimensions directly.



Figure 9. The adapted 6C framework: three pathogenic stressors to minimize and three salutogenic outcomes to maximise, derived from Antonovsky (1993)

1.3.4. A Mixed-Methods, Design-Driven Approach

Across the four phases this project combined qualitative primary research, desk-based synthesis, iterative prototyping and empirical validation. Discover combined a design oriented literature review, an AI assisted scan using Elicit, nine semi structured interviews with women aged 55 to 75, five expert interviews in the research phase and a sixth expert during validation and a written follow up round. Define used a Harris Profile to choose between four directions, personas and a journey map to hold the findings, and a PESTEL based future visioning exercise to set the horizon. Develop used Lotus Blossom and how to questions to diverge, and the Weighted Objectives Method to converge on three concepts; the one carried forward was built as a Wizard of Oz prototype and evaluated with four women and a general practitioner. Deliver built functional prototypes, a production CAD assembly and a service model, and tested them across six sessions with participants, one session at a jeweller's bench and one with the client, alongside correspondence with fourteen organisations, a finite element analysis of the sensing wall and a power budget built from datasheets. Where a method could not settle a question, that limit is stated where the result is reported.

1.3.5. Project partners, roles, and collaboration boundaries

This project is developed in collaboration with Silvie Health B.V. as the external client and project partner, formalised through a graduation contract in accordance with the IDE MSc graduation requirements. The collaboration defines a clear division of roles: TU Delft, through the student and supervising academic staff, retains full academic independence and is responsible for all research design, data collection, analysis, and reporting decisions. Silvie Health contributes contextual knowledge, provides feedback on emerging design directions, and grants access to relevant product and market information. It does not direct the research agenda, influence data interpretation, or have access to raw participant data.

Raw research data (including interview recordings, transcripts, and signed consent forms) is stored exclusively on TU Delft OneDrive and is accessible only to the student and the supervising academic staff. Silvie Health receives only anonymised and aggregated insights, communicated in project meetings and in the final thesis deliverable. This arrangement reflects the boundaries verified through the HREC ethics review process (see Section 1.3.6) and is consistent with the Data Handling Agreement and external-party provisions set out in the graduation contract.

1.3.6. Ethics, privacy, and data management

All human-participant research in this project (including the qualitative interviews with women 55+) has been conducted in accordance with the ethics requirements of the TU Delft Human Research Ethics Committee (HREC). Prior to any participant contact, a completed HREC checklist was submitted and reviewed by the responsible academic supervisor (Stefan Persaud) and was approved to proceed.

Participant recruitment and data handling follow the procedures documented in the HREC submission. All participants received a written informed consent form explaining the study purpose, data use, their right to withdraw at any time without consequence, and the confidentiality arrangements in place; consent was obtained and signed before any interview began. Participants are identified in all data files only by a pseudonymous code; names, contact details, and other directly identifying information do not appear in any research data file.

All data is stored on TU Delft's institutional OneDrive environment and is not shared with or accessible to the project partner (Silvie Health). Contact information collected for recruitment purposes is managed separately from research data and will be deleted at the end of the project (August 2026). Audio recordings are transcribed and deleted once the accuracy of the transcript has been verified; only anonymised transcripts are retained. Consent forms are stored separately from interview data to prevent re-identification. No data transfer agreement with Silvie Health is required, as no raw or identifiable participant data is shared with the external party.

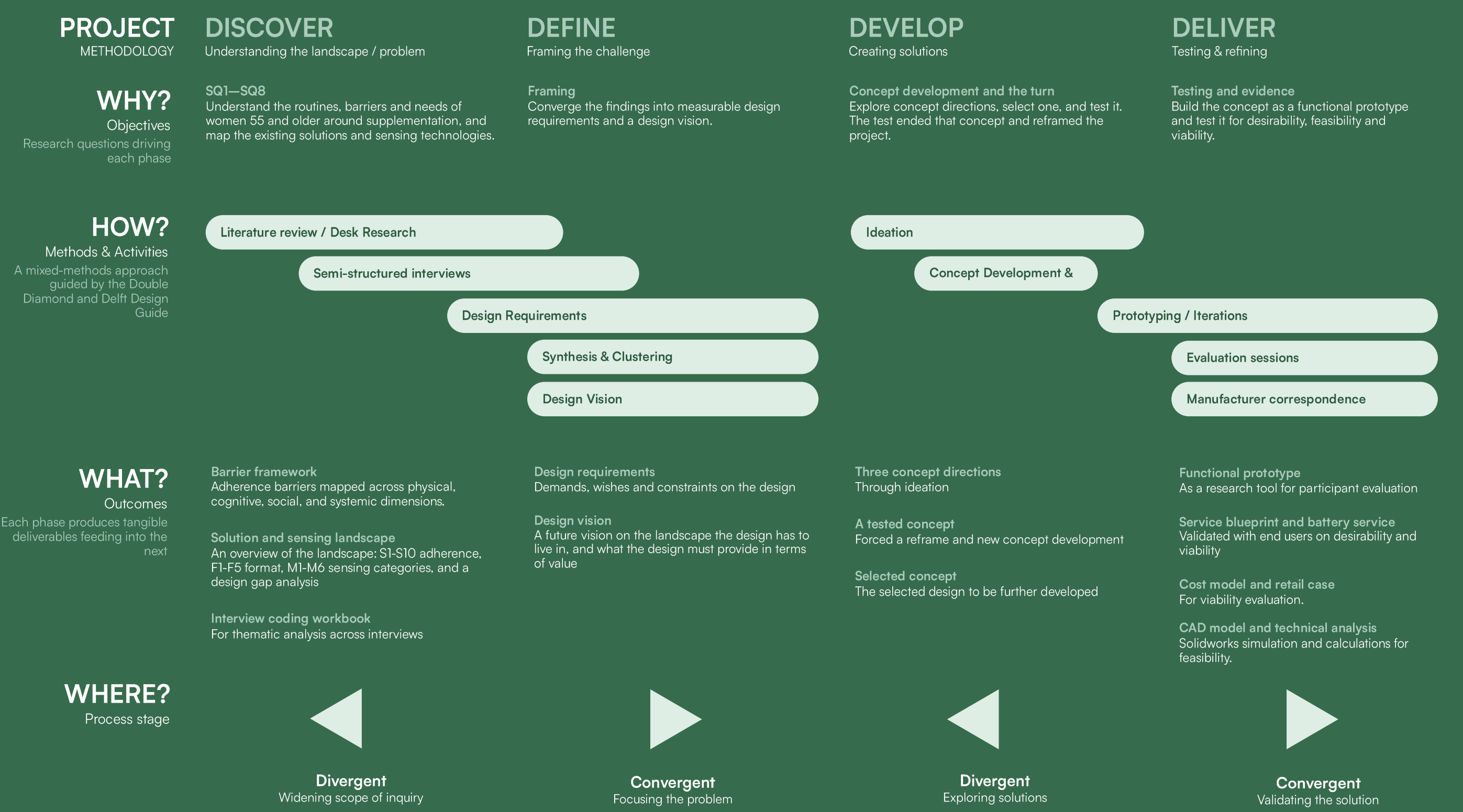
No external ethics approval (for example, from a hospital or clinical ethics board) is required for this study, as the research does not involve medical interventions, clinical populations, vulnerable groups outside the scope of the HREC framework, or data categories that would trigger additional oversight. The research period runs from February to August 2026.

1.3.7. Note on AI-assisted tools

In the interest of academic transparency and in alignment with the TU Delft IDE Rules & Guidelines from the Board of Examiners (2025-2026) regarding authorship and academic integrity, this project discloses the use of generative AI tools at five specific points in the research process:

- Literature Synthesis: An AI-assisted literature scan was conducted using Elicit to identify peer-reviewed evidence on supplementation adherence and health behaviour in older adults. All sources returned were independently read, assessed, and verified for accuracy and relevance by the researcher before inclusion.
- Drafting and Editing: Claude (Anthropic), ChatGPT (OpenAI), and Gemini (Google) were used as writing assistants to support the structuring and linguistic refinement of written sections. All final content has been reviewed, substantially edited, and approved by the researcher to ensure it represents the author's original analysis.
- Image generation: Some images were generated (or edited) by OpenAI and Gemini, where this applies is written in the figure captions.
- Data Analysis (Coding Support): Claude (Anthropic) was used to assist in the initial coding of manually anonymized interview transcripts. The AI suggested candidate codes and segment highlights, which were then reviewed, adjusted, and validated by the researcher. All interpretive judgments and final coding decisions remain the sole work of the author, as detailed in Section "Interview analysis and coding approach".
- Arduino programming: The firmware was written with an AI coding assistant to help speed up the process of getting to test the functional prototype with participants.

1.3.8. Methods overview



2.

Discover

This chapter presents the findings from the Discover phase: the divergent exploration of the problem space. It begins with the research design, explaining how desk research and qualitative interviews were combined to build a grounded understanding of supplementation routines. The chapter then works through eight sub-questions, each addressing a different dimension of the adherence challenge: barriers and strategies (2.1), correct use and common errors (2.2), routine moments and intervention opportunities (2.3), low-burden adherence (2.4), trust formation (2.5), long-term motivation (2.6), and the landscape of existing solutions (2.7). Each sub-question integrates literature findings with interview evidence from nine women in the target group, highlighting where desk research predictions hold, where they shift, and what new patterns emerge.

Research design for the Discover phase

The Discover phase includes a mixed-methods approach that combines a desk-based literature review with semi-structured qualitative interviews. The two are complementary: the literature review establishes what is known about supplementation adherence in older adults and maps the landscape of existing solutions, while the qualitative interviews generate insight into the specific routines, experiences, and motivations of the target group. Together they provide the empirical grounding for the synthesis and design direction work that follows.

Overview of desk research areas

DESK RESEARCH AREA	SUBQUESTIONS	LITERATURE DOMAINS	STUDY DESIGNS
1 Adherence barriers, strategies, and routine formation	SQ1, SQ4	Medication adherence, behavioural science	Systematic reviews, RCTs, qualitative and mixed-methods studies
2 Correct supplementation use and error patterns	SQ2	Medication safety, self-management	Structured interview studies, systematic reviews
3 Trust, motivation, and sustained engagement	SQ5, SQ6	Digital health, health psychology, gerontology	Surveys, experimental studies, qualitative interviews, cohort studies
4 Existing solutions, alternative formats, sensing technologies, and regulations	SQ7, SQ8	Pharmaceutical technology, biomedical engineering, product documentation, regulatory documents	Formulation studies, clinical trials, systematic reviews, ethnographic studies, grey literature

Table 1. Overview of desk research areas, subquestions addressed, literature domains consulted, and study designs included.

Desk research and literature review

The desk research strand provides the evidence base for the subquestion analyses in Chapter 2. It covers four complementary topic areas, each targeting different subquestions and drawing on different source types. Together, they establish what is known from existing research and practice before the qualitative interviews add first-hand insight from the target group. One sub-question is intentionally absent from the desk research: SQ3 (routine moments and intervention opportunities). Because it concerns the lived sequence of a daily routine, it is addressed primarily through the qualitative interviews and the six-moment framework built from them (Section 2.3).

Source identification approach

The literature review followed a design-oriented approach rather than a formal systematic review protocol. The goal was not to produce an exhaustive or statistically weighted synthesis of a clinical evidence field, but to build a sufficient, verified evidence base to inform design decisions across multiple subquestions.

Sources were identified through two complementary channels. The primary channel was an AI-assisted literature scan using Elicit (elicit.com), a research tool that searches academic databases and generates structured summaries of retrieved papers. For each topic area, questions were formulated in Elicit aligned with the relevant subquestions. The resulting reports were reviewed and relevant papers skimmed or read in depth to assess their relevance and quality. Elicit served as a search and orientation tool: it accelerated the identification of relevant papers and provided initial summaries that helped navigate unfamiliar topic areas more efficiently. The secondary channel was manual searching, used primarily for the grey literature: product and competitor websites, regulatory documents, and commercially available sensing technologies. All identified sources were collected and organised in Zotero.

Across both channels, source selection was based on relevance to the research questions (by own judgement). There was no formalised scoring rubric for inclusion; rather, each source was assessed on whether it contributed meaningfully to understanding the barriers, strategies, contexts, or solution landscape relevant to the subquestion at hand. This approach led the researcher to identify problems and opportunities grounded in evidence. All synthesis, interpretation, and writing are the researcher’s own work, supported by AI writing assistants for structuring and language refinement (see Section 1.3.7 for full AI tool disclosure).

Topic areas and evidence characteristics

Adherence, routine formation, and burden (SQ1, SQ4)

Because supplement-specific adherence evidence is limited, this area draws primarily on the adjacent medication adherence literature. For SQ1 (barriers and strategies), an Elicit scan of 50 papers was reviewed, from which 8 sources (predominantly systematic reviews, published between 2008 and 2026) were selected. These cover prospective memory failures, regimen complexity, routine disruption, and the comparative effectiveness of behavioural, educational, and combined interventions. For SQ4 (low-burden adherence), a broader Elicit scan of 500 papers was assessed, from which approximately 12 studies spanning systematic reviews, RCTs (Randomized Controlled Trials), qualitative and mixed-methods designs (2006-2026) were selected, addressing burden drivers as well as burden-reduction strategies. Most included studies across both scans focus on adults aged 60+ or 65+ rather than 55+ or focused on medication adherence, meaning the findings are interpreted with caution regarding direct applicability to the subquestion. This transferability assumption is explicitly tested through the qualitative interviews in subsequent sections.

Correct use and error identification (SQ2)

An Elicit scan of 50 papers was reviewed, from which 7 sources (structured interviews, systematic reviews, qualitative studies 2004-2023) were selected that together define what “correct” supplementation means in practice across four dimensions: what to take, when to take it, how to take it, and what to do when a dose is missed. Sources were selected for their relevance to home-based, self-managed routines rather than clinical administration.

Trust in health systems and supplementation (SQ5)

Direct evidence on trust formation in supplementation systems for this demographic is scarce. An Elicit scan of 500 papers was assessed, from which approximately 17 studies (experimental studies, surveys, qualitative interviews, and systematic reviews, 2005-2025) were selected, drawn from medication adherence, digital health tools, and health information systems. These were chosen because their trust mechanisms (source credibility, design quality, transparency, autonomy) are applicable to supplementation contexts. The resulting trust cues and principles are ranked by evidence strength based on cross-study convergence rather than individual study quality.

Long-term use and motivation (SQ6)

An Elicit scan surfaced 25 studies spanning supplementation programmes (1 study), medication adherence (7), exercise interventions (11), and wearable/digital health tools (6), of which approximately 22 were selected for the final analysis based on relevance to sustained behaviour in non-clinical, self-managed contexts among older adults. Study durations ranged from 30 days to 5 years, with most following participants for 6-24 months.

Existing solutions, delivery formats, and sensing technologies (SQ7)

The solution landscape was mapped through three Elicit scans supplemented by manual searching. For adherence-support solutions, an Elicit scan of 21 sources was reviewed; approximately 15 academic sources (including systematic reviews, RCTs, and ethnographic studies) were retained. For alternative delivery formats, an Elicit scan surfaced 135 sources from pharmaceutical technology and formulation science literature (primarily 2010-2026), from which approximately 35 were selected covering formats beyond traditional pills. For micronutrient sensing technologies, a scan of 80 sources was reviewed, from which approximately 25 informed the analysis. For all three scans, manual searching complemented the Elicit scans, particularly for product reviews and commercially available technologies and products.

Regulatory context (SQ8)

The regulatory scan covers EU and Dutch food supplement regulations relevant to the design concept's feasibility and compliance boundaries, including the EU Food Supplements Directive, EFSA health claims regulations, and NVWA enforcement guidelines.

Source quality and limitations

Several characteristics of this evidence base should be noted. First, the review is broad by necessity: the project spans adherence behaviour, trust formation, delivery technology, and existing solutions across eight Elicit scans totalling over 1,300 initially retrieved papers, from which sources were retained through purposive selection. No single topic area receives the depth of coverage that a dedicated systematic review would provide; this breadth is a deliberate trade-off for this project as it must synthesise across domains to identify design opportunities, as well as manage to diverge widely within the time given for this project. Second, the reliance on medication adherence literature as a proxy for supplementation adherence introduces a transferability assumption that is tested through the interview findings. Third, the use of Elicit as a primary search tool means the review is shaped by that tool's database coverage (Semantic Scholar and OpenAlex, approximately 138 million papers) and retrieval algorithms; manual searching and citation following were used to mitigate this dependency, but the review does not claim to have exhaustively covered any single database. Finally, source selection was based on judgement of relevance rather than a predefined protocol, which introduces a degree of selection bias that is inherent to any purposive review approach.

Despite these limitations, the review provides sufficient evidence base for the design decisions it supports: each subquestion section in Chapter 2 makes explicit which sources inform which claims, and the interview findings provide an independent check on whether the literature's predictions hold for this specific target group and context.

Qualitative semi structured interviews

Interviews were chosen as the core primary research method in the Discover phase because they allow a deeper understanding of people's beliefs, needs, motivations and routines. In the context of supplementation, it is not enough to observe what people do; the key is understanding why they do it that way, what they trust or doubt, and what causes the routine to break down on difficult days. Interviews also make it possible to probe further, clarify apparent contradictions, and explore edge cases in a way that structured surveys cannot. They are therefore well suited to surfacing the friction points relevant for design: where decisions feel risky, where confidence is low, and what people would need to feel more in control. Following the Delft Design Guide guidance (Technische Universiteit Delft, 2021) the interviews were conducted in six steps:

Step 1: Interview guide development and pilot testing

A semi-structured interview guide was developed based on the main research question and eight sub-questions (SQ1-SQ8). The guide was organised as a topic list rather than a fixed questionnaire, moving from general everyday experiences toward more specific questions as rapport was established. Topics covered the participant's current supplement routine (what, when, where, how), storage and preparation practices, experiences with missed doses and disruptions, trust and information sources, motivation and perceived benefit, familiarity with existing tools and solutions, and openness to alternative formats and monitoring. The guide was tested through a pilot interview, after which question phrasing and topic order were refined to improve conversational flow (see Appendix B for the interview guide).

Step 2: Participant recruitment and selection

Target group definition

The age range of 55-75 is treated as a practical starting point rather than a hard boundary: people enter ageing related life phases at different moments, and interviews may therefore include a small number of participants slightly outside this range when they match the same routine and context characteristics.

Recruitment approach

Participants were recruited through a combination of personal network and purposive sampling. Part of the sample was approached in person in Delft, at locations where the target group was likely to be present, including a public library, community centres, a health-food retailer and a local gym (see Figure 10).

A poster (Appendix A) was made which included the purpose of the study, contact details if one wanted to participate (tear-off strip) and a

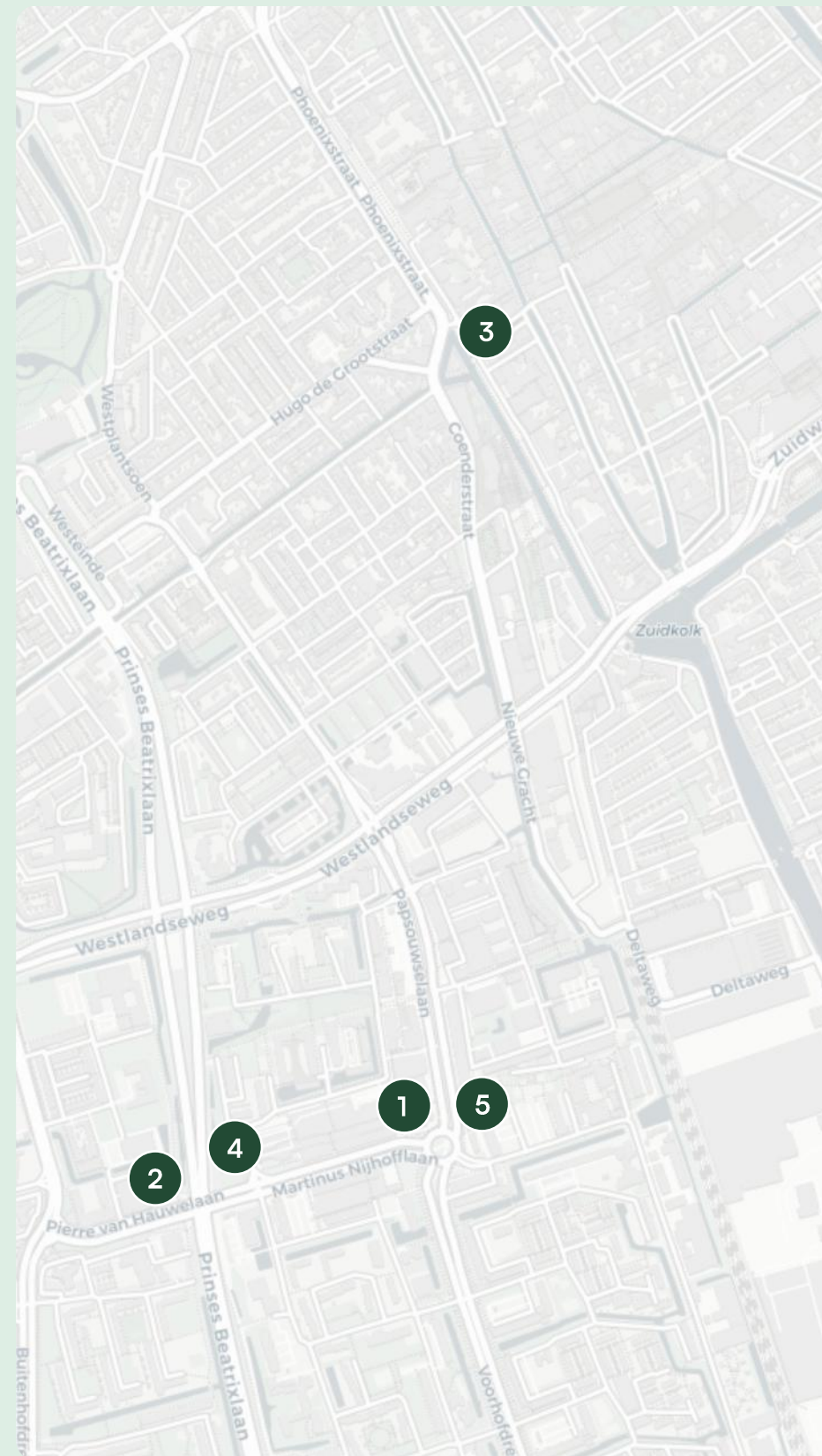


Figure 10. In-person recruitment sites supplement use interviews, women 55-75, Delft



Recruitment channels

1. Holland & Barrett - Health & wellness store
2. DOK Voorhof - Public Library
3. Apotheek Hof van Delft — Pharmacy
4. Wijkcentrum de Vleugel — Community centre
5. SportCity Delft - Gym & fitness

QR code with link to a sign-up quiz (see Appendix C). Upon initial interest, potential participants were approached through their preferred medium (email, WhatsApp, phone call) to plan a moment for a 30-45 minute interview.

Inclusion criteria

Participants were eligible if they:

- identify as female and are 55-75 years old
- live independently (at home)
- currently take supplements at least several times per week, or actively intend to but struggle with consistency
- are willing to discuss their daily routine and how supplements are stored, prepared, and taken.

To ensure rich insight into both "success patterns" and failure modes, the sample intentionally included variation in routine quality: some participants who were already consistent ("ritualised" routines) and others who experienced friction, missed doses, uncertainty, or had scepticism of supplements. A similar variation in age was pursued to cover the age range as well as possible. These variations were deliberately made to support identifying practical design requirements and commonalities/differentiators across different users in the target group.

Exclusion criteria and scope control

Participants were not included in this first research phase if they:

- lived in assisted living or a nursing home, where supplementation becomes embedded in staff workflows and a different system context
- relied primarily on clinically prescribed nutrition/medical nutrition products as part of treatment
- required caregiver-led daily routines due to severe cognitive impairment

These exclusions were used to keep the project aligned with its primary scope: designing for a self-managed preventive routine rather than a medically managed care workflow.

Final sample

Nine participants (P01-P09) were included in the final sample. Recruitment aimed for variation in age within the 50-75 range, living situation (alone, with partner, with family), supplement stack size and format, and current level of adherence consistency.

Table 2 Overview of the five supplementary expert interviews (E1-E5)

Expert Participant code	Expert
E1	Founder of a personalised, data-driven supplementation business
E2	General practitioner (huisarts)
E3	General practitioner (huisarts)
E4	Food and design researcher (TU Delft, IDE)
E5	Sensing-technology expert (TU Delft, outside IDE)

Supplementary expert interviews

In addition to the target-group interviews, five supplementary expert interviews (E1 to E5) were conducted to deepen the project's understanding of topics that fell outside the participants' direct experience. Within TU Delft, one expert affiliated with the Faculty of Industrial Design Engineering contributed knowledge on food and design, while a second expert from electrical engineering inside the TU Delft (outside IDE) brought expertise in sensing technologies. Two general practitioners (huisartsen) were interviewed to ground the project in primary-care perspectives on supplementation among older adults. In addition, the founder of a personalised, data-driven supplementation business, a contact of the project's client, was consulted.

A sixth expert, E6, was consulted later in the project rather than in this round: a working jeweller and watchmaker, approached during the feasibility and viability work to test whether the trade would service the pendant and stock it. That session is reported in Chapter 5.

These conversations were used to pressure-test early assumptions around supplementation format feasibility, delivery mechanisms, and the current state of micronutrient sensing: topics that the desk research had flagged as relevant (see Sections 2.7.3 and 2.7.5) but that required specialist interpretation. Additional outreach was made to professors at Wageningen University, private clinic owners and sociologists from Utrecht University, but these contacts did not result in interviews. The expert interviews were exploratory and contextual in nature: they informed the researcher's understanding of the solution space rather than representing end-user perspectives, and their input is referenced where relevant in the analysis. All expert conversations were treated as contextual input and are not merged with the main participant dataset.

Step 3: Informed consent and study explanation

Prior to each interview, participants were provided with a written informed consent form explaining the study purpose, data use, their right to withdraw at any time without consequence, and the confidentiality arrangements in place (see Appendix E for the informed consent sheet). Consent was obtained and signed before any interview began. Their contact data was managed and stored on TU Delft OneDrive and not shared with any external parties. Participants were given a pseudonymous code and all data was pseudonymised. The full ethical framework and HREC approval process are described in 1.3.6. A separate consent sheet was used for the expert interviews, reflecting the different nature of these conversations (contextual input rather than personal supplementation routines).

Step 4: Conducting the interviews

All nine interviews were conducted following the semi-structured topic guide, with each interview lasting approximately 30-45 minutes. Interviews were audio-recorded with participant consent. The semi-structured format allowed the conversation to follow the participant's own narrative while ensuring all research relevant topics were covered.

Step 5: Transcription and anonymisation

All nine interviews were transcribed verbatim using “Buzz”; a software that transcribes audio offline locally on a PC (to respect participant privacy). Prior to analysis, each transcript was manually anonymised by the researcher: participant names were replaced with identifiers (P01-P09), references to specific locations, workplaces, family members, and other potentially identifying details were removed or generalised. The anonymised transcripts form the basis for all subsequent analysis; original recordings were stored securely on TU Delft OneDrive and accessible only to the researcher and supervisory team.

Step 6: Analysis and coding

The analysis followed a deductive-inductive coding approach. The eight sub-questions (SQ1-SQ8) served as an a priori coding framework: each transcript segment was first assigned to the sub-question it most directly addressed (e.g., SQ1-BARRIER, SQ3-MOMENTS, SQ5-TRUST). Within each sub-question, secondary codes captured more specific phenomena (e.g., "routine-anchoring," "swallowing-difficulty," "autonomy-control"). This deductive layer ensured that every part of the analysis could be traced back to a specific research question. At a sample size of nine participants the goal is not statistical generalisation but rich, situated understanding of how supplementation routines work and fail in daily life. For this thesis depth of insight per case matters more than breadth of sample, and nine in-depth interviews provide sufficient variation to identify recurring patterns, contrasting strategies, and design-relevant friction points across different routine types and living situations.

On top of the deductive framework, an inductive thematic layer was applied. After completing the initial coding pass, the researcher reviewed all coded segments across participants to identify themes that were not captured by any single sub-question. This surfaced five emergent themes (e.g., "discipline as identity," "seasonal flexibility and autonomy," "doctor as gatekeeper") that cut across multiple sub-questions and reflect deeper attitudinal patterns. Additionally, for SQ3, a quantitative scoring layer was applied: each routine moment was rated per participant on a 0-2 friction scale (0 = no issue, 1 = minor friction, 2 = significant issue affecting adherence), yielding a design relevance ranking across the six moments.

The coding was performed manually using a structured spreadsheet workbook with dedicated sheets for participant profiles, coded segments, illustrative quotes, interview-versus-literature comparisons, emergent themes, and design implications. An AI assistant (Claude, Anthropic) was used to support the initial extraction of coded segments from the anonymised transcripts: the researcher provided each anonymised transcript to the AI, which returned candidate codes and segment highlights. These were then reviewed, adjusted, and validated by the researcher against the original transcripts. The AI never had access to non-anonymised data. This workflow was chosen because it accelerates the most time-intensive part of qualitative analysis, the initial line by line reading and tagging, while keeping analytical judgment and interpretive authority with the researcher. All final coding decisions, theme definitions, and design implications were made by the researcher.

Step 7: Deepening follow-up round

Following the cross-cutting analysis, a short follow-up round of four deepening questions was sent to the nine participants via written or voice message in April 2026. The questions probed (1) the personal reason for starting supplementation, (2) whether any perceived health issue triggered the first purchase, (3) what would cause them to stop or change their regimen, and (4) the degree of certainty they felt about their current intake. Six of the nine participants responded (P01, P02, P03, P04, P06, P07). The responses were analysed alongside the original transcripts and used to validate the direction selection in Chapter 3 and to sharpen the “problem beneath the problem” articulation in chapter 3.1.2.

2.1. SQ1 Barriers & strategies for adherence

SQ1: What are the main barriers affecting consistent supplementation routines among women 55+ and what strategies distinguish women who are consistently adherent? (Field research)

The desk research used here mainly draws on older-adult medication adherence research, because supplementation-specific evidence is limited. The evidence found consists largely of systematic reviews published between 2008 and 2026 (Campbell et al., 2012; Cross et al., n.d.; Gellad et al., 2011; Kini & Ho, 2018; Nieuwlaat et al., n.d.; Schlenk et al., 2008; Scotti et al., 2026) supplemented by one small observational study in independent living (Scotti et al., 2026) and one non-systematic review (Mukhtar et al., 2014). Most studies focus on people aged 60+ or 65+ rather than 55+. This means the findings are best interpreted as general adherence mechanisms (memory, routine fit, complexity, trust) that are likely relevant to supplementation routines.

2.1.1. Barriers to consistent adherence

The literature points to a set of barrier themes that repeatedly show up when older adults try to stick to daily health routines:

Forgetting and cognitive load

Forgetting is often driven by a failure in prospective memory; the specific brain function required to remember to perform a planned action in the future (Campbell et al., 2012; Gellad et al., 2011). Why this is a factor here is a matter of "mental bandwidth." When cognitive function is low, the brain struggles to hold onto a "to-do" item while multitasking or dealing with stress. In practice, this means the routine fails because the brain treats the supplement as a "low-priority signal" that gets drowned out by more immediate environmental noise.

Regimen complexity

The difficulty isn't just the number of pills, but the executive function required to manage them. Complexity rises with "polypharmacy" (taking multiple medications), which forces the user to constantly plan, monitor, and switch between different instructions (Campbell et al., 2012; Gellad et al., 2011; Scotti et al., 2026). This happens because of decision fatigue: every additional item or specific timing requirement ("take with food," "take two hours before other pills") adds a layer of micro-decisions. For supplementation, the design implication is that as the "mental map" of the day becomes more cluttered, the likelihood of a system-wide collapse increases.

Routine disruption

Adherence depends on contextual cues; stable triggers in the environment that tell the brain it is time to act. Barriers arise when these cues are "diluted," such as when the same cue (like eating breakfast) is linked to too many different tasks, causing the brain to overlook one of them (Valenzuela-Beltrán et al., 2022). Habits are fragile; they are tied to specific places and sequences. If the sequence changes (such as traveling, having a guest, or even just sleeping in) the "trigger" is never pulled, and the behaviour is simply never initiated. This also appears in “maintenance moments” such as refilling organisers, ordering supplies, and preparing for travel. These tasks are easy to postpone and difficult to recover from once missed, making them common breakpoints in otherwise stable routines (Faisal et al., 2020; Nimkar et al., 2025; Swinglehurst & Fudge, 2021). Designing for portability and low-effort replenishment therefore becomes part of designing for adherence.

Beliefs and motivation

This is essentially a subconscious cost-benefit analysis. Non-adherence often stems from a lack of "perceived necessity"; if the user doesn't feel an immediate difference, the "cost" (effort, money, or swallowing a large pill) starts to outweigh the "benefit" (Banning, 2009; Gellad et al., 2011; Mukhtar et al., 2014). This is worsened by low health literacy, where a person doesn't fully grasp how the supplement works. When value is low, any small friction becomes a reason to stop.

Social context

Living alone removes social scaffolding; the informal reminders and "monitoring" provided by others (Campbell et al., 2012; Scotti et al., 2026; Valenzuela-Beltrán et al., 2022). Humans often rely on "co-regulation"; we perform better when our environment includes people who mirror or prompt our healthy behaviours. Furthermore, "routine competition" (especially for those with household responsibilities, usually women) means that caring for others often takes priority over self-care, pushing supplementation to the bottom of the list.

Healthcare system factors

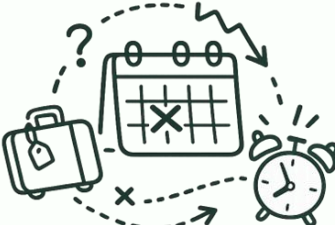
Adherence is deeply tied to trust and credibility. If the relationship with a provider is poor, or if a doctor doesn't prioritize discussing supplements, the user lacks a "validation signal" (Banning, 2009; Gellad et al., 2011; Scotti et al., 2026). Without professional guidance, the user feels they are "guessing," which creates a sense of insecurity. This lack of authoritative "buy-in" makes it much easier for the user to abandon the routine when they encounter a minor obstacle.

Physical and functional barriers

Physical and functional barriers often stem from a mix of adverse effects, dexterity issues, and problems with medication appropriateness. Adverse effects are the unwanted physical reactions a person might have, ranging from a sour stomach and nausea to a bad aftertaste or skin rashes. Dexterity and sensory issues such as poor eyesight or difficulty opening child-proof packaging and handling small pills create a physical "wall" between the user and their routine. Appropriateness refers to how well the supplement fits a person's physical needs and their specific abilities, such as whether a pill is easy enough to swallow or if the dosage is right for their body weight. This happens because the human body is biologically programmed to avoid things that cause pain, frustration, or discomfort. When taking a supplement makes someone feel slightly sick or becomes a physical struggle, the brain creates a negative feedback loop that naturally discourages the habit. This internal signal effectively trains the person to stop the behavior because the mind begins to associate the routine with a negative or difficult physical experience. (Campbell et al., 2012; Gellad et al., 2011)

Barriers

Routine Disruption



Adherence breaks when daily structure is disrupted (travel, unexpected activities); cues and patterns are broken and habits collapse.

Social Context



Living alone removes informal support and reminders, and household responsibilities can add competing demands, making routines harder to maintain.

Physical & Functional Barriers



Forgetting and mental overload often lead to missed doses. When routines rely on remembering one more thing, adherence tends to slip.

Beliefs & Motivation



Beliefs about necessity/benefit, perceived risks, and health literacy influence whether people stick with a routine.

Forgetting & Cognitive Load



Forgetting and mental overload often lead to missed doses. When routines rely on remembering one more thing, adherence tends to slip.

System & Support Friction



Trust and adherence weakens when users lack “buy in” from health professionals.

Regimen Complexity



More products and timing requirements make adherence harder.

Strategies

Anchoring



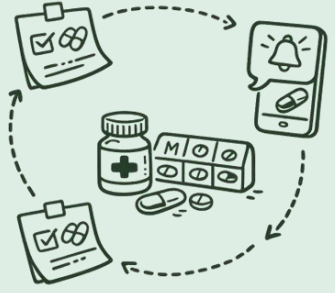
Linking supplement intake to an existing daily cue, such as breakfast or brushing teeth, makes the routine easier to remember and less dependent on effort or motivation.

Human Support



Support from partners, family, or professionals can reinforce routines through encouragement, accountability, and reassurance when doubts or disruptions arise.

Memory aids



Reminders, visible placement, and simple prompts help offload memory and reduce the chance that supplements are forgotten in the flow of everyday life.

Simplification



Reducing steps, decisions, and complexity makes routines easier to follow correctly and lowers the cognitive burden of staying consistent over time.

Figure 11. Barriers and Strategies to consistent adherence. Source: author, partly generated with Google's Nano Banana 2

2.1.2. Strategies for adherence

The literature points to several strategies that repeatedly help people stay consistent, primarily because they reduce the "brain tax" required to maintain a daily routine:

Anchoring the routine to stable cues

This strategy relies on habit automation. By linking a new behaviour to a stable, existing habit (such as eating breakfast or brushing one's teeth), the environment effectively does the remembering for the user. This works because the brain switches from using "prospective memory" (the effortful task of remembering a future plan) to "procedural memory" (an automatic, triggered action). However, this can fail if the cues become "diluted." For instance, if a morning routine is too unpredictable, the brain does not receive a clear enough signal to trigger the supplement-taking behaviour (Valenzuela-Beltrán et al., 2022).

Memory aids and reminders

These systems facilitate "cognitive offloading." Because human memory is inherently fragile, successful interventions move the "to-do list" out of the user's mind and into the physical environment. Whether it is a telephone reminder or an electronic pillbox, these tools provide an external "interrupt signal" that breaks through the noise of a busy day (Kini & Ho, 2018; Schlenk et al., 2008). Externalising the reminder ensures that even when a person's mental bandwidth is low, the prompt to act is still delivered by an outside source. Moreover, research suggests that prompts timed to "opportune moments" can be more effective and less disruptive than purely time-based alarms, because they fit the flow of daily life instead of adding noise. This reinforces that the goal is not more alerts, but better-timed support that reduces mental work without creating alert fatigue. Lastly, any technological intervention should adjust to the habits and lifestyle of the patient (Mira et al., 2014). Mira et al. (2014) advise that "such devices should not only include alerts for medicines, but also reminders of how to put advice on healthy habits into practice."

Simplification

Reducing the number of daily actions is effective because it lowers the "executive demand" on the user. Every additional pill, specific timing requirement, or "take with food" instruction acts as a friction point where a mistake is likely to occur. Combination pills or streamlined schedules work by reducing "decision fatigue"; when there are fewer steps to manage, there are fewer opportunities for confusion or mental exhaustion to derail the process (Kini & Ho, 2018; Scotti et al., 2026)

Human support matters

Human communication often outperforms automated alerts because it provides social accountability and contextual adaptation. Unlike a digital "beep," a person (such as a pharmacist, spouse, or friend) can provide reassurance, troubleshoot physical side effects, and offer personalised problem-solving (Banning, 2009; Campbell et al., 2012). Humans are socially motivated; we are more likely to stay consistent when we feel a sense of shared responsibility and trust, which provides a layer of emotional support that technology alone cannot replicate. Other strategies to increase adherence include having a "collaborative rather than an authoritarian approach to care", and personalization of the regimen (Pyatak et al., 2013).

What tends not to work well

The literature suggests that education alone has a limited impact due to the "knowledge-action gap." While providing information may change a person's intentions, it does not provide the practical tools or environmental triggers needed to execute the behaviour (Cross et al., n.d.; Schlenk et al., 2008). Knowing that a supplement is beneficial does not make a person any less likely to forget it during a hectic morning. Furthermore, many interventions fail in the long term because they impose a "maintenance burden": if the solution itself, such as a complex tracking app, requires too much effort to use, the user will eventually abandon it once the initial novelty fades (Nieuwlaat et al., n.d.; Scotti et al., 2026). In new solutions, a mistake is to introduce a new maintenance layer: refilling, charging, updating, or preparing the tool becomes an extra chore, and the routine breaks at these upkeep moments rather than at intake itself (Nimkar et al., 2025; Patel et al., 2022). In other words, even if the concept improves remembering, it can still fail if it increases maintenance burden.

2.1.3. Interview findings SQ1 Barriers & Strategies

The interviews broadly confirm the literature's barrier framework but shift the emphasis in important ways. Forgetting, identified as the dominant barrier in the literature, was less prominent in this sample: most participants had already developed strong anchoring strategies that made forgetting rare. The barriers that caused the most actual friction were physical and format-related (swallowing difficulty in P02, P07, and P09), lack of perceived effect (P01, P02, P07 described "just in case" supplementation without tangible benefit), and routine disruption during travel or weekends (P02, P07, P09). P07 described a long-standing aversion to swallowing pills: "Het is echt het idee van een pil" (It's really the idea of a pill), which is unrelated to pill size and represents a barrier not captured in the medication adherence literature. Industry distrust also surfaced: P01 described the supplement industry as comparable to "a mafia," reflecting scepticism that goes beyond the "beliefs and motivation" barrier described in the literature.

Regarding strategies, routine anchoring emerged as overwhelmingly dominant and confirms the literature. Every consistently adherent participant anchored supplementation to an existing daily moment: breakfast (P04, P06, P07, P09), bedtime tooth-brushing (P05), evening medication (P01), or morning coffee (P02). The most frictionless setups were the simplest: P04 places a single multivitamin on the breakfast table and never forgets; P05 keeps vitamin D next to her toothbrush with the same result. Weekly preparation systems (P03, P06, P08) introduce a secondary maintenance burden, which the literature warns about but which participants accepted because the trade-off (consolidating daily decisions into a weekly ritual) reduced cognitive load on most days. Memory aids were used selectively: P03 relies on phone alarms as her primary system, while the majority did not use any digital reminders. Human support appeared indirectly rather than as a formal intervention: P04's healthcare-professional partner, P09's annual doctor review, and P06's trusted apothecary all served as ongoing validation rather than prompting. This extends the literature's "human support" finding by showing that for this group, the support function is more about trust reinforcement and regimen confidence than about reminding.

Expert consultations reinforce the participant findings. A preventive health entrepreneur (E1) confirmed that keeping the initial supplement count low is critical for therapy adherence, stating he tries "not to go above 3-4 supplements, especially for a first step." This aligns with pill burden research showing that regimen complexity directly undermines adherence (Lindquist et al., 2014). Both general practitioners interviewed (E2, E3) corroborated that adherence failure sits more in personality and lifestyle patterns than in supplement-specific factors. E2 compared supplement forgetting to young women forgetting oral contraceptives, noting that "some people can pick up a fixed routine easily and others are just more chaotic," which aligns with evidence linking conscientiousness to medication adherence (Molloy et al., 2014). E3 confirmed that GPs have "zero visibility" into supplement adherence, positioning this as outside their professional scope. Both GPs agreed that routine disruption is personality-dependent rather than event-dependent, extending the participant finding that travel and weekends destabilize some users but not others.

2.1.4. Design implications

For women aged 55+ and their supplementation routines, this research provides a clear framework. The desk research identifies forgetting, high cognitive load, and routine disruption as the primary threats to consistency, while personal beliefs and trust determine whether users feel the effort is worthwhile. The interviews confirm and sharpen this picture. Routine anchoring emerged as the overwhelmingly dominant success strategy: every consistently adherent participant tied supplementation to an existing daily moment; breakfast (P04, P06, P07, P09), bedtime tooth-brushing (P05), evening medication (P01), or morning coffee (P02). The simplest setups (P04: one multivitamin on the breakfast table; P05: one vitamin D next to the toothbrush) produced near-perfect adherence and zero perceived burden, confirming the literature’s prediction that radical simplification is the most effective lever.

However, the interviews shift the barrier emphasis: forgetting was less prominent than expected because most participants had already developed anchoring strategies. The barriers that caused the most actual disruption were travel and weekend routine shifts (when the anchoring cue disappears), swallowing difficulty (affecting three of nine participants), and low perceived necessity (“just in case” supplementation without tangible effects). Expert E1 confirmed that keeping the initial supplement count low (“not above 3-4 supplements, especially for a first step”) is critical for adherence, aligning with pill burden research. Participants consistently preferred autonomy over automation: subscription models were rejected (P02, P03, P06) because they conflicted with personal control, and no participant expressed interest in app-based tracking or device notifications. To be successful, design interventions must therefore create “environmental scaffolding”: routine anchoring, cognitive offloading, and radical simplification, while preserving the user’s sense of control and ownership over her routine.

2.2. SQ2 “Correct” supplementation use and error identification

SQ2: What does “correct” supplementation mean in day-to-day use and where do misunderstandings or errors occur? (Field research + desk research)

In the context of women over 55, “correct” supplementation can be understood as executing an agreed routine as it is meant to be executed: following the instructions provided by a healthcare professional or the product manufacturer regarding the what, when, how, and what to do if a dose is missed (Aldila & Walpola, 2021). In practice, this is not a “medical” issue as much as a daily-life execution issue. Research shows that a large share of adults struggle to follow these routines properly, which means that even a good plan can fail if it is hard to carry out consistently at home (Sanders & Van Oss, 2013).

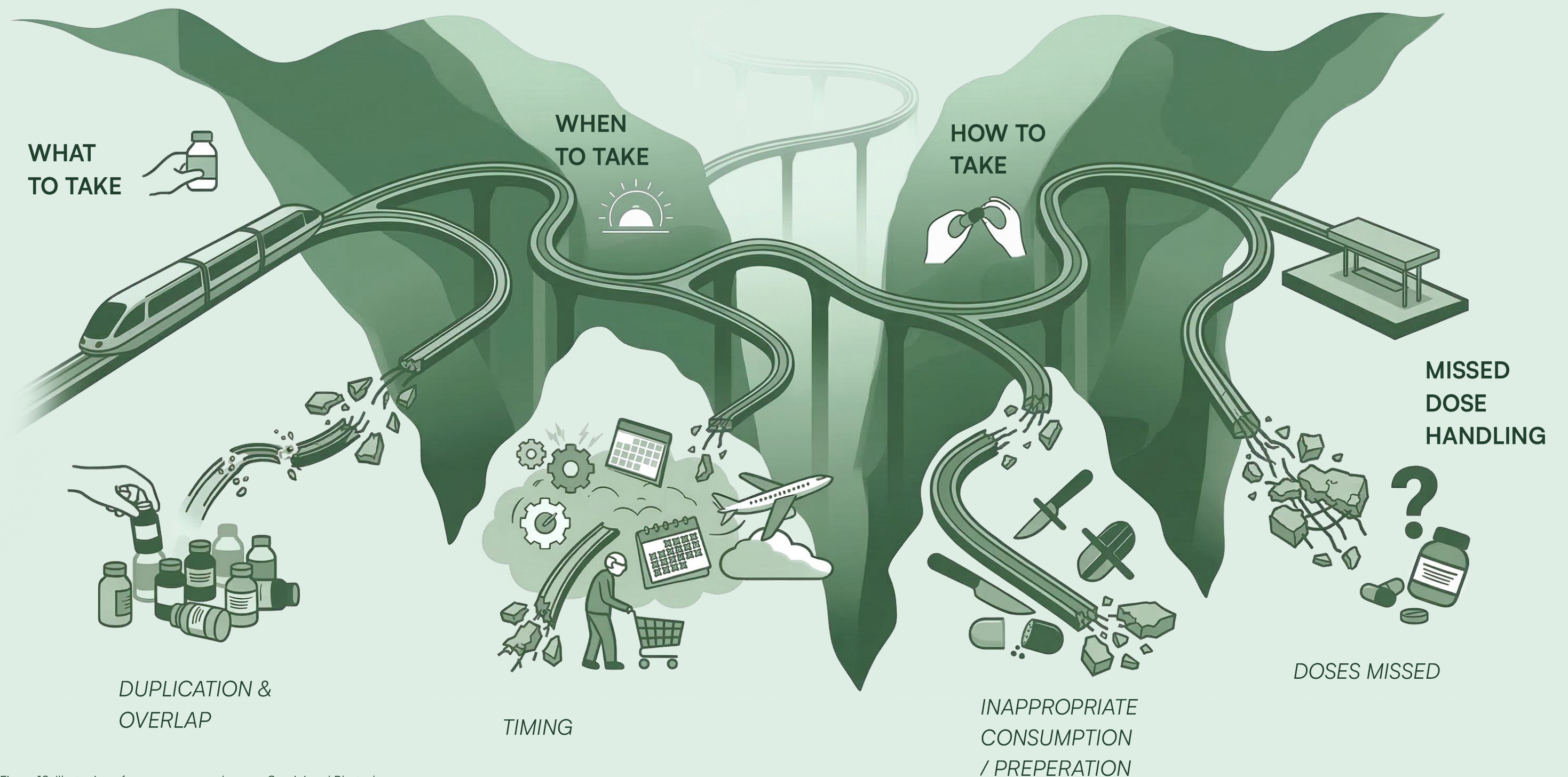


Figure 12. Illustration of common use and errors. Gemini and Photoshop.

2.2.1. What “correct” use looks like in day-to-day life

Table 3. Correct use and misunderstandings

Components of “correct” use	What correct use requires	Where misunderstandings or errors occur
What to take	Selecting the intended product and avoiding accidental duplication of the same active ingredient (Aldila & Walpola, 2021). This can become difficult when several vitamins or look-alike pills are used at the same time.	People may unintentionally take overlapping products, especially when they do not clearly distinguish between prescription medicines, over-the-counter products, and supplements. For example, calcium may be taken both as a supplement and as an antacid, resulting in accidental duplication (Aldila & Walpola, 2021; Lam & Bradley, 2006).
When to take it	Following the intended timing and frequency, for example daily or linked to a meal (Aldila & Walpola, 2021; Lam & Bradley, 2006). In everyday life, adherence is often supported by activity based cues such as breakfast or brushing teeth (Gualtieri et al., 2023; Sanders & Van Oss, 2013).	Errors commonly occur when doses are forgotten or omitted. Even when people know the intended schedule, maintaining it consistently in daily life can be difficult.
How to take it	Using the intended administration method, for example swallowing a tablet whole rather than altering it (Aldila & Walpola, 2021).	Some people crush or split tablets because swallowing is difficult, even when the product is intended to be taken intact. This may reduce effectiveness or introduce risks (Aldila & Walpola, 2021).
What to do when a dose is missed	Knowing the appropriate response to a missed dose, such as taking it later or waiting until the next scheduled intake moment (Spiers et al., 2004).	Missed doses are not only common, but also poorly understood. People often know what to take and when, but are unsure how to respond after forgetting a dose, making this a frequent area of misunderstanding (Spiers et al., 2004).

2.2.2. Why these errors happen

In real life, the system breaks down for predictable reasons: routines get busy or disrupted, managing multiple items becomes mentally demanding, and people may not receive practical guidance on how to organise self-management at home. One reason routines become “incorrect” in practice is that timing instructions are difficult to combine. Even with a fixed regimen, people often split intake across more daily moments than necessary because they feel uncertain about combining items (drug interactions), struggle to interpret medication/timing and concerns for when to take the drug (i.e. after a meal) (Lindquist et al., 2014; Wolf et al., 2011). This increases cognitive load and creates more opportunities for missed or wrong-time intake. Declining cognitive or physical abilities can make the execution harder (remembering, planning, opening packaging, distinguishing similar items), and the routine can also fail at “maintenance moments” like refilling pillboxes or ordering new bottles (“refill fatigue”).

2.2.3. Interview findings

The interviews suggest that “correct use” errors in supplementation routines differ from the medication adherence literature in important ways. The most prominent literature concern, accidental duplication of active ingredients, did not surface in any interview (perhaps also because it was unnoticed). Instead, the dominant issues were timing uncertainty and knowledge gaps about why specific supplements are taken. P08, who works in healthcare, manages a complex timing protocol (first medication 30 minutes before food, then supplements with breakfast), which creates a multi-step sequence where errors accumulate under time pressure. P09 follows a similar iron supplement first, then breakfast protocol, demonstrating that timing complexity is not limited to medication but extends into supplement routines when absorption requirements apply. Most participants could name what they take but struggled to articulate the rationale: P07 takes magnesium, fish oil, and vitamins B and C but could not explain why these specifically, beyond a general sense that they are “good for you.” This “knowledge gap about why” rather than “knowledge gap about what” extends the literature’s framing of misunderstandings.

Regarding missed-dose handling, the literature identifies this as a common area of confusion. The interviews partially confirm this: most participants described a pragmatic “just skip it and continue tomorrow” approach (P01, P04, P05, P09), which is generally appropriate for supplements but reflects an absence of explicit guidance rather than confident knowledge. P03 provides the strongest illustration of what happens when a dose truly matters: after missing one week of B12 injections, she experienced severe fatigue and described recovering “visibly” once she resumed. This case demonstrates that for some supplements, missed-dose consequences are real and personally experienced, which the general “supplement” framing can obscure. Physical administration errors (crushing, splitting) identified in the literature were not observed, but alternative workarounds were: P02 takes supplements with bread to manage swallowing difficulty, and P07 embeds all pills in food (banana, sandwich), which could theoretically affect absorption for certain compounds. These workarounds suggest a design opportunity for formats that eliminate the need for such adaptations.

Expert consultations add further dimensions to these error patterns. E2 identified the most common misconception she encounters: patients believing they need a vitamin B-complex supplement while eating a healthy diet, when evidence does not support this. She also highlighted a regulatory gap: supplement manufacturers are permitted to print “for (condition X)” on packaging without proving efficacy, unlike pharmaceutical drugs which must meet far stricter evidence requirements under EU Regulation (EC) No 1924/2006 (Regulation No 1924/2006, 2006) on nutrition and health claims. This regulatory asymmetry fuels the knowledge gap about “why” that participants described. E3 provided a clinical illustration of how even normal-dose supplements can cause diagnostic confusion: a patient’s creatine supplementation elevated serum creatinine levels, mimicking reduced kidney function and triggering unnecessary investigation. Both GPs independently flagged St. John’s Wort (Sint-Janskruid) as a supplement that interacts dangerously with many medications, yet patients often do not disclose its use (Henderson et al., 2002). E2 noted that patients sometimes “shake out a bag of everything they take” onto her desk, but this visibility is the exception. E3 confirmed that GPs have “no visibility whatsoever” into supplement use because it is over the counter and patients do not report it. These expert observations extend the participant findings by showing that errors are not only execution failures but also systemic gaps: unclear labelling feeds misconceptions, and the healthcare system lacks a feedback loop that would catch interactions or unnecessary supplementation before problems arise.

2.2.4. Implications for Design

This evidence points to a clear design direction: a useful system should reduce the need for people to "figure it out" themselves by making correct execution easier at the moment it matters. In practical terms, that means:

- Clear product identity and accessible reasoning so users can reliably distinguish what is what and avoid duplication, but also understand why they take each supplement. The interviews show that the dominant knowledge gap is not "what" but "why": most participants could name their supplements but not articulate their rationale (P07, P04), and expert E2 confirmed that manufacturers can print health claims on packaging without proving efficacy, fuelling this confusion. A system should make the reasoning behind each supplement visible and personal.
- Routine-anchored timing support; helping users link intake to real daily cues and handle disruptions. The interviews confirm this but shift the emphasis: the dominant error type is not accidental duplication (as the medication literature predicts) but timing uncertainty. P08 manages a forced two-stage protocol (medication 30 minutes before food, then supplements with breakfast), and P09 follows a similar iron-first sequence, demonstrating that timing complexity extends into supplement routines when absorption requirements apply.
- Calm, contextualised missed-dose guidance so the user is not left guessing when something goes wrong. Participants universally default to "skip it and continue tomorrow" (P01, P04, P05, P09), which is generally appropriate but reflects absent guidance rather than confident knowledge. P03's B12 case shows that for some supplements, a missed period has real consequences. The system should provide supplement-specific reassurance rather than leaving users to rely on intuition.
- Support for physical execution so the routine does not become a swallowing or dexterity problem that forces workarounds. The interviews surface this as a broader issue than the literature anticipated: P02 requires bread to get pills down, P07 has a long-standing aversion to swallowing pills, independent of their size, and P09 depends on orange slices for large tablets. These workarounds suggest a design opportunity for formats that eliminate the need for such adaptations entirely.
- Service support for maintenance; refills, re-ordering, and changes over time, so the routine does not collapse at the "chore" layer. Participants replenish reactively (when a bottle runs out) and resist subscriptions on autonomy grounds (P02, P06), so the system should offer flexible replenishment support (suggest, not auto-ship) that preserves user control.
- A low-effort channel for professional review; expert consultations reveal a systemic gap: GPs have "no visibility whatsoever" into supplement use (E3), patients sometimes disclose their full supplement use only by "shaking out a bag" onto the desk (E2), and dangerous interactions (e.g., St. John's Wort) go undetected. A supplementation system should bridge this gap by making it easy for the user to share her regimen with a healthcare professional when she chooses to, without mandating it.

2.3. SQ3 Routine moments and intervention opportunities

SQ3: Which routine moments are most design relevant, and where in these moments could a product service system realistically support the user?

This section identifies the routine moments in which supplementation adherence most often succeeds or fails, and maps where a product-service system could realistically support women 55+ without adding burden. Findings are based on nine semi-structured interviews (P01-P09) and photo documentation of storage locations and current setups. The goal is to move from “general barriers” to concrete, designable moments: when and where a system can reduce cognitive load, prevent errors, and support routine resilience during real-life variability.

2.3.1. Framework: the supplementation routine as six moments

To structure the analysis, the supplementation routine is described as six recurring moments. These moments span the full “lifecycle” of taking supplements, from supply and storage to intake and recovery when something goes wrong. They also align with where friction accumulates: memory, decision-making, physical handling, and maintenance.

Routine moments

1. **Acquire & Replenish** (ordering, stock, running out)
2. **Store & Place** (where it lives; visibility; shared spaces)
3. **Prepare** (sorting/portioning; deciding “what today”)
4. **Intake** (timing; water/food; swallowing; confirmation)
5. **Exceptions & Disruptions** (travel, weekends, guests, stress)
6. **Recovery & Adjust** (missed dose rule, changes in regimen, advice)

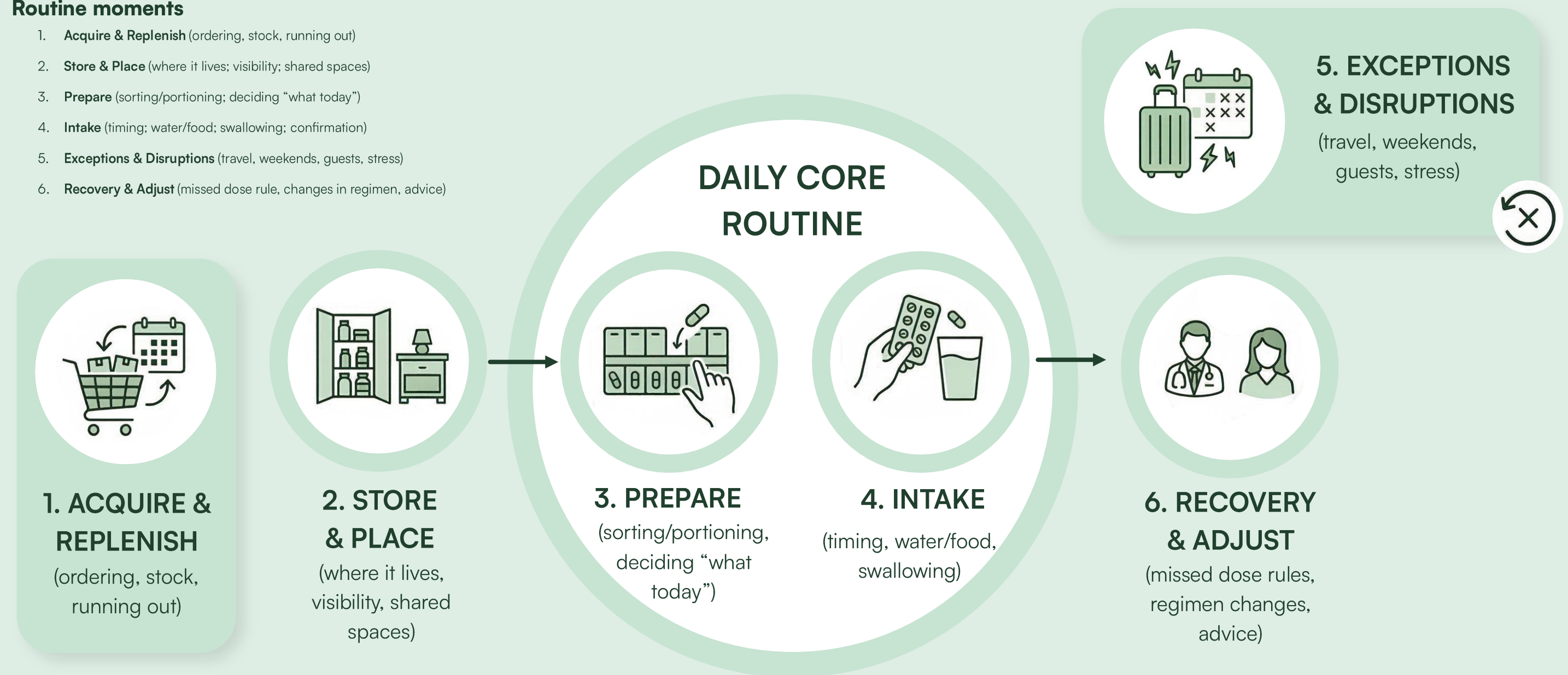


Figure 13. The supplementation routine can be understood as six moments. Design opportunities tend to appear where users must remember, decide, or recover after disruption.

What happens in each moment (interview based findings)

1. Acquire & Replenish

What participants do now

Replenishment approaches range from simple pharmacy purchases such as the ‘Kruidvat’ or ‘Etos’ (P04, P05, P07, P08) to online bulk ordering (P02, P03) and apothecary visits with personalised advice by the pharmacist (P06). Most participants replenish reactively, when a bottle runs out, rather than proactively. P09 expressed strong interest in a pharmacy-style app for stock management and reordering. P06 and P02 actively rejected subscription models: P02 described feeling “forced” by a previous subscription and described distrust in dosage quantity of this subscription-based company, while P06 cancelled a subscription service because it conflicted with her autonomy. P08’s choice is primarily driven by price: “If I come across it somewhere and I know it’s cheap, or there’s an offer, then I buy it.” P09 buys supplements abroad at roughly one-third of Dutch prices, indicating that pricing transparency and perceived markup can erode trust in a replenishment service.

Where it breaks

Running out without warning (no stock visibility system; most participants rely on noticing a nearly empty bottle). Subscription resistance driven by autonomy concerns (P02, P06) removes a common industry solution. Price sensitivity and international price gaps reduce trust in pricing (P09). P01 worries about switching brands, not knowing whether she would buy the same again, as there is no notable improvement in what she bought the supplement for. This indicates that any regimen changes (starting or stopping a supplement) require a new purchasing decision with no system support to know whether it’s fitting/works.

2. Store & Place

What participants do now

The kitchen is the primary place where supplements are stored (6/9 participants). The two participants with the simplest and most frictionless routines (P04 and P05) both use strategic visible placement: P04 keeps her multivitamin directly on the breakfast table alongside bread and spreads; P05 places vitamin D next to her toothbrush. Both report near-perfect adherence and attribute it directly to this visibility. Other participants use kitchen cabinets (P07, P09), kitchen drawers with glass bowls (P06), or bathroom locations (P01). P03 uses a medication box at her bedside for probiotics plus a separate box for other supplements. Multiple storage locations appear in participants with larger supplement stacks (P06, P09), creating fragmentation.

Where it breaks

Cabinet storage reduces visibility (“out of sight, out of mind” for participants who store supplements inside closed cupboards). P03’s medication box is too small for her full regimen, forcing split storage. Upon being asked how much space any routine products should take up, P02 preferred 10×10 cm. Multiple storage locations increase the chance of forgetting individual items. Notably, the literature’s concern about stigma or “medical feel” in shared households did not surface strongly in these interviews; no participant described hiding supplements from others or feeling embarrassed about visible supplement storage.



Figure 14. Common storage places by participants.

3. Prepare

What participants do now

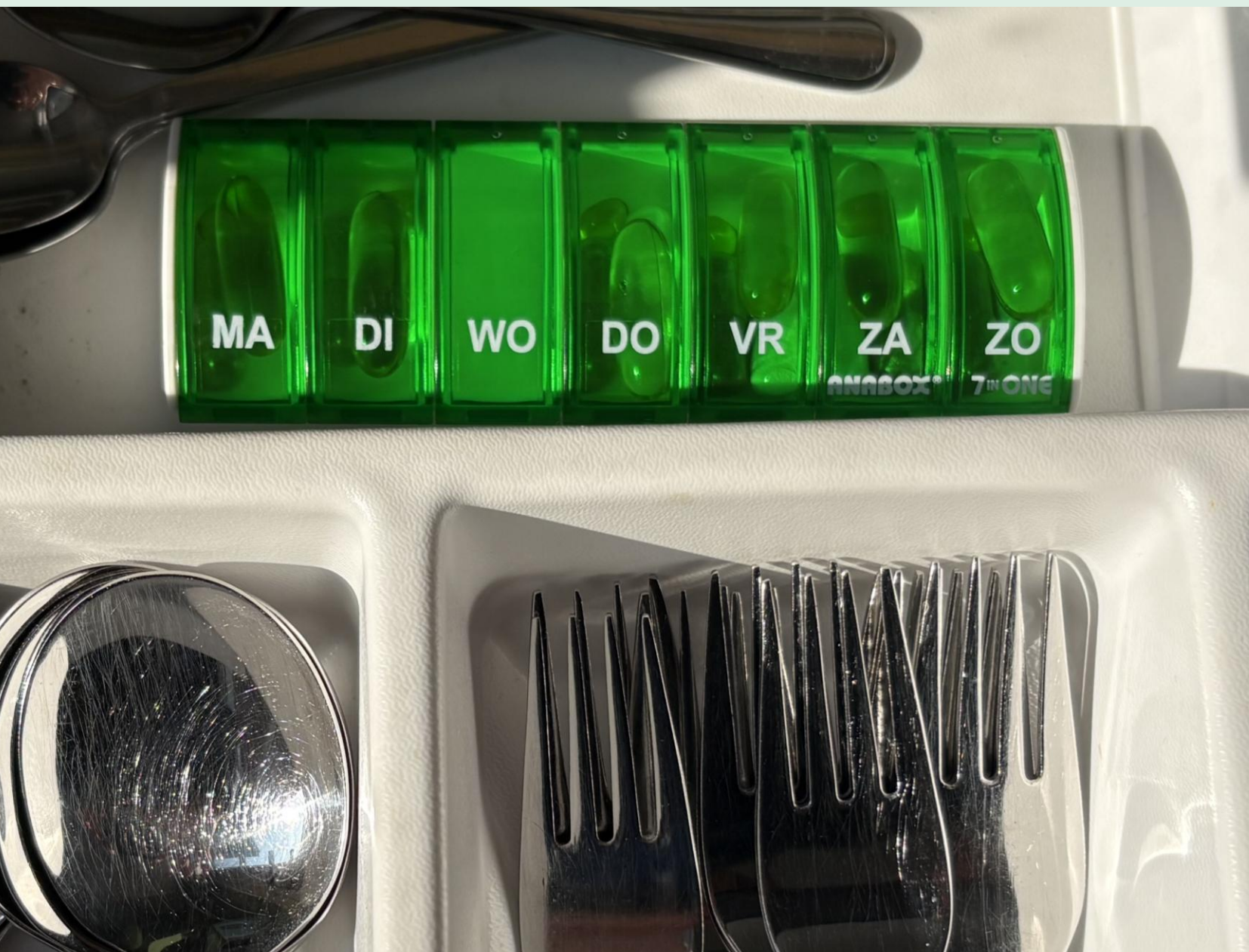
Preparation strategies split into three patterns:

1. No preparation needed (P04 and P05, single supplement, taken directly from bottle)
2. Daily plate/bowl preparation (P02 uses a small plate each morning, P09 lays supplements out on a plate as a ritual)
3. Weekly batch preparation (P03 refills her medication box on Sundays; P06 fills a weekly container system; P08 fills a medication box weekly). P08 described that before adopting the weekly box, she regularly forgot doses when taking from individual jars, the box system “solved” this problem. P06 varies what she includes week to week based on season and activity level, making her preparation moment also a decision moment.

Where it breaks

Weekly refill is a recurring maintenance burden that is easy to postpone. P03 reports doing this consistently on Sundays, but for participants with flexible schedules, this moment is fragile. The preparation moment carries hidden decision load for participants with larger stacks: deciding “what today?” is cognitively heavier when the regimen includes optional or seasonal supplements (P06, P09). Confusion can arise when regimens change: P07 described a dose confusion when she changed her magnesium schedule. P08’s pre-box forgetting illustrates how much adherence depends on whether the preparation step is designed into the system or left to individual initiative.

Figure 15. How participants prepare their weekly supplement doses.



4. Intake

What participants do now

Intake is anchored to meals (breakfast for most, bedtime for P01 and P05) and executed as a brief moment within a larger routine. Most participants bundle all supplements into a single daily intake moment. Water is the standard vehicle, though P07 and P09 require food (banana, orange, sandwich) to manage swallowing. P08 has a forced two-stage intake: one medication 30 minutes before food, then supplements with breakfast.

Swallowing difficulty is the single most reported intake barrier, affecting three participants. P02 cannot swallow large pills at all. P07 has a long-standing aversion to swallowing pills (“Het is echt het idee van een pil”) that is independent of pill size. P09 finds large pills difficult and depends on taking them with orange slices. Timing complexity creates cognitive burden for P08 and P09, who must sequence intake around absorption requirements. “Did I take it?” doubt was not strongly reported, likely because most participants use visible systems (plate, box) that provide implicit state feedback. The literature’s “timing with food” uncertainty appeared mainly in participants with medical knowledge who understood absorption interactions (P08, P09), while others took supplements with food by default without concern.

5. Exceptions & Disruptions

What participants do now

Travel and weekend deviation are the primary disruption types. Participants use ad-hoc portability solutions: P01 repurposes an earplug box, P06 created a weekly container system originally for travel (now also used at home), P04 and P05 carry small pillboxes, and P09 uses plastic bags. P02 takes a simplified travel version of her routine (multivitamin only) for “emotional comfort” rather than strict necessity. P03 represents the exception: she does not travel and therefore never experiences disruption. Weekend sleeping-in disrupts P02’s routine because her morning coffee anchor shifts.

Where it breaks

The primary disruption mechanism is anchor disappearance: when the regular morning routine shifts (sleeping in, different meal timing, different location), the environmental cue that triggers supplementation is absent. P02 misses doses on weekends for exactly this reason. P07 sometimes skips supplementation entirely when travelling because it feels like “not a must,” revealing how low perceived necessity combines with disruption to cause complete routine abandonment. Packing is done last-minute and ad-hoc, with no participant describing a systematic portable system beyond improvised containers. Social context effects (skipping because others are present) were not strongly reported, which diverges somewhat from the literature.

6. Recovery & Adjust

What participants do now

When a dose is missed, the universal response across participants is pragmatic: skip and continue tomorrow. No participant described doubling up or feeling significantly anxious about a single missed dose (with the exception of P03’s B12 injection, where a missed week caused severe fatigue). Regimen adjustments happen through two channels: professional guidance (P09’s annual doctor review, P03’s specialist recommendations, P06’s apothecary consultations) and self-directed experimentation (P06 adjusts seasonally, P08 added probiotics based on literature review). P09’s doctor validated annual review represents the strongest adjustment model: blood work informs what to change, and a phone consultation translates results into action.

Where it breaks.

There is no explicit missed dose protocol for any participant; all rely on intuition. While this is generally appropriate for supplements, the absence of guidance leaves users without confidence about whether missing matters. P03’s B12 case shows that for some supplements, a missed period has real consequences. Regimen changes (adding, stopping, or switching supplements) destabilise the “mental map” and currently lack system support; the user must figure out new timing, storage, and purchasing independently. Most participants cannot articulate why they take specific supplements, suggesting that if a trusted advisor changes the regimen, the user may not understand or remember the rationale, making the adjustment fragile.



Figure 16. Intake rituals by participants.



Which moments are most design-relevant?

Note: The ranking below reflects the adherence-oriented framing of SQ3. The Discover synthesis later revealed that clarity, not adherence, is the deeper unmet need (see Synthesis, Section 2.9). The routine moments remain valid as a structural framework for understanding when and where friction occurs, but their relative design relevance shifts when viewed through the clarity lens. This reframing is addressed in the Define phase.

Across the nine interviews, the moments that concentrate the highest friction and the greatest consequences for adherence are: (1) Intake, where five of nine participants report some form of friction (driven primarily by swallowing difficulty, timing complexity and taste); (2) Exceptions and Disruptions, where three participants report actual missed doses during travel or weekends and improvised portability solutions dominate; and (3) Prepare, where weekly maintenance systems work but are fragile, and the “what today?” decision creates hidden cognitive load for participants with larger regimens. Acquire and Replenish acts as a “silent failure” moment: no participant described running out as a crisis, but the absence of stock-awareness systems and the active rejection of subscription models suggest that this moment needs quiet, autonomy-preserving support rather than automated solutions. Store and Place is strongly linked to adherence through visibility (the two participants with the most frictionless routines both use strategic visible placement), but presents fewer active breakdowns. Recovery and Adjust is the weakest moment in terms of interview evidence (most participants rarely adjust and handle missed doses pragmatically) but the absence of explicit guidance represents a latent design gap. No additional routine moments beyond the original six were needed to capture the interview data, although “seasonal flexibility” (PO6, PO8, PO9 intentionally varying what they take) emerged as a cross-cutting theme that affects the Prepare and Recovery moments in particular.

Table 4 ranks the six routine moments by design relevance. Design relevance = (Frequency × 1) + (Severity × 2) + (Breakpoints × 0.5). Severity is weighted double because actual missed/incorrect doses represent a greater design concern than minor friction. Breakpoints are weighted at 0.5 because they reflect opportunity density rather than user-reported impact. This table was made based on an interview coding workbook that scored per participant on a 0-1-2 scale (0 = no issue reported, 1 = minor friction, 2 = significant issue affecting adherence). This scoring is not statistically rigorous; it is a transparent heuristic to support design prioritisation with n=9. Cell shading reflects intensity (darker green = higher count).

2.3.2. Design Implications

Mapping the six routine moments against interview data reveals where design intervention can have the greatest impact. Intake and Exceptions/Disruptions are the two highest-ranked moments for design relevance: intake concentrates the most friction (swallowing difficulty for PO2, PO7, PO9; timing complexity for PO8 and PO9; taste aversion) while exceptions and disruptions (primarily travel and weekend shifts) are the moment where routines most often collapse entirely. The interviews also reveal that visible placement is a decisive adherence factor: the two participants with the simplest, most frictionless routines (PO4, PO5) both use strategic visible placement (on the breakfast table or next to the toothbrush) and attribute their near-perfect consistency directly to this spatial cue. By contrast, cabinet storage creates an “out of sight, out of mind” effect. Preparation burden is the hidden third layer: weekly refilling (PO3, PO6, PO8) is accepted but fragile, and deciding “what today?” adds cognitive load for participants with larger or seasonally varying stacks (PO6, PO9).

For this thesis, SQ3 establishes that a supplementation system should be designed around the routine moment structure, prioritising the highest-friction moments (intake format, disruption resilience) and the highest-leverage design mechanism (visible, consolidated placement). The system should consolidate storage into a single visible “home base,” build portability into the primary design rather than as an afterthought, simplify or eliminate the “what today?” decision through pre-portioning or clear grouping, and provide embedded missed-dose guidance that replaces the current universal “skip it” intuition with calm, supplement-specific reassurance.

Routine moment coding summary and design relevance ranking

ROUTINE MOMENT		FRICTION FREQUENCY	CONSEQUENCE SEVERITY	BREAKPOINTS IDENTIFIED	DESIGN RELEVANCE	CHARACTERISATION
4	Intake	5/9	2/9	5	11.5	Swallowing difficulty (P02, P07, P09) and timing complexity (P08, P09) dominate. Highest-impact moment.
5	Exceptions & Disruptions	4/9	2/9	4	10.0	Travel and weekend deviation cause actual missed doses. All portability solutions are improvised.
3	Prepare	5/9	0/9	4	7.0	Weekly refill is fragile maintenance; "what today?" decision load rises with stack size.
1	Acquire & Replenish	4/9	0/9	5	6.5	Silent failure: no stock awareness, subscription rejected for autonomy, price sensitivity.
6	Recovery & Adjust	2/9	1/9	4	6.0	Rare but latent gap: no missed-dose protocol, regimen changes unsupported.
2	Store & Place	3/9	0/9	4	5.0	Visibility correlates with adherence; cabinet storage reduces cues; stigma not confirmed.

Intensity:

0

high

Table 4 Design relevance of the six supplementation routine moments, based on coded interview data (n = 9). Friction frequency = participants reporting any friction; Consequence severity = participants where friction led to missed or incorrect doses; Breakpoints = distinct failure points coded per moment. Design relevance = (Freq × 1) + (Severity × 2) + (Breakpoints × 0.5).

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2.4. SQ4 Low-burden adherence

SQ4 What does low-burden adherence mean for women 55+ in terms of steps, time, cognitive load, and maintenance, and which factors most effectively reduce burden in real routines? (Desk research + field research + prototype research)

“Low-burden adherence” is not just about motivation, it is about whether a routine is light enough to execute on a normal day without feeling like a chore. In practical terms, burden shows up as (1) the number of actions required, (2) the time it takes, (3) the mental work of remembering, deciding, and checking, and (4) the maintenance work that keeps the system running (refilling, re-ordering, charging, updating routines). Burden can be measured in a number of ways: studies report wide variation in setup time and interaction steps when people use adherence-support products, and usability and workload measures differ strongly across solutions. This means that “adding a tool” can either reduce burden or unintentionally add a new layer of friction. (Faisal et al., 2022; Patel et al., 2020)

A useful way to define low-burden adherence for this thesis is therefore as a simple execution threshold: a routine that can be completed in a short time window, with few steps, and without requiring constant checking or upkeep. The reviewed evidence suggests that burden can be expressed as an actionable target: keep the routine within a small number of steps and minutes, and ensure the interaction remains usable (acceptable usability scores) rather than cognitively taxing (Faisal et al., 2022; Patel et al., 2020). From a design perspective, this is important because it gives a concrete test for later prototypes: does the concept reduce steps, time, and mental effort compared to current practice, and does it avoid creating new maintenance chores?

2.4.1. What increases burden in real routines

Burden rises quickly when a routine spreads across too many moments in the day. Even with a fixed regimen, people tend to distribute intake into more separate occasions than necessary, because they struggle to consolidate timing instructions or feel uncertain about combining items (Lindquist et al., 2014; Wolf et al., 2011). This creates a compounding effect: more daily “micro-moments” means more chances to forget, more decisions, and more disruption sensitivity. Additionally, tool complexity can backfire: some designs reduce effort, while others increase perceived workload and usability, meaning that a poorly fitting device can become an extra system to manage rather than a support (Faisal et al., 2022; Patel et al., 2020). This helps explain why “smart” devices or complex apps can fail even when the user is motivated. For this target group, what counts is whether the tool reliably reduces steps and mental effort.

Finally, maintenance is often the hidden burden. Even when intake itself is simple, routines can fail at “chore” moments such as refilling organisers, ordering new supplies, or preparing for travel because these tasks are easy to postpone and hard to recover from once missed (Faisal et al., 2022; Nimkar et al., 2025; Swinglehurst & Fudge, 2021).

2.4.2. What reduces burden most effectively

Across the literature, the most reliable burden reducers are the ones that remove steps and decisions, rather than the ones that add features.

- Simplification and consolidation. Reducing the number of daily actions (fewer products, fewer intake moments, clearer grouping) lowers the executive demand of the routine and reduces the number of failure points. (Bazargan et al., 2017; Lindquist et al., 2014; Sluggett et al., 2020)
- Routine integration (anchors). Low-burden routines often sit inside existing habits (e.g., meals, morning/evening rituals), which reduces the need for active remembering and makes the routine easier to repeat (Gualtieri et al., 2023; Sanders & Van Oss, 2013)
- Context-aware prompting. Reminders can help, but prompting that aligns with real “opportune moments” can reduce burden more than purely time-based alarms, because it interrupts less and fits the flow of daily life (Hayes et al., 2009)

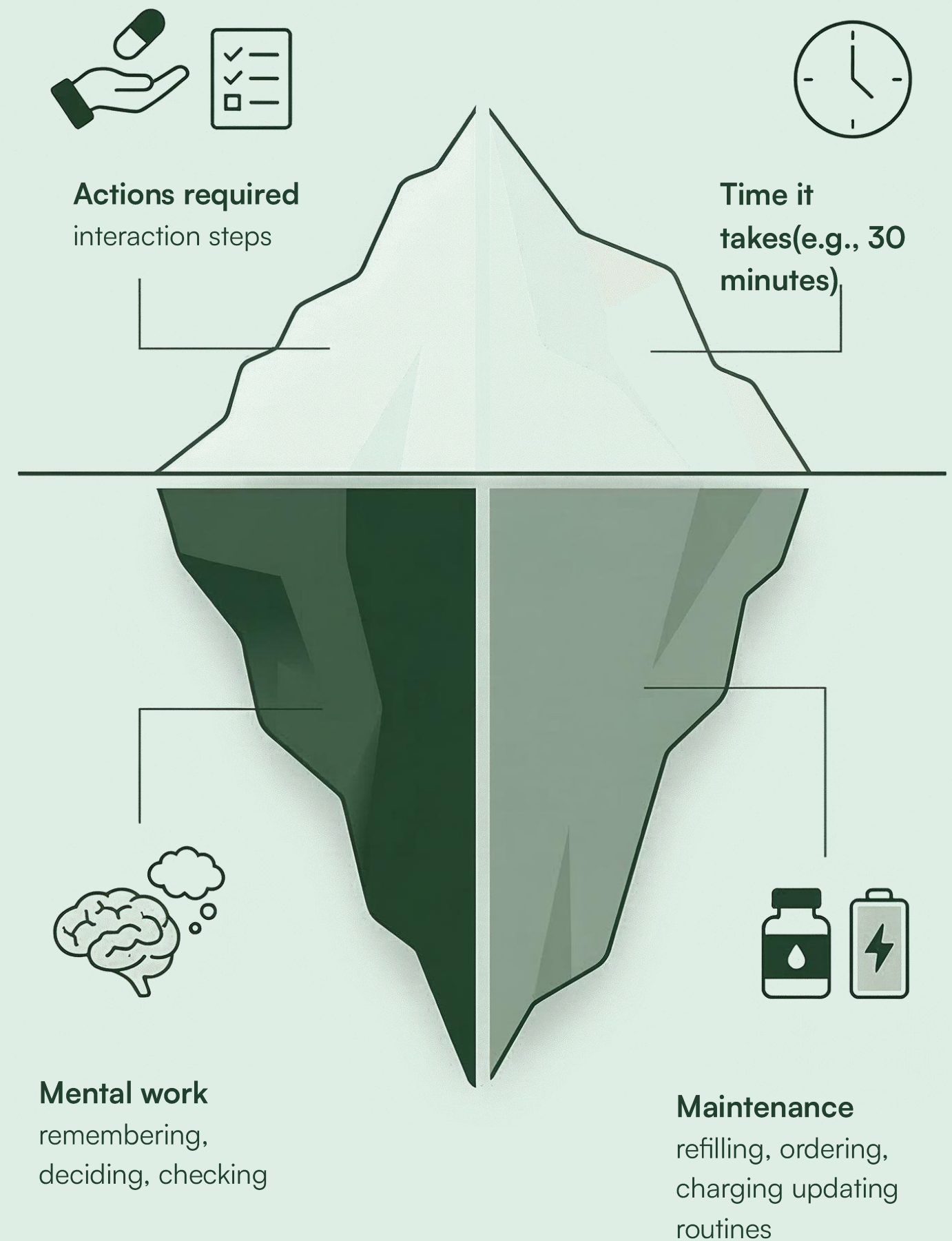


Figure 17. The Supplementation Iceberg visualising (hidden) burden.

- Organisation that reduces “hidden work.” Simple organisational aids (e.g., clear packing/portioning) can lower daily decision-making, but only when refill and portability are easy. Otherwise, the aid shifts burden from “taking” to “maintaining” (Nimkar et al., 2025; Patel et al., 2022; Simpson, 2006).
- Light human support. Human support is most valuable when it reduces uncertainty, helps recovery after disruption, or prevents the routine from collapsing at moments of change (e.g., questions, side effects, switching products) (Sanders & Van Oss, 2013; Simpson, 2006).

2.4.3. Interview findings

The interviews strongly confirm the literature’s finding that fewer steps and fewer daily moments correlate with better adherence. The two participants with the simplest routines (PO4: one multivitamin on the breakfast table; PO5: one vitamin D next to the toothbrush) report near-perfect consistency and zero perceived burden. Both describe supplementation as almost “invisible” within their existing routine; no separate preparation, no decisions, no maintenance. At the other end, participants with more complex regimens (PO8: medication-first timing protocol; PO9: 7+ supplements with iron-first sequencing) remain adherent but describe higher cognitive load and more elaborate rituals (plate setup, timed sequences, weekly refilling). This confirms the literature’s prediction that burden rises with moment-multiplication, but adds an important nuance: burden tolerance appears moderated by perceived value. PO9 maintains a complex routine because she has annual doctor validation showing tangible health improvement; PO7 maintains a simpler but still burdensome routine (food-dependent pill-taking) with weaker commitment because she cannot articulate why her supplements matter. This suggests that “low burden” is not absolute but relative to the value the user perceives.

Maintenance burden surfaced primarily in the Prepare moment: weekly refilling of pillboxes or containers (PO3, PO6, PO8) is accepted but fragile, and it represents the most common “hidden work” layer that the literature warns about. Travel preparation adds a secondary maintenance spike: most participants improvise portable solutions (earplug boxes, plastic bags, small containers) rather than using a system designed for portability. Regarding automation versus control, participants consistently preferred autonomy over automation. Subscription models were rejected by PO2, PO3, and PO6 specifically because they felt like an imposition on personal choice. The preferred burden-reduction pattern is consolidation (fewer items, fewer moments, pre-portioned) combined with optional support (stock awareness, reorder suggestions) rather than automated control (subscriptions, app-driven schedules, device prompts).

Expert consultations reinforce the importance of routine coupling and simplification. E2 confirmed that for patients who already take medication, the morning medication moment is the most effective anchor for adding supplements: "if people already use medication, that's usually in the morning, so it can most conveniently be added there." For non-medicated individuals, she recommended coupling to a meal. She also observed that solutions patients devise themselves tend to work best ("alle oplossingen die mensen zelf verzinnen, werken het beste"), supporting the autonomy-preserving design principle that emerged from the participant interviews.

E1 framed supplementation as one of five interdependent "health pillars" (sleep, nutrition, exercise, mental health, and supplementation), arguing that when any one pillar collapses, the others can compensate, but when two fail, "the house of cards starts to collapse." This framing aligns with integrative wellness frameworks that treat health as a system of interdependent lifestyle domains (Lipman, 2018) and positions supplements as both a "foundation" need (vitamin D, omega-3) and a "therapy" tool (e.g. mitochondrial support), which has implications for how burden could be justified to the user: framing supplements as the foundation means they should be as invisible as possible, yet just as important as other health pillars, while viewing it as therapeutic frames supplements as if they can warrant a higher-effort routine because the user has a clearer reason. E2 further reinforced this by describing how she links vitamin D supplementation to existing routines during consultations: "what fits best in your routine? Is that when you brush your teeth, or with a fixed morning moment?" language that mirrors the habit-stacking mechanism described by Lally et al. (2010).

2.4.4. Design Implications

For the design of a supplementation system, these findings establish that low burden must be a structural property, not an add-on. The following constraints shape the solution space:

Reduce daily steps and consolidate intake moments: the simplest routines in the sample (PO4: one multivitamin on the breakfast table; PO5: one vitamin D next to the toothbrush) produce near-perfect adherence and zero perceived burden, confirming the literature’s prediction that fewer actions and fewer daily moments correlate with better consistency. Participants with multi-step protocols (PO8, PO9) remain adherent but at the cost of higher cognitive load and more elaborate rituals.

Minimise ongoing maintenance: weekly refilling of pillboxes (PO3, PO6, PO8) is the most common "hidden work" layer and is accepted but fragile, particularly for participants with flexible schedules. Travel preparation adds a secondary spike: most participants improvise portable solutions (earplug boxes, plastic bags, small containers) rather than using a system designed for portability. The system should make refill and portability effortless rather than shifting burden from "taking" to "maintaining"

Keep usability high enough that the tool does not become the new barrier: a poorly fitting device adds workload instead of removing it.

Preserve autonomy over automation: participants consistently preferred consolidation (fewer items, fewer moments, pre-portioned) combined with optional support (stock awareness, reorder suggestions) over automated control. Subscription models were rejected by PO2, PO3, and PO6 specifically because they conflicted with personal choice. PO1 described reminders as making her feel like a "robot." The preferred model is a quiet tool the user chooses to engage with, not one that initiates contact or tracks compliance.

Anchor to existing routines, ideally self-devised ones: E2 confirmed that the morning medication moment is the most effective anchor for supplement addition, and for non-medicated individuals, coupling to a meal. She also observed that "solutions patients devise themselves tend to work best," supporting an autonomy-preserving design that scaffolds rather than prescribes. E2’s consultative language: "what fits best in your routine? Is that when you brush your teeth, or with a fixed morning moment?". This mirrors the habit-stacking mechanism described by Lally et al. (2010) and suggests the system should help users identify their own best anchor rather than imposing one.

Differentiate foundation from therapeutic burden justification: E1’s framing of supplementation within five interdependent "health pillars" implies that foundation supplements (vitamin D, omega-3) should be as invisible as possible in the routine, while therapeutic supplements (with a clearer personal rationale) may warrant a higher-effort routine because the user has a stronger reason. The system could use this distinction to calibrate how much interaction each supplement warrants.

2.5. SQ5 Trust in supplementation

How do women 55+ form trust in a supplementation system, and what design cues build trust without relying on medical claims?

Direct evidence on trust formation in supplementation systems for this demographic is scarce, but convergent findings from 25 studies across medication adherence, digital health tools, and health information systems reveal consistent trust mechanisms that are highly applicable to supplementation contexts (Q. V. Liao & Fu, 2014; Sillence et al., 2007; Zulman et al., 2011). Trust develops through a three-stage process: (1) rapid initial screening based on design and source cues, (2) deeper evaluation of content credibility and personalisation, and (3) integration with existing trust networks including healthcare providers and social relationships (Sillence et al., 2007). Older adults show lower baseline trust in new health systems yet and are less sensitive to standard credibility cues (Q. V. Liao & Fu, 2014). However, this distrust is not fixed; it stems primarily from information overload and unclear sourcing, and when these factors are addressed through clear design, age-related distrust disappears entirely (Zulman et al., 2011).

2.5.1. Interview findings

Trust formation in this sample follows a clear hierarchy. The strongest trust source is a personal medical professional: P09’s entire regimen confidence rests on her doctor’s annual review; P04 and P05 trust national guidelines and their own medical knowledge; P08 relies on literature evidence combined with personal clinical experience. The second trust source is personal experience of efficacy: P03’s dramatic B12 recovery, P06’s restless leg relief from magnesium, and P08’s reduced infection rate from probiotics all created strong, self-sustaining trust. The third source is a trusted expert relationship: P06’s 20-30 year relationship with a specialised apothecary functions as her primary guidance channel. Notably, brand trust was weak or absent: most participants buy the cheapest available option (P07, P08) or generic pharmacy brands (P04), relying on regulatory trust (“the government has regulations, so it must be okay”) rather than brand-specific trust. P01 expressed the deepest distrust, comparing the supplement industry to a “mafia” and questioning whether synthetic ingredients are safe. This combination of professional trust with industry scepticism suggests that a product—service system should build credibility through transparency and professional endorsement rather than branding or marketing claims.

Expert consultations deepen the trust picture in several ways. E1 confirmed that physician involvement is the decisive trust factor for supplement purchases: “that’s really the deciding factor, yes.” He also described generational trust differences: [women aged 55-75](#) tend to treat the doctor’s authority as “sacred” (“wat de dokter zegt is heilig”), millennials collaborate in shared decision-making, and adults under 30 use the doctor primarily as a “tool” to reach their own goals. This has direct implications for the target group: any supplementation system for women 55+ must prioritize professional endorsement over influencer marketing. E2 critiqued supplement regulation from a trust perspective, noting that manufacturers can claim their product is “for condition X” without proving efficacy, unlike pharmaceutical drugs, and that she wishes the distinction between “a claim” and “a proven effect” were clearer to consumers. This supports the trust breaking cue of vague health claims identified in the literature and grounds it in clinical experience. E3 added an interesting trust observation: patients trust certain pill colours more than others, with some colours perceived as more potent stimulants or sedatives (Amawi & Murdoch, 2022). While this applies primarily to pharmaceuticals, it suggests that supplement format and visual design carry implicit trust signals that a product-service system could leverage.

2.5.2. Trust-building cues (ranked by evidence strength)

The following table ranks the design cues that build trust in health systems among older adults.

Table 5 Design cues that build trust for older adults. Darker means more consistent evidence across studies, not a better single study.

Evidence	What builds trust	Sources
Strongest	People trust information most when it clearly shows who is behind it. Backing from doctors, pharmacists, and official bodies carries the most weight (older adults trust doctors and pharmacists ‘a lot’ for this: 79.9% and 66.4% respectively).	(Donohue et al., 2009; Q. V. Liao & Fu, 2014; Zulman et al., 2011)
Strong	Designs that are easy on older eyes and hands earn more trust. Clean layouts, large text, high contrast, and simple navigation lower effort and show the product was made with these users in mind.	(El-Attar et al., 2005; Liu et al., 2021; Zulman et al., 2011)
Strong	People trust what they can check. Naming the source and author, and keeping the message consistent across channels, lets users judge credibility for themselves.	(Hussein et al., 2018; Q. V. Liao & Fu, 2014; Zulman et al., 2011)
Moderate	Outside confirmation (third party) adds trust. Seals of approval, author names and dates, and other users’ ratings back up what the brand claims about itself.	(Huseth-Zosel & Fuller, 2023; Hussein et al., 2018)

Evidence	What builds trust	Sources
Moderate	Clear feedback makes a system feel reliable. Simple confirmations like ‘you took it’ or ‘this is the right one’ remove doubt during everyday use.	(Liu et al., 2021; Pak et al., 2012)
Emerging	Staying in control sustains trust. Clear privacy choices and an easy way to turn things off (control technology) or change them support user autonomy.	(Schwaninger et al., 2021)

2.5.3. Trust-breaking cues (ranked by evidence strength)

Table 6. What erodes trust for older adults, ranked the same way. Darker means more consistent evidence across studies.

Evidence	What breaks trust	Sources
Strongest	Too much information is the most consistently found trust-breaker. Cluttered screens, dense text, and no clear order overwhelm older adults, who then accept what they see without questioning it.	(Q. V. Liao & Fu, 2014; Zulman et al., 2011)
Strong	When the source of the information is unclear it prevents older adults from assessing credibility	(Q. V. Liao & Fu, 2014; Zulman et al., 2011)
Strong	If something is hard to use, people reject it at once, even when the content is good. Confusing layouts and feeling unable to control the device cause anxiety and signal unreliability.	(El-Attar et al., 2005; Schwaninger et al., 2021; Sillence et al., 2007)
Moderate	Mixed messages damage trust. When professionals and family say different things, older adults get stuck deciding and may give up on the system.	(Huseth-Zosel & Fuller, 2023; Q. V. Liao & Fu, 2014; Ross & Gillett, 2020)
Moderate	Anything that feels like selling raises suspicion of bias. Ads, and distrust of supplement companies (a reason 9.5% of older adults avoid them), make the product seem self-interested.	(Patskanick & Miller, 2020)
Moderate	Being watched with no clear benefit is a deep trust-breaker. Cameras, recording, or tracking in private spaces like the home clash with older adults’ wish to control their own health decisions.	(Ross & Gillett, 2020; Schwaninger et al., 2021)

2.5.4. Design trust principles for a supplementation product-service system

These principles translate the evidence above into actionable design requirements. They are ordered by evidence strength and relevance to a supplementation PSS for women 55+.

Table 7. The evidence above, turned into actions for the product-service system. Ordered by evidence strength and relevance; darker means higher.

#	Design principle	Sources
1	Show authoritative source identity, keep the main view simple and then keep detail one layer deeper.	(Liu et al., 2021; Zulman et al., 2011)
2	Work with the people users already trust instead of replacing them. Make it easy to share with doctors, family, and peers, and support those conversations rather than acting as the only authority.	(Liu et al., 2021; Zulman et al., 2011)
3	Provide guidance for decision making, but leave the user in charge. Avoid anything that feels controlling, keep an easy pause or off-switch, and phrase suggestions as support ('based on your preferences...') rather than orders.	(Donohue et al., 2009; Ross & Gillett, 2020)
4	Make senior-friendly the default. Use large text, high contrast, simple consistent layouts, and big touch targets. This signals respect for users' needs while functionally supporting use.	(Nal et al., 2025; Schwaninger et al., 2021; Zulman et al., 2011)
5	Keep messaging across touchpoints consistent; packaging, app and peer information should all line up, since mixed messages damage trust.	(El-Attar et al., 2005; Liu et al., 2021; Zulman et al., 2011)
6	Include confirmation mechanisms (especially as older adults are less forgiving of system errors than human errors). Handle mistakes without blaming the older adult.	(Huseth-Zosel & Fuller, 2023; Q. V. Liao & Fu, 2014)
7	Collect as little data as possible and make privacy protections easy to see. Do not track without a clear benefit, and present any tracking as the user's own record, not monitoring, especially in personal spaces such as the home.	(Carrillo et al., 2021; Liu et al., 2021; Pak et al., 2012)
8	Borrow professional credibility without making medical claims. Show certifications, third-party testing, and affiliations; say 'recommended by healthcare professionals' rather than claiming effects. Facilitate professional involvement ("ask your doctor about...") rather than substituting for it.	(Schwaninger et al., 2021)

2.5.5. Design Implications

For the design, these trust findings establish clear boundaries: the system must earn credibility through professional endorsement and visible evidence of efficacy rather than through branding or marketing claims. Any trust building mechanism must align with the hierarchy observed in the interviews: professional validation first, personal experience second, institutional credibility third.

2.6. SQ6 Long term use and motivation

SQ6: What do women 55+ need to stay motivated and continue using a supplementation system over time? (Desk + Field research)

For women 55+, “staying motivated” is less about constant willpower and more about whether a routine becomes self-sustaining. The literature across supplementation (Brunner et al., 2009), medication adherence, (Arain et al., 2021; Faisal et al., 2022; Salter et al., 2014; Unni et al., 2016; Vandermause et al., 2016; S. Yang et al., 2023) exercise programs (Findorff et al., 2009; Finnegan et al., 2019; Litt et al., 2002; Machacova et al., 2025; McAuley et al., 2007, 2011; Seguin et al., 2010; Viljoen & Christie, 2015; Xu et al., 2024; Y. Yang et al., 2024), and digital health tools (Mitzner et al., 2019; Moore et al., 2021; Peng et al., 2021; Pettersson et al., 2023; Vandelanotte et al., 2022) suggests that sustained engagement typically evolves through phases. Early on, people benefit from external structure (routine, supervision, social commitment), but over months the driver shifts toward internalised value (“this supports my wellness”) and eventually toward habit and simplicity rather than new features or frequent prompts (Vandelanotte et al., 2022; Viljoen & Christie, 2015). Once a routine is established, past behaviour becomes the strongest predictor of continued engagement, while self-efficacy remains important for maintaining behaviour over years (Litt et al., 2002; McAuley et al., 2007)

A central theme across studies is autonomy and preserving self. Older women describe autonomy as a powerful motivator, and sustained use tends to break down when a system feels medicalised, paternalistic, or like surveillance (Salter et al., 2014). This is not an argument against support, it is an argument for support that is self-directed: available when needed, but not controlling. Trust and credibility also matter: supportive professionals helped users overcome barriers such as side effects and uncertainty (Salter et al., 2014) yet that support must be balanced so it reinforces confidence without making the user feel dependent (Finnegan et al., 2019; Salter et al., 2014). Identity fit plays into this: when people accept self-care and lifestyle practices as “part of who I am,” adherence becomes easier to sustain (Pettersson et al., 2023; Salter et al., 2014)

From an experience-design perspective, long-term engagement depends strongly on simplicity and low maintenance burden. Systems that reduced mental load through automation (e.g., dispensing support) can reduce everyday burden (Arain et al., 2021), while long-term “super engaged” users of a digital health program emphasised ease of use and low maintenance as essential, and showed modest uptake of new features once habits formed (Vandelanotte et al., 2022). Similarly, wearable-device studies report that frequent charging, complicated setup, discomfort, inaccuracy, or mismatch with expectations contributes to abandonment (Moore et al., 2021; Peng et al., 2021). Taken together, the evidence suggests that to support long-term use, systems should simplify over time, not accumulate features (Vandelanotte et al., 2022)

Another key requirement is disruption resilience. Across multiple studies, a substantial share of discontinuation was linked to life disruptions such as travel, illness, health problems, or busy periods, rather than lack of interest (Finnegan et al., 2019; Viljoen & Christie, 2015). This shifts the design goal from “perfect consistency” to recovery after breaks. Several studies point to practical patterns that support this: digital exercise tools used prompts/cues to maintain routines through disruptions (Pettersson et al., 2023), a medication dispensing system offered flexibility (e.g., early dispensing for travel) (Arain et al., 2021), and long-term wearable users described coping planning, positive mindset, and strategies for lapses as part of habit maintenance (Peng et al., 2021).

Finally, social support helps: but only when it feels helpful rather than intrusive. In a supervised resistance-training cohort, social contact became a major factor for full program adherence (Viljoen & Christie, 2015), and social cohesion supported retention during the intervention (Viljoen & Christie, 2015). However, the evidence also shows variation: some people stop when social interaction is absent, while others may feel “accountability” as intrusive depending on the form it takes (Litt et al., 2002; Viljoen & Christie, 2015). In technology contexts, one-on-one training and help-line support reduced barriers to continued use (Mitzner et al., 2019), and remote monitoring could provide accountability without necessarily feeling surveillance-like when designed carefully (Arain et al., 2021).

2.6.1. Interview findings

The interviews reveal a clear distinction between two motivation profiles. Participants who have experienced tangible effects from supplementation (PO3: dramatic B12 recovery; PO6: restless leg relief from magnesium; PO8: reduced infections from probiotics; PO9: improved markers via annual blood work) demonstrate stable, long-term commitment. Their motivation is self-sustaining because it is grounded in personal evidence. In contrast, participants who supplement “just in case” without perceiving a clear benefit (PO1, PO2, PO7) show more fragile commitment and are more likely to skip during disruptions or question whether supplementation is worthwhile. PO7 continues “just in case” but cannot explain why her specific supplements matter, and PO1 embodies this ambiguity with the Dutch expression “Baat het niet, schaaadt het niet” (If it doesn’t help, it doesn’t hurt). This extends the literature’s finding about internalised value: the interviews suggest that perceived effect is the discriminator between stable and fragile long-term motivation.

Regarding autonomy, the literature’s finding that medicalised or surveillance-like systems undermine adherence is strongly confirmed. PO6 explicitly rejected a subscription service despite liking the products because it conflicted with her sense of control. No participant expressed interest in tracking or monitoring features; several actively resisted the idea of notifications, apps, or devices that “check on” them. PO1 described reminders as making her feel like a “robot.” The preferred model is what might be called “available support”: professional guidance that is accessible when the user chooses to seek it (PO9’s annual doctor review, PO6’s apothecary consultations) but never imposed. However, PO9 expressed strong interest in the idea of a pharmacy-style app for stock management and reordering. This confirms the literature’s autonomy-preservation requirement and specifies it further: for this group, the system should fade into the background once the routine is established, offering support on demand rather than proactively.

Expert consultations reinforce the centrality of personal evidence for sustained motivation. E1 described blood test confrontation as a powerful motivation trigger: “when you’re confronted with yourself, that’s usually a trigger for change.” He recommends testing every three months until biomarkers stabilize, then twice yearly, creating a feedback loop that sustains long-term adherence through self-monitoring, a mechanism known in health behaviour research (Burke et al., 2011). E1 also observed that people who receive free blood tests value the results less than those who pay, suggesting that financial investment may serve as a commitment device. The food design expert (E4) added a distinct long-term adherence concern for non-pill formats: taste fatigue. He noted that consumers get bored quickly with repeated flavours. For food-like supplement formats, this implies that regular flavour rotation would be necessary to prevent sensory-specific satiety, the well-documented decline in pleasantness with repeated exposure to the same food stimulus (Rolls et al., 1981). E4 suggested that technologies such as AirUp-style scent-based flavouring or mixing supplements into drinks could mitigate this, but warned that any format requiring daily taste engagement faces an inherent long-term adherence risk that pill formats avoid by being flavour-neutral.

2.6.2. Design Implications

For long-term engagement, the design must:

- provide more structure early (initiation and routine building), then fade into a low-touch “background” routine once habits form (Vandelanotte et al., 2022; Viljoen & Christie, 2015);
- preserve autonomy and identity (avoid a medicalised/surveillance feel; keep the user in control) (Salter et al., 2014)
- keep interaction extremely simple and low-maintenance, and resist feature creep over time (Moore et al., 2021; Vandelanotte et al., 2022);
- build disruption resilience through recovery support (normalise lapses, support travel/illness scenarios) (Arain et al., 2021; Finnegan et al., 2019; Peng et al., 2021; Pettersson et al., 2023; Viljoen & Christie, 2015);
- offer optional support (human or professional) in a way that reinforces confidence without dependence (Arain et al., 2021; Mitzner et al., 2019; Salter et al., 2014)

The interviews ground these design principles in specific participant evidence. Two distinct motivation profiles emerged: participants with tangible personal evidence of efficacy (P03’s B12 recovery, P06’s restless leg relief, P08’s reduced infections, P09’s improved blood markers) show stable, self-sustaining commitment, while “just in case” supplementers without perceived effects (P01, P02, P07) are more fragile and susceptible to discontinuation. This confirms that a system supporting long-term use should make personal evidence visible (through periodic self-assessment, biomarker tracking, or simple symptom journaling, or other) so that efficacy is felt, not just assumed. Expert E1 reinforced this, describing blood test confrontation as a powerful motivation trigger and recommending quarterly testing until markers stabilise, then twice yearly, creating a feedback loop that sustains commitment. Autonomy was the strongest confirmed design requirement: P06 rejected a subscription despite satisfaction with the product; P01 described reminders as making her feel like a “robot.” The system should therefore position itself as a quiet support tool that the user chooses to engage with, not one that initiates contact or tracks compliance.

2.7. SQ7 Existing Solutions and why they work or fail

SQ7: Which existing solutions are used or known, and why do they work or fail for this target group?

The supplementation solutions landscape can be understood through the problems these solutions attempt to solve. When a woman in her fifties decides to start taking supplements, she faces three distinct challenges: remembering to take them every day, managing the practical complexity of her routine, and figuring out whether what she takes is actually right for her. The existing market offers solutions for each of these problems, but as the evidence below shows, the first two are reasonably well-served while the third, personalisation, remains the least developed and most promising design space. This sub-question maps the landscape across three domains: adherence solutions (how people stay on track), alternative delivery formats (what form supplements could take beyond conventional pills), and micronutrient status sensing (how people might learn what they actually need).

2.7.1. Category overview existing solutions



Figure 18. Existing categories mapped on two axes: setup and maintenance burden and routine fit resilience.

Figure 18 positions the ten solution categories identified in the desk research on two axes. The horizontal axis captures setup and maintenance burden: how much ongoing work a solution adds to a user’s life through set-up, refilling, cleaning, troubleshooting, managing schedules, charging or subscriptions. High burden is a known reason for abandonment in older populations (Arain et al., 2021; Patel et al., 2020). The vertical axis captures routine resilience: how well a solution survives real life (travel, disrupted days, weekends, and refills) without the routine collapsing.

Simplifying the routine: organisers and pre-portioned systems

The simplest and most widely accepted solutions are those that reduce the daily cognitive load of supplementation without introducing new technology. Manual organisers (S2) such as weekly pillboxes externalise memory and provide a visible cue to the state of whether today’s dose has been taken (Littenberg et al., 2006; Nimkar et al., 2025). They are low-cost, require no charging or connectivity, and work immediately. The trade-off is recurring maintenance: every week the organiser must be refilled, and travel requires either repacking or bringing the full container. Pre-portioned packaging (S1) addresses this by sorting items per intake moment at the point of production. Blister packaging and pouch services such as the Dutch medicatierol eliminate daily sorting entirely (Faisal et al., 2022; Schneider et al., 2008; Service Apotheek, 2026; Simpson, 2006). Day / time labelled sorting trays and packaging are also inherently portable, making this category the most resilient during travel or disrupted days. The limitation is that pre-portioned systems depend on a reliable way of doing refills and regimen changes.

Remembering to take supplements: reminders and prompts

A second cluster of solutions targets the act of remembering itself. Smartphone reminder apps such as Medisafe and MyTherapy (S3) are the most widely deployed approach, combining time-based notifications with optional logging and social support features (Kupiec et al., 2021; Medisafe, 2026a; Mira et al., 2014; MyTherapy, 2026). Context aware prompting, where reminders arrive at moments that are actually feasible in daily life, can outperform fixed time alerts (Hayes et al., 2009), but notification fatigue and configuration burden remain a problem (Medisafe, 2026b). Timer caps (S5) display the time since the bottle was last opened and provide a lightweight state cue without requiring a phone (TimerCap, 2026). Smart bottles (S6) add sensing and notifications to the container itself (Ellsworth et al., 2021), while voice prompts via smart speakers (S7) deliver ambient reminders that feel less intrusive than app notifications (Jiang, 2019). Automated dispensers (S4) such as Hero and MedMinder store and dispense doses (Arain et al., 2021, 2021; Hero, 2026; MedMinder, 2026), but their setup burden, maintenance requirements, and low portability make them unsuitable for independently living older adults (Arain et al., 2021; Faisal et al., 2020; Patel et al., 2020). Smart packaging (S8) such as the Smart Blister Card embeds tracking into the pack itself, locating feedback where the action happens (Schreiner MediPharm, 2023), but at higher cost and with a potentially clinical feel.

The shared limitation of all reminder based solutions is their underlying assumption: that the core problem is forgetting. For women 55+ who are already motivated but uncertain about what they take, the issue is rarely that they forget a dose, it is that they are not sure the dose is right. Reminder technology solves a real but secondary problem.

Personalising the regimen: subscriptions and guided programs

The third cluster addresses the question: what should I be taking? Personalized supplement subscription services (S9) such as Vitl and Persona combine pre-portioned daily packs with some degree of personalisation based on intake questionnaires (Persona Nutrition, 2026; Vitl, 2026). The format borrows the convenience benefits of pre-portioned packaging while adding a layer of regimen customization. However, these services are not evaluated as adherence interventions in peer reviewed literature, and operational sustainability can be fragile: large brand shutdowns illustrate that business-model pressures can end a service even when the concept is attractive (Ha, 2024). Fully personalised programs (S10) such as Bioniq, Rootine, and Nourished represent the most ambitious attempt, combining blood biomarker analysis with algorithmic supplement formulation (Bioniq, 2026; Castela Forte et al., 2022; Nourished, 2026; Rootine, 2026). These programs close the loop between testing and supplementation, but at high cost (€199 monthly for Bioniq), with onboarding complexity, and with a positioning that can drift toward medical territory if boundaries are unclear.

This third cluster is where the most significant design opportunity lies. The first two clusters, simplifying and remembering, are well served by existing low tech solutions. But the personalization cluster addresses the uncertainty that, as the interview findings showed, is the dominant emotional experience of supplementation for this target group. A system that could make personalization accessible, affordable, and trustworthy would address the root cause rather than the symptoms.

2.7.2. Interview findings current solutions

The interviews confirm the desk research’s positioning of manual organisers as the most accepted category. PO8’s weekly medication box is described as “essential” and directly solved a prior forgetting problem. PO6 created her own weekly container system, originally for travel, and now uses it at home with complete satisfaction. Both cases illustrate that simple organisers work when they reduce daily decisions, but both also carry the weekly refill burden the literature predicts (Nimkar et al., 2025). No participant uses or expresses interest in automated dispensers, confirming that high setup/maintenance burden and low portability make these unsuitable for independently living women 55+. Reminder apps are effectively absent from this sample: only PO3 uses phone alarms, framing these as personal reminders rather than an app based system. PO9 expressed interest in a pharmacy style stock management app, not for reminding but for tracking supply and reordering, which extends the desk research by suggesting that digital support is wanted for logistics, not for behaviour prompting. Subscription models were actively rejected by PO2, PO6, and PO3 for autonomy reasons: they want to choose what they take and when, not delegate that decision to a service.

2.7.3. Alternative delivery formats for supplementation routines

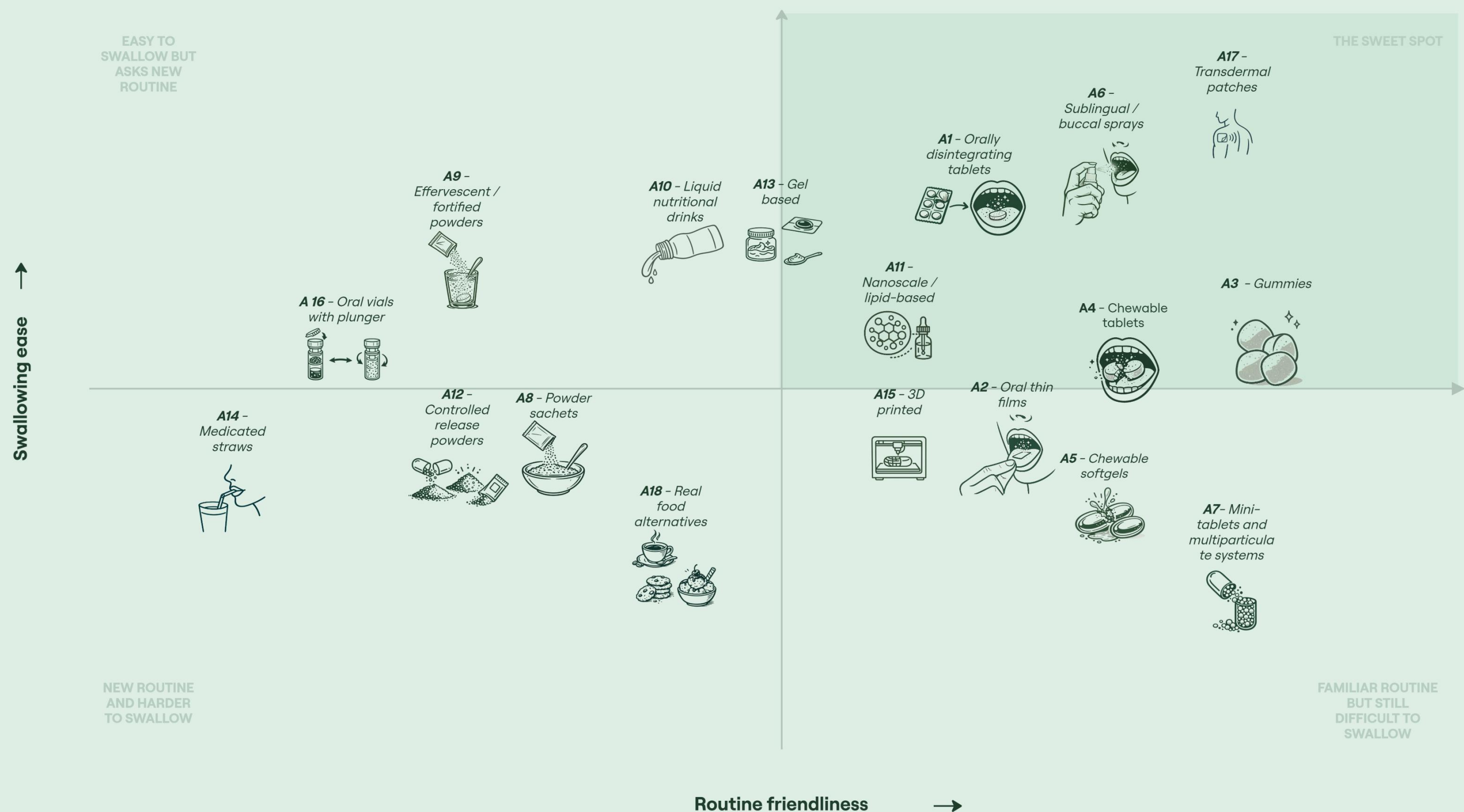


Figure 19 Alternative delivery formats mapped on two axes: routine friendliness and swallowing ease.

Beyond how supplements are organised and remembered, the physical form of the supplement itself shapes the experience. All nine interview participants currently take conventional pills, tablets, or capsules, yet a substantial minority report friction with this format. The desk research identified nineteen alternative delivery formats (A1-A18), which can be understood along a gradient from immediately adoptable to entirely speculative. The formats most relevant to women 55+ share two properties: they reduce swallowing friction and they integrate into existing routines without adding complexity.

Formats with highest relevance for women 55+

Five formats stand out for their combination of routine-friendliness and swallowing ease. Orally disintegrating tablets (A1) dissolve in the mouth without water, removing the “need to find water” friction and reducing choking risk for people who struggle with swallowing (Pandian et al., 2024; Şenel & Comoglu, 2018). Oral thin films (A2) offer similar convenience as strips that dissolve on the tongue or cheek, with the added benefit of inherent portability (Amin et al., 2015; Ruchika et al., 2024; Saini et al., 2012). Gummies (A3) are the most palatable option: highly acceptable, easy to chew, no water required, and with evidence of improved vitamin D bioavailability compared to tablets in at least one study (Asan et al., 2025; Khadri et al., 2025; Wagner et al., 2019). Chewable tablets (A4) avoid swallowing large pills entirely, with preference data showing strong favourability over effervescent alternatives in a calcium/vitamin D trial (Bhusnure, 2015; Reginster et al., 2005). Chewable softgels (A5) extend this logic to softgel formats, targeting geriatric populations specifically (Naharros-Molinero et al., 2026). The shared constraint across all five is taste masking: because these formats dissolve or are chewed in the mouth, unpleasant active ingredients are experienced directly rather than being swallowed past the taste buds. Humidity sensitivity and specialised packaging requirements add manufacturing complexity, but these are supply side problems rather than user barriers (except maybe for long term storage).

Formats with trade-offs

A second group of formats offers clear benefits in specific situations but introduces trade-offs that limit adoption. Sublingual and buccal sprays (A6) deliver nutrients without water and are highly portable; vitamin D evidence shows sprays can match capsules in healthy adults and may outperform them in malabsorption contexts (Koval et al., 2025; Todd et al., 2016; Williams et al., 2018). However, sprays also have their limitations because of taste, and P09’s taste based rejection in the interviews illustrates that acceptance is not guaranteed. Mini tablets (A7) of 3mm or less improve swallowability substantially while retaining the advantages of conventional tablet sizes (Aleksovski et al., 2015; Levina et al., 2017), but they require tight manufacturing process control. Powder sachets mixed into food (A8), such as micronutrient Sprinkles, can be portable and easy to use (Hartman-Craven et al., 2009), but mixing changes the taste and texture of the carrier food. Both P01 and P06 rejected powders on sensory grounds.

Formats with limited or speculative relevance

The remaining formats occupy the speculative end of the landscape. Effervescent powders and fortified beverages (A9) require dissolution and mixing, adding preparation steps that studies show lead to poorer preference and lower complete dose consumption than simpler formats (Reginster et al., 2005). Liquid nutritional drinks (A10) achieve high adherence in supervised clinical settings (Lester et al., 2022; Liljeberg et al., 2019), but qualitative evidence from healthy older adults reveals strong resistance due to taste, texture, and associations with illness. Nanoscale and lipid-based technologies (A11) can improve bioavailability (Mercola, 2025), but remain closer to “technology promise” than routine consumer format. Further along the speculative axis, controlled release powders (A12), gel-based systems (A13), medicated straws (A14), 3D-printed personalised delivery (A15), oral vials (A16), transdermal patches (A17), and “real food” alternatives to clinical nutrition drinks (A18) each address a genuine limitation of conventional formats but face barriers of manufacturing readiness, regulatory validation, cost, or consumer acceptance that place them outside the near term design space for preventive supplementation (Rawat et al., 2023; Rejinold et al., 2019; Taranum & Mittapally, 2018; X. Yang et al., 2025).

Across the landscape, we can see that the formats closest to adoption are those that minimize change from the existing pill taking ritual. Gummies, chewable tablets, and ODTs succeed precisely because they feel familiar while removing the specific friction points (swallowing difficulty, water dependency, size) that the interviews identified. The more a format departs from this familiarity, the more it must justify the transition through a compelling experiential advantage, and the desk research suggests that most experimental formats have not yet made that case.

2.7.4. Interview findings alternative delivery formats

All nine participants currently take their supplements as conventional pills, tablets, or capsules. Most have never actively explored alternative formats, not because they are satisfied with pills, but because alternatives are unavailable for their specific supplements, unfamiliar, or assumed to be inferior.

Two participants report significant swallowing barriers. P02 cannot swallow large pills and requires bread to get them down, calling this “a very important topic for me.” She prefers spray format (she already uses a B12 spray) and small coated vit D capsules that “glide down,” and would rather take many small pills than a few large ones. P07 has a long-standing aversion to swallowing pills, unrelated to their size and copes exclusively by embedding pills in bites of food. She has tried gummies and would use them, but finds that not all supplements are available/easily accessible in that format.

Powder formats are rejected by both participants who have tried them. P01 abandoned collagen powder after a few days despite its high cost, describing the taste as “fish eye powder” and the texture as persistently grainy. She states a clear preference for pills over dissolved powders. P06 shares this rejection and adds a transparency concern: with sachets and powders “you don’t actually know what you’re taking,” whereas individual pills from labelled jars allow targeted, autonomous choices.

Spray format receives mixed reactions. P02 actively likes it, while P09 rejects the idea of an oral spray on taste grounds, though she admits this is assumption rather than experience. P09 does use vitamin D drops and sublingual B12 without issue, suggesting her resistance is to the spray mechanism specifically, not to non-pill formats in general. Pill size is a practical concern for P09, whose glucosamine and multivitamin tablets are “quite large” and harder to take. Combined with P02’s difficulty, this suggests size is a common friction point, yet participants with smaller pills (P04, P05) never encounter the issue.

The interviews suggest that the alternative formats landscape is relevant primarily for a subset of users: those with swallowing barriers (physical or psychological), those with multi-supplement regimens where pill burden accumulates, and those who have experienced sensory rejection. For participants with simple, small single pill routines, format is not an issue. The design implication is that format choice should be offered rather than imposed, and that powder and sachet formats, despite their commercial popularity, face active resistance from this sample on grounds of taste, texture, transparency, and autonomy.

Expert interviews reinforced these findings. E4, a food and design researcher, emphasized that unconventional delivery formats (edible gels, chewing gum, toothpaste-based delivery, sublingual strips) are technically feasible for many micronutrients but must be designed from the user’s lifeworld rather than from pharmaceutical logic: the language, texture, and ritual surrounding a format shape acceptance as much as bioavailability. E4 highlighted transdermal patches as a promising low burden option that avoids first pass metabolism entirely, but cautioned that sensory properties remain the main barrier to adoption of any novel format. E1 added that the supplement industry is increasingly diversifying formats (gummies, sprays, drops) in response to growing consumer demand, yet quality control and dosing accuracy in these formats often lag behind traditional tablets (Dwyer et al., 2018).

2.7.5. Micronutrient status sensing: from lab to body

The sections above look at how to help someone take supplements consistently, and at which physical form makes them easiest to take. Neither answers a more basic question: how does a woman know what she actually needs to be taking? A growing body of research is trying to answer it faster, cheaper, or continuously, with sensors that would let someone see her own nutrient levels without a trip to a lab. The literature scan was organised into six categories (M1-M6) and were plotted in Figure 20. The two axes are sensing maturity (how close the technology is to being a real product a woman can buy today) and feedback richness (how much a user actually learns from the output beyond a number on a screen). The finding here is that the sensors themselves are not the bottleneck. What is missing in almost every category is the design work between raw sensor data and guidance a user can act on.

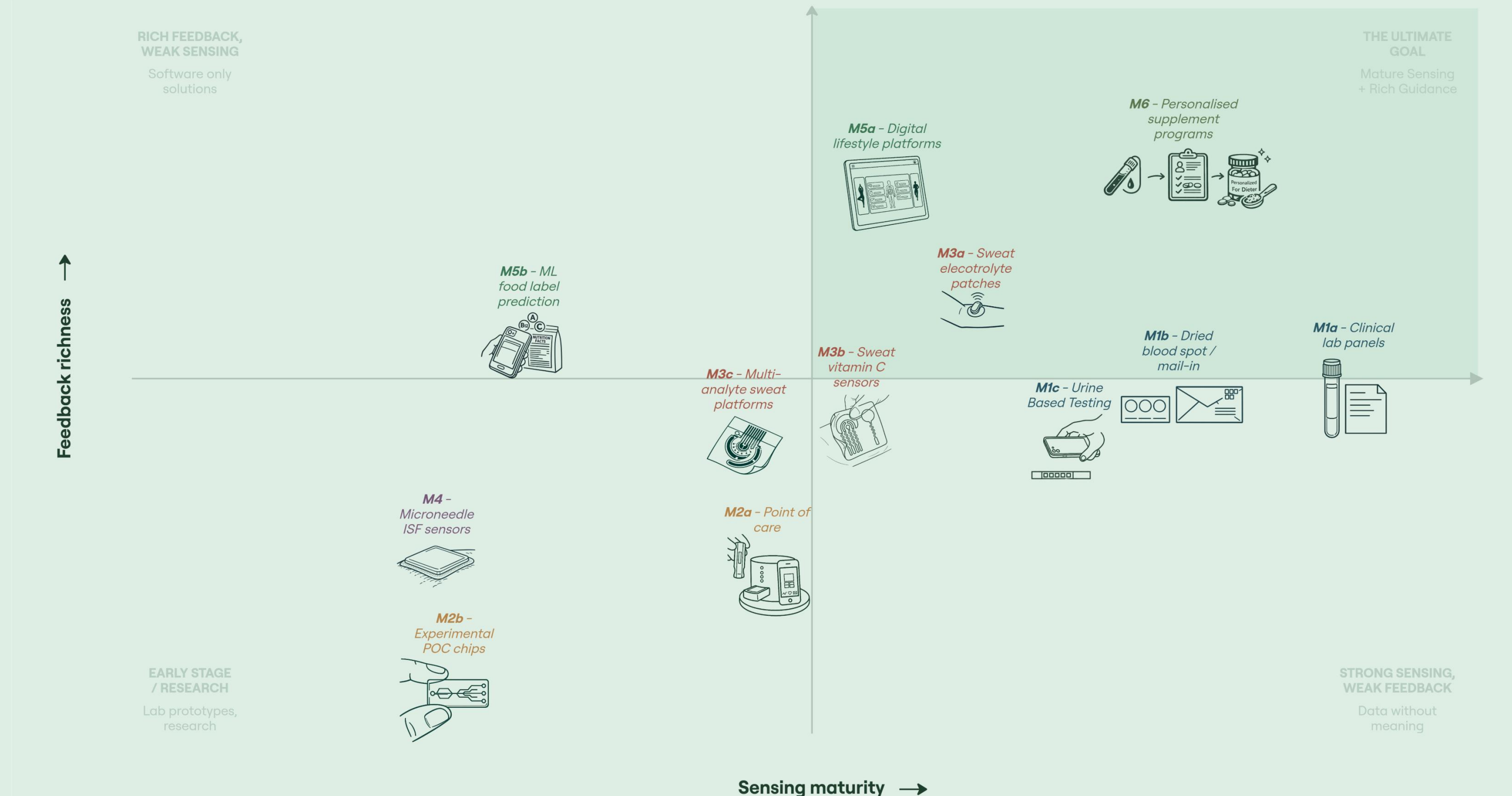


Figure 20. Micronutrient monitoring landscape; sensing maturity vs. feedback richness, categories M1-M6

The landscape draws on an Elicit AI screening of roughly 500 sources combined with a manual scan of the devices a consumer can actually buy today. The sub-sections below describe each of the six categories.

M1 Clinical and at-home laboratory testing

The gold standard remains laboratory testing (M1a). Standard panels rely on techniques such as chromatography and antibody-based assays, the same methods used in a GP laboratory, and accuracy is high. In a Dutch cohort, Castela Forte et al. (2022) found at least one micronutrient out of range in 86.5% of 348 adults, which indicates how common nutrient gaps are even in a healthy population. Dried blood spot tests (M1b) extend the same analytical capability into the home. A user pricks a finger, places a drop on a collection card, and mails the card to a centralised laboratory. Over fifty substances can be quantified this way, including vitamins A, D, B12, and folate as well as iron, zinc, and selenium, at clinical-grade accuracy and for less than the cost of a clinic visit (Everlywell, 2026; LetsGetChecked, 2026; Verisana, 2026). A third variant uses urine instead of blood (M1c): Healthy.io's MinuteKidney, for instance, has the user photograph a standard test strip with a smartphone, and the colour change is read by an algorithm (Healthy.io, 2026). Urine-based testing is less invasive than blood testing, but urinary biomarkers primarily reflect recent intake and kidney function rather than longer-term nutrient status in tissue.

The shared limitation of all laboratory-based approaches is that it is temporal and interpretive: the results provide a snapshot rather than a trend. Most mail-in services present numerical values within a traffic-light range and a generic recommendation to consult a GP. For a user deciding whether to continue, adjust, or stop a supplement, this feedback is too infrequent and too abstract to guide daily behaviour.

M2 Point of care and smartphone-based diagnostics

A second group of technologies aims to bring laboratory-grade accuracy into decentralised settings: a GP's office, a kitchen counter, or a user's hand. NutriPhone (M2a) runs a finger-prick sample through a cartridge plugged into a desktop device and returns vitamin levels in approximately fifteen minutes, with accuracy equivalent to ELISA, a standard laboratory immunoassay (Lee et al., 2014, 2016). TIDBIT measures iron, vit A, and vit C from a single strip at approximately \$1.50 per test (Lu et al., 2017). A dual biosensor chip reads vitamin C and D from saliva within 25 minutes (Ruiz-Valdepeñas Montiel et al., 2021). These devices move sensing physically closer to the user, but none have reached commercial availability, and the user facing output on each remains a raw concentration value on a phone screen: no dietary guidance, no trend over time, no supplement recommendation.

M3 Wearable sweat biosensors

Sweat biosensing is the fastest growing category in the published literature. A small patch adhered to the skin picks up analytes in sweat and reports them wirelessly, in principle continuously and without a finger-prick. Vitamin C is the most studied analyte (Sempionatto et al., 2020; Zhao et al., 2020), with devices also demonstrated for riboflavin (Shi et al., 2024), electrolytes (Alizadeh et al., 2018; Noor et al., 2025), and minerals such as zinc (Seker et al., 2024). Wang et al. (2022) demonstrated the most ambitious platform in the category: a graphene sensor with molecularly imprinted polymers capable of detecting several nutrients simultaneously. The only sweat biosensors currently available to consumers, however, are hydration-focused electrolyte patches. Gatorade Gx is a single-use patch read with a smartphone camera, and Nix Biosensor is a real-time Bluetooth device; both are marketed to athletes (Gatorade, 2026; Nix Biosensors, 2026). Their feedback targets hydration rather than nutrient status.

Three barriers keep this category out of the supplement market. First, for most nutrients, the correlation between sweat concentrations and blood concentrations has not yet been validated (Balch et al., 2024), and blood remains the clinical reference. Second, the analytes these sensors currently read (vitamin C, electrolytes) are not the clinically prioritised deficiencies for this population (iron, vitamin D, folate, B12). Third, almost every micronutrient-relevant device in the literature remains a research prototype without regulatory approval (Sempionatto et al., 2020; Shi et al., 2024)

M4 Microneedle and interstitial fluid sensors

Microneedle patches access interstitial fluid (ISF), which is compositionally closer to blood than sweat. The Metyos K-Patch demonstrated continuous potassium monitoring for 8 days with no pain upon placement (Chashchina et al., 2024), and Huang et al. (2023) developed a 3D microneedle array for continuous calcium, potassium, and sodium sensing with wireless monitoring. ISF sensing bridges the gap between sweat and blood, but current coverage is limited to ions rather than the vitamins and minerals most relevant to supplementation decisions.

M5 Digital nutrition platforms and AI integration

Digital nutrition platforms, where the sensing is a conventional blood test and the value is added in the software layer, provide the richest feedback among sensing-adjacent technologies. Ancora Health (CE Class I certified) pairs a blood panel with sixteen weeks of chat- and video-based coaching; Castela Forte et al. (2022) report that 67-86% of participants achieved measurable improvement in their nutrient status over the course of the programme. Amballa (2020) described a mobile application that integrates pathology results with AI-driven dietary recommendations. (Razavi & Xue, 2023) trained machine-learning models to estimate the nutrients not reported on food labels from those that are. The pattern across the category is that the intelligence sits in the software and the human coach rather than in the sensor: the data already exists, and the innovation lies in turning it into behaviour change.

M6 Personalised supplement programs

The category closest to a functioning consumer product, and the most commercially mature, is the personalized supplement programme. Bioniq PRO is the clearest example: a blood test at sign-up, an algorithm drawing on more than six million biochemical data points, a personalised granule formula containing up to 120 ingredients, retesting every six months, and a nutritionist consultation for interpretation of results. The company reports over 100,000 users globally (Bioniq, 2026). Rootine and Persona offer a more accessible version of the same model using standard pill formats (Persona Nutrition, 2026; Rootine, 2026). These programmes sit in the top-right of *Figure 20* because they close the loop between what the test showed and what the user should take. The sensing component, however, remains a conventional blood panel; the personalisation lies in the algorithm rather than in any new measurement technology; and the price is high enough to limit broad adoption.

The feedback gap in micronutrient monitoring

A recurring observation across the six categories is the disconnect between sensing sophistication and user-facing feedback. Most studies do not describe how results reach a user, or describe only a raw numerical output. Actionable guidance, meaning dietary recommendations, risk-level categorisation, or trend visualisation, is concentrated in the M5 and M6 platforms rather than in the sensors themselves. This does not mean consumer health lacks feedback design more broadly: wearables such as Oura and Whoop already deliver continuous, personalised feedback loops for sleep, recovery, and activity, with evident user engagement (Oura, 2026a; WHOOP, 2026a). What remains underserved is the specific closed loop for micronutrient supplementation: a system that takes validated biomarker data, feeds it into supplement-dosage guidance, tracks status over time, and tells the user when and how to adjust, while preserving her autonomy over the decision.

Interview findings micronutrient status sensing

Only two of nine participants currently receive any form of nutrient-level blood testing: P02 gets an annual vitamin D check and P09 sees a doctor who runs a yearly panel and provides personalised supplement advice based on the results. P09’s case is the closest real-world example of the “test-interpret-adjust” loop: before finding this physician she over-supplemented impulsively, and now reports measurable improvement and high trust in her regimen. The remaining seven participants do not test at all, relying entirely on cultural knowledge, family advice, or package instructions.

Attitudes toward blood-test-based personalisation split into three groups. Four participants are actively interested: P04 articulates a full plan-do-check-act model with lab values and follow-up consultations, calling untested supplementation “guessing”; P06 is frustrated that her GP refuses annual nutrient checks and would pay €50 per session twice yearly for independent testing; P02 already tests vitamin D and would welcome a subscription service that periodically re-checks her levels. Two participants are sceptical: P05 trusts her GP to flag any issue that matters and sees no benefit in proactive testing, and P08 considers nutrient monitoring unnecessary for someone who “eats normally.” The remaining three occupy a middle ground of passive openness: they would welcome testing if it were easy and affordable but have never sought it out.

These findings anchor the desk research’s monitoring landscape in lived experience. The two GP sceptics caution that advanced sensing is only valuable when clinical yield justifies cost and burden. At the same time, the frustrated majority validates the desk research’s identification of a “feedback gap”: participants want to know whether their supplements are doing anything, yet the current healthcare system does not routinely offer the testing, interpretation, or follow-up that would make this possible.

2.7.6. Expert interview findings

A cross-cutting observation from the expert interviews concerns the structural gap in professional oversight of supplementation. E1 argued that the current Dutch healthcare system leaves supplement users largely unsupported: general practitioners are not trained in micronutrient supplementation, consultations are too short to address it, and there is no reimbursement incentive to do so. Both interviewed GPs (E2 and E3) confirmed this assessment from the clinical side, stating that supplement guidance falls outside their perceived professional remit. E2 noted that patients rarely mention supplements during consultations, and that she does not proactively ask about them unless a direct interaction risk is apparent. E3 echoed this, adding that the sheer volume of available products makes it impractical for GPs to stay informed. The practical consequence is a supervision vacuum: the very population that could benefit most from professional guidance (older adults taking multiple supplements alongside prescription medications) is the least likely to receive it.

2.7.7. Design Implications

The combined evidence across adherence solutions, delivery formats, and monitoring technologies converges on six design requirements for a supplementation system targeting women 55+.

First, the system should prioritise simple, user-controlled organisation over technological sophistication. Manual organisers are the only solution category that participants actively endorse; automated dispensers, smart bottles, and app-based reminders all introduce maintenance, technology dependency, or surveillance concerns that this target group resists. The design benchmark is the weekly pillbox: extremely low-tech, yet the only tool that participants describe as having genuinely solved an adherence problem.

Second, the system should offer format flexibility as an option, not a default. Swallowing difficulty is a real barrier for a substantial minority (P02, P07, P09), but most participants are satisfied with conventional pills when size is manageable. Expert input confirms that unconventional formats are technically feasible but must be designed from the user’s sensory experience inward, not from the formulation outward (E4). The system should accommodate multiple formats without requiring all users to change what already works for them.

Third, the feedback architecture should build on existing data inputs rather than novel sensors. The monitoring landscape shows a clear bottleneck: not sensing capability but the translation layer between data and behaviour. Wearable micronutrient sensors remain years from consumer readiness (E5), and most sensing research stops at a raw numerical readout. The realistic near-term path is to take periodic blood test results and convert them into clear status indicators, trend visualisation, and concrete supplement guidance, closing the loop that participants like P04 and P06 are actively seeking.

Fourth, the system must address the feedback gap that drives “guessing” behaviour. The majority of participants want to move from intuition-based to evidence-based supplementation but lack an affordable, routine pathway to do so. P09’s physician guided blood work demonstrates what closing this loop achieves: a transformation from impulsive supplementation to confident, evidence-based adherence. The system should lower the barrier to periodic status assessment and make the results personally meaningful.

Fifth, the system should bridge the structural gap in professional oversight. GPs are not trained in micronutrient supplementation, consultations are too short, and there is no reimbursement incentive (E1, E2, E3). The system should create a lightweight channel for professional input: not replacing the GP consultation, but making it possible for a user to share her regimen and receive informed guidance when she chooses to.

Sixth, the system must stay portable, disruption-resilient, and non-surveillance-like. Solutions fail when they are tied to a single location, create lifestyle mismatch, or feel like monitoring. The system must work across home, social, and travel contexts; support routine variability and recovery after disruption; and keep the experience calm and autonomy-preserving.

2.8. Regulatory and technical feasibility constraints (SQ8)

SQ8: What regulatory and technical feasibility constraints govern the design of a supplementation product-service system in the EU, and how do these constrain the solution space?

The preceding sub-questions establish what users need (desirability). This section maps the regulatory boundaries that determine what can actually be built and brought to market in the European Union. For a supplementation system that may combine physical product design (storage, dispensing, portability), alternative delivery formats (non-pill forms), digital features (tracking, feedback, professional review), and potentially biomarker data, multiple regulatory frameworks apply simultaneously. Understanding these constraints early prevents concept development from drifting into legally infeasible territory.

2.8.1. Food supplement product regulations

Any product that stores, portions, or dispenses food supplements in the EU falls under the Food Supplements Directive (European Parliament & Council of the European Union, 2002). This directive defines a list of which supplements are and are not allowed to be marketed. For novel food supplements, the Novel Food Regulation (European Parliament & Council of the European Union, 2015) applies, requiring a safety assessment by EFSA. This process typically takes approximately two years.

Labelling requirements say the label must state the names of nutrients, the recommended daily portion, a warning not to exceed the stated dose, a statement that supplements should not substitute a varied diet, and a warning to keep it out of reach for children. The labelling and marketing must not claim to cure or prevent a disease. This directly constrains any language the system uses in its interface or packaging. (European Parliament & Council of the European Union, 2002)

Design implication: if the system pre-portioned or repackages supplements (rather than storing them in original packaging), it may itself become subject to food supplement labelling requirements. The system's physical materials must also comply with the Food Contact Materials Regulation (European Parliament & Council of the European Union, 2004), which requires that any material in contact with food (or food supplements) does not transfer substances in quantities that could endanger health or change the product's composition. This applies to dispensing mechanisms, storage compartments, and any reusable containers. (European Commission, 2011).

2.8.2. Health and nutrition claims

Further regulations govern what can be said about a food supplement's benefits, on packaging, in an app, or in any associated marketing. The regulation distinguishes nutrition claims ("high in vitamin D," "source of calcium") from health claims ("vitamin D contributes to normal bone function") (Regulation No 1924/2006, 2006). Both types are restricted to a positive list of authorised claims evaluated by EFSA.

This is directly relevant to interview finding E2's observation that supplement manufacturers print "for condition X" on packaging without proving efficacy. While such claims are technically prohibited unless authorised, enforcement varies. The NVWA (Nederlandse Voedsel- en Warenautoriteit, 2024) is the enforcing body in the Netherlands, and inspection data suggests that compliance rates across food business operators are around 45%.

Design implication: any text the system displays (whether on a physical device screen, in an app, or on packaging, must use only EFSA-authorized health claims (European Food Safety Authority, 2024).

2.8.3. Medical device boundary

The EU Medical Device Regulation (European Parliament & Council of the European Union, 2017) defines a medical device as something (be that a device or software) that is "intended for medical purposes". Software qualifies as a medical device when it is specifically made for one or more medical purposes (this includes also predicting, collecting data and diagnosing). Software for general lifestyle or wellbeing purposes does not.

This creates a clear boundary for the supplementation system. A physical organiser that stores and portions supplements is not a medical device. An app that logs intake and sends reminders is a lifestyle/wellbeing tool, not a medical device. However, the moment the system claims to diagnose a deficiency, recommend a therapeutic dose, or monitor a health condition based on biomarker data, it may cross into medical device territory. A biomarker feedback feature that says "your vitamin D level is 22 ng/mL, which is below the clinical threshold" and recommends dosage adjustment would likely be a Software as a Medical Device (SaMD) (European Parliament & Council of the European Union, 2017).

Design implication: if the concept were to provide biomarker feedback, it must carefully do so. Displaying raw lab values with general educational information ("what does vitamin D do?") is likely outside MDR scope. Providing individualised dosing recommendations based on those values is likely inside MDR scope. The design could present a raw measurement value and direct the user toward professional consultation. Expert E5's caution about wearable sensors reinforces this: building sensors and getting the regulatory ok takes a long time.

2.8.4. Data protection and eHealth

If the system collects, stores, or processes any health data (supplement intake logs, biomarker results, health questionnaires, or symptom tracking) the General Data Protection Regulation (European Parliament & Council of the European Union, 2016) applies. Processing is only permitted with explicit, informed consent that is specific, freely given, and revocable. Separate consent is required for unrelated uses such as marketing or data sharing with third parties.

This aligns strongly with the interview findings on privacy: participants resisted anything that felt like monitoring or surveillance (P01, P06), and the trust literature identifies privacy violations in intimate home health contexts as particularly strong trust barriers. GDPR compliance and user trust requirements converge: the system should minimise data collection, store data locally where possible, make privacy protections immediately visible to the user, and never share health data without explicit consent. If the system facilitates professional review of the user’s regimen, the data sharing with the healthcare professional must be user-initiated and transparently controlled.

2.8.5. General product safety

The General Product Safety Regulation (European Parliament & Council of the European Union, 2023), applies to all non-food consumer products not covered by specific legislation. It requires that only “safe” products are placed on the market, with risk assessment explicitly considering vulnerable consumer groups including older people. Manufacturers must conduct an internal risk analysis and prepare technical documentation. If the product has electronic components (e.g., a timer, LED indicator, or connectivity), additional requirements under the Low Voltage Directive (Low Voltage Directive 2014/35/EU, 2014) and the Radio Equipment Directive (European Commission, 2014) may apply.

2.8.6. Design implications

The regulatory landscape constrains the solution space in five concrete ways. First, any claim or guidance the system provides about supplement benefits must use only EFSA-authorized health claims; the system cannot make therapeutic promises even if users want reassurance. Second, if the system repackages or pre-portion supplements outside their original packaging, it takes on food supplement labelling obligations and food contact material compliance requirements. Third, if biomarker-based feedback is considered, it must be carefully positioned below MDR, as it would trigger substantial cost and time implications. Fourth, any health data collection requires GDPR-compliant explicit consent, which conveniently aligns with the user trust requirements identified in SQ5. Fifth, the physical product must meet general product safety requirements with specific attention to the older adult user group. These constraints do not prevent the design directions identified in SQ1-SQ7, but they shape how features are framed, what language is used, and where the system directs the user toward professional consultation rather than providing guidance itself.

2.9. Synthesis / Conclusion

The Discover phase set out to answer eight sub-questions, most of which were framed around supplementation adherence: what barriers prevent it, what strategies support it, how routines function across six moments, and what existing solutions look like. These questions yielded actionable findings. However, when the evidence is examined across sub-questions rather than within them, a pattern emerges that the adherence framing alone does not fully capture. This section synthesises the cross-cutting themes that surfaced repeatedly across participant interviews, expert consultations, and the literature review, and identifies four promising design directions that the Define phase will evaluate.

2.9.1. Problem deconstruction: what the research revealed

Before examining the cross-cutting themes, it is useful to deconstruct the problem as it was understood at the start of the project and compare it with what the research actually revealed. The WWWWWH method (Who, What, Why, When, Where, How) provides a structured way to do this.

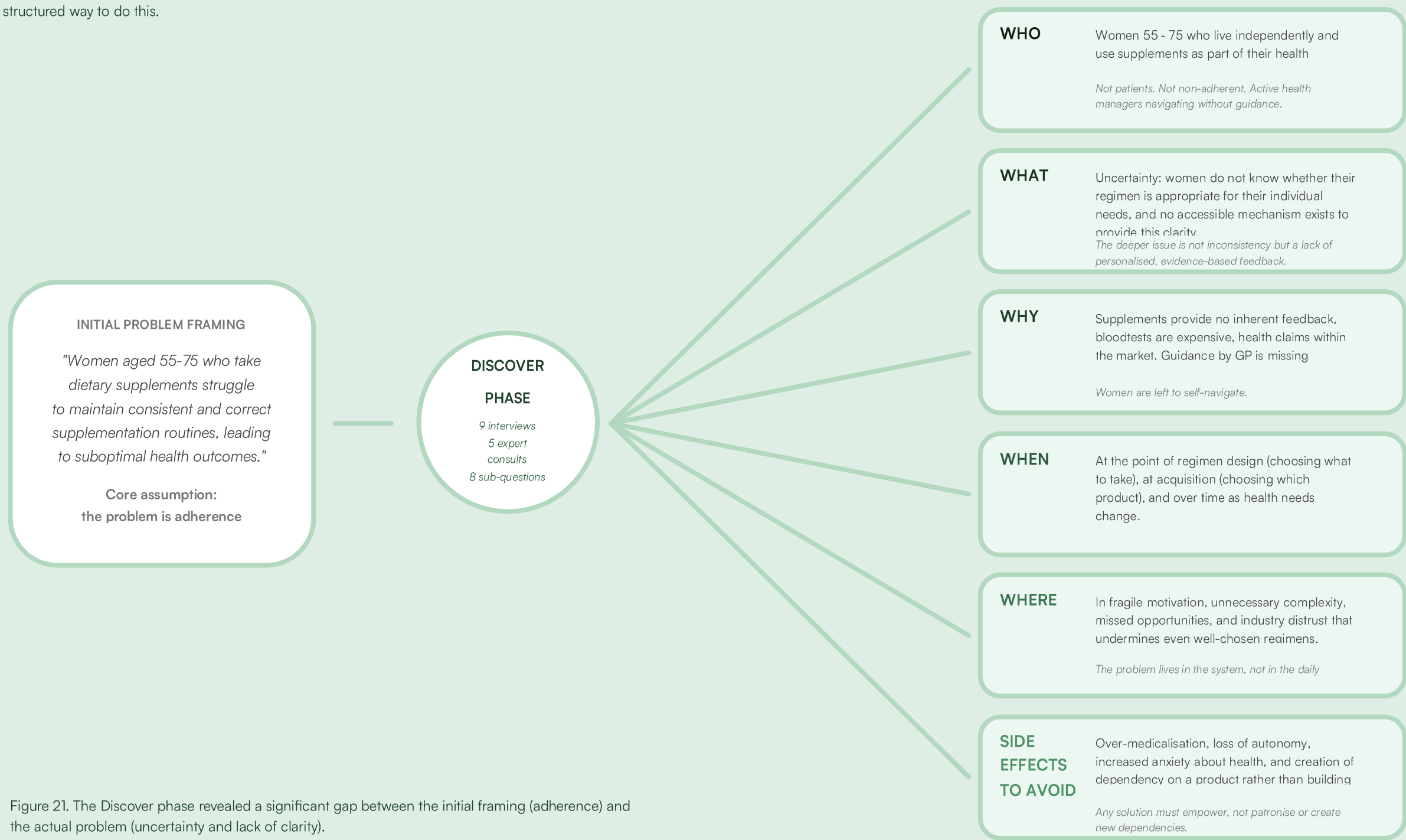


Figure 21. The Discover phase revealed a significant gap between the initial framing (adherence) and the actual problem (uncertainty and lack of clarity).

2.9.2. Cross-cutting themes beyond adherence

Cross-cutting themes: participant evidence strength

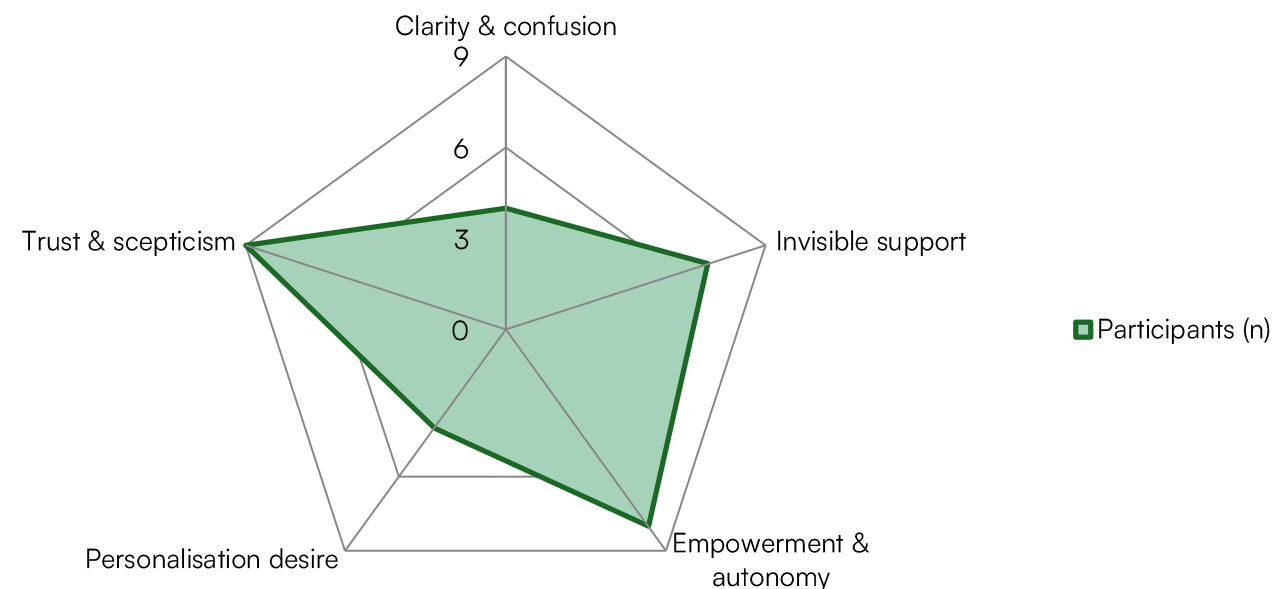


Figure 22 Evidence strength of the five cross-cutting themes across the nine participants (P01 - P09).

The sub-questions of this project were deliberately structured around adherence to supplementation routines. This framing was useful for generating specific, actionable findings about when, where, and how routines succeed or fail. However, adherence is a downstream behaviour: it reflects whether someone takes their supplements consistently, but it does not address whether they are taking the right supplements, whether they understand why, or whether the broader system around them supports informed decision-making. When the interview data is examined for themes that cut across sub-questions, five recurring patterns emerge that point beyond the adherence narrative.

Note on counting: a participant is counted as exhibiting a theme when their interview contained at least one explicit statement or observable behaviour providing clear evidence of that theme. Counts refer to the nine participants (P01 - P09); the expert interviewees are reported separately where their input is relevant. Because these themes emerged inductively across the dataset rather than as pre-coded variables, counts should be read as an indication of evidentiary breadth, not as a statistical measure. Figure 22 summarises the evidence strength of each theme across P01 - P09.

Clarity and confusion: “Am I even doing the right thing?”

Four of nine participants and both expert interviewees showed evidence that clarity about what to take, why, and whether it is working is a more fundamental concern than remembering to take it. P01 captures this with her “baat het niet, schaad het niet” attitude (if it doesn’t help, it doesn’t harm), which reveals a fragile motivation underneath outwardly consistent behaviour. P06, despite her carefully self-designed regimen, openly questioned the scientific basis for what she was taking (“ja, wat is het wetenschappelijk bewijs van dit?”), showing that confusion persists even among the most engaged users. P07 buys the cheapest available option without any research into what she takes or why. P08, who works in healthcare, experienced confusion after a regimen change and took a half-dose rather than risk an error. The expert interview with the supplement entrepreneur confirmed the scale of the problem: in a saturated market with many providers, each claiming superiority, consumers have no reliable way to distinguish evidence-based products from marketing-driven ones. Both GPs interviewed observed that patients frequently self-diagnose nutrient deficiencies based on vague symptoms, drawing causal conclusions that are rarely supported by clinical evidence.

This uncertainty was further confirmed in the deepening follow-up: when asked directly how sure they were that their current intake matched their body’s needs, five of the six respondents (P01, P03, P04, P06, P07) admitted partial or full uncertainty, with P04 stating “Nee, ik weet het niet zeker, maar ga uit van baat het niet, schaad het niet” and P07 describing her approach as “Kop in het zand steken en hopen op het beste”. Only P02, who tests her vitamin D annually, expressed evidence-based confidence.

This theme aligns directly with the Confusion dimension of the 6C framework and suggests that a system addressing only adherence may improve consistency while leaving the underlying uncertainty untouched.

Trust and scepticism: the bottleneck for adoption

All nine participants exhibited identifiable trust patterns, and trust emerged as the single most important factor determining whether a supplement regimen is adopted, maintained, or abandoned. Trust is built through three mechanisms, ranked by evidence strength. First, dramatic personal experience: P03’s extreme fatigue after missing B12 created a lasting, visceral motivation; P06’s relief from restless legs through magnesium reinforced her entire system. Second, professional validation: participants with healthcare backgrounds (P04, P05, P08) or those who receive annual blood work review (P09) showed the highest confidence in their regimens. Third, long-term personal relationships: P06’s 20-30-year relationship with a specialised apothecary provides a trust anchor that no digital platform has replicated.

On the negative side, industry distrust runs deep. The evidence in 2.5 (the “mafia” perception, industry markups, confusion caused by advertising) applies here. These findings suggest that any product entering this space must earn trust through transparency, professional endorsement, and visible evidence rather than through branding or marketing claims.

Personalisation desire: one size does not fit all

Four of nine participants expressed a desire for supplement recommendations tailored to their individual health profile, lifestyle, or life stage. P01 explicitly stated willingness to pay up to €5 per day for a personalised, evidence-based regimen. P06 independently designed her own seasonal adjustment system, varying her supplement intake based on exercise intensity and dietary changes. P09 values her annual blood work review as the primary mechanism for validating whether her regimen remains appropriate. The supplement entrepreneur built his practice around blood-test-driven personalised programs and considers professional consultation to be the only credible mechanism for regimen design.

However, medical professionals in the sample voiced caution. P05, who has a clinical background, described personalised blood testing as “too expensive” and “medicalising normal ageing.” Both GPs warned against making testing without indication standard practice. This tension between consumer desire for personalisation and professional concern about over medicalisation points toward a design opportunity: light personalisation (periodic rather than continuous, guiding rather than prescribing) that respects clinical boundaries while addressing the consumer’s need to feel that their regimen is right for them.

Empowerment and autonomy: understanding, not compliance

Eight of nine participants demonstrated that autonomy over their supplementation practice is strongly valued. P06 created her own container system, varies her regimen seasonally, and reported being “helemaal content” (completely satisfied) with her self-designed setup. P09 frames adherence as “discipline,” a character trait, and explicitly rejected pre-filled dispensers as a threat to her sense of control. P02 and P06 both rejected subscription models despite acknowledging their convenience, because the perceived loss of control outweighed the ease-of-use benefit.

The GP offered a key insight: “solutions people invent themselves work best.” This aligns with the Coercion-free dimension of the 6C framework and the salutogenic principle of building health capacity rather than managing deficits. It also reframes what “support” means in a supplementation context: the goal is not to simplify the routine for the user, but to equip them with the understanding and tools to manage it themselves.

Invisible and passive support: the best systems disappear

Across seven of nine participants (all except P06 and P09), the routines with the highest adherence and lowest friction were those requiring zero conscious effort at the moment of intake. P04 stores her single multivitamin on the breakfast table next to the bread and spreads; she reports zero barriers and perfect consistency. P05 keeps vitamin D next to her toothbrush. In both cases, the supplement is spatially integrated into an existing daily ritual so completely that the act of taking it has become invisible.

For participants with more complex regimens, a two-layer strategy emerged: concentrated weekly effort (preparing a medication box or container system) enables passive daily intake. P08 calls her weekly medication box “essential” and credits it with eliminating the forgetting that plagued her previous bottle by bottle approach. This pattern, visible weekly preparation followed by effortless daily use, is consistent across P03, P06, P08, and P09.

Notably, no participant uses a supplement specific app, and several explicitly rejected digital reminders. P01 dislikes “robot” reminders; P05 stated she has “no interest in additional tools.” Even P03, who uses a phone alarm, uses it as a simple trigger rather than an interactive application. The GP suggested a physical device with an audio cue rather than a digital solution. This evidence consistently points away from app based interventions and toward physical, tangible, spatially anchored design solutions.

Why clarity remains the core problem despite the count distribution

The evidence strength for Clarity and confusion (4/9 telling so explicitly) is lower than for Empowerment and autonomy (8/9) or Invisible support (7/9), which at first reading might suggest autonomy or support as the stronger candidate problem. Two considerations override that reading. First, the 4/9 measures only participants who articulated their confusion. Problems people cannot name are not less real; they are harder to address, which makes them more valuable design targets. Second, autonomy and trust register as values and variables rather than problems: no participant’s autonomy is structurally denied (the market grants full autonomy by default), and trust is universally strained precisely because confusion exists.

2.9.3. Problem Tree Analysis

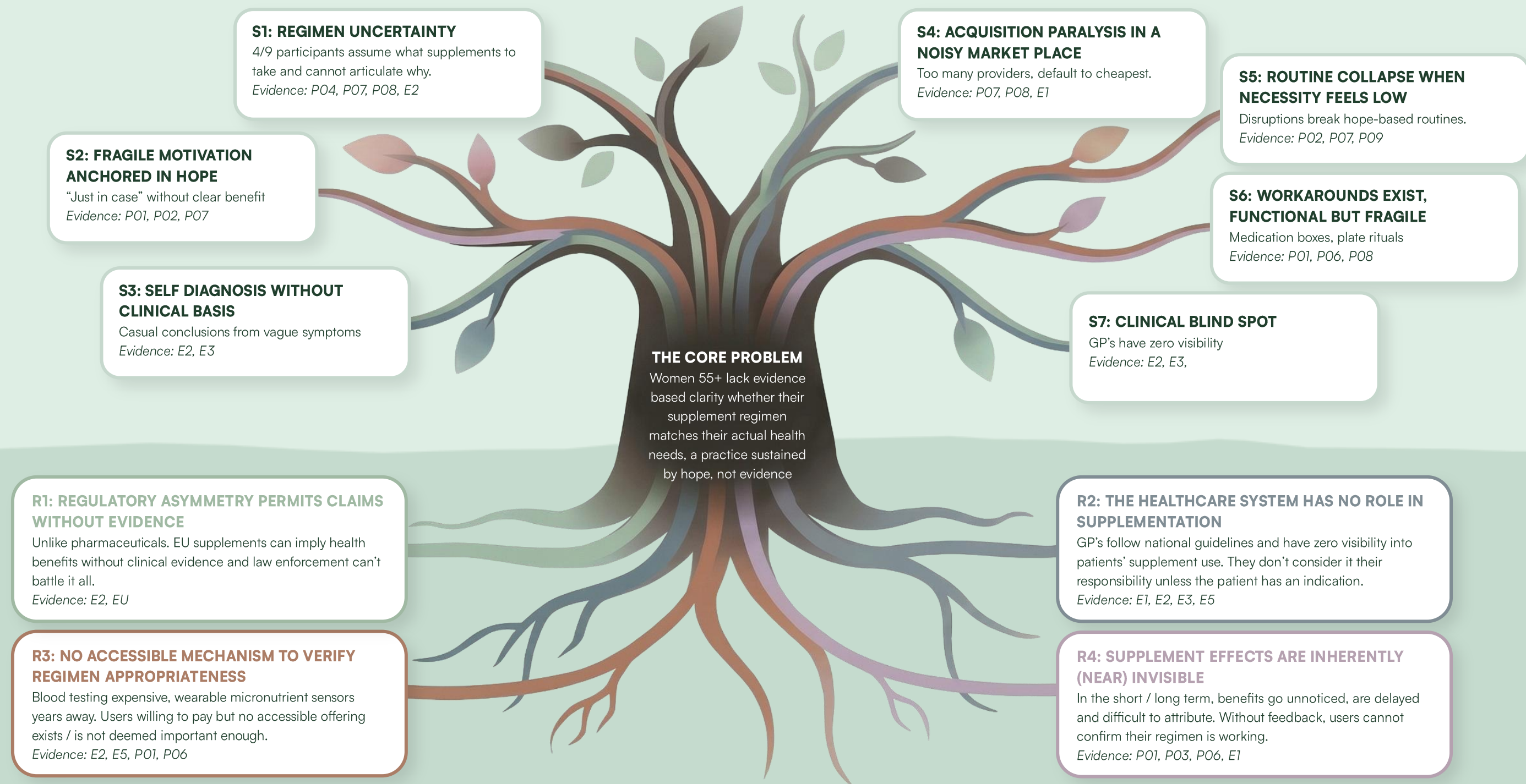


Figure 23. Problem Tree visualizing the core problem (the trunk), its observable symptoms (branches) and the systemic root causes that sustain it (roots).

To systematically unpack the layers of the supplementation problem, a Problem Tree Analysis was conducted (Snowdon et al., 2008). The method distinguishes between a core problem (the trunk), its observable symptoms (branches), and the systemic root causes that sustain it (roots). Figure 23 presents the tree; the text below presents what the figure cannot show: the evidence behind each layer and how the layers interact.

The core of the problem

The trunk states the reformulated core problem. The case for it was made in 2.9.2: routines are largely consistent, but four of nine participants could not articulate why they take most of their supplements (SQ2), so the deeper issue is appropriateness, not consistency.

Observable symptoms

The branches of the tree represent seven observable symptoms that manifest from the core problem, organised into three categories: cognitive, behavioural, and systemic.

At the cognitive level, **regimen uncertainty (S1)** reaches even the most expert participant: P08, who works in healthcare, halved her dose after a regimen change rather than risk an error (SQ2). **Fragile motivation (S2)** manifests in participants who supplement “just in case” without perceiving clear benefit (P01, P02, P07), making their routines vulnerable to disruption. This contrasts with participants with tangible evidence of efficacy (P03, P06, P09) who demonstrate stable long-term commitment (SQ6). **Self-diagnosis without clinical basis (S3)** describes how women draw causal conclusions from vague symptoms; E2 identified this as the most common patient misconception, with advertising actively feeding self-diagnosis (SQ2).

At the behavioural level, **acquisition paralysis (S4)** reflects the breakdown of rational decision-making in a crowded marketplace; most participants default to the cheapest option or friend recommendations. Information poverty masquerading as consumer choice (P07, P08, E1). **Routine collapse (S5)** during travel and weekends occurs specifically when perceived necessity is low (SQ3). **Workarounds (S6)** emerge as participants build coping systems: container systems, plate rituals, earplug boxes repurposed for travel.

At the systemic level, supplementation is a **clinical blind spot (S7)**: the GP-visibility gap (SQ2) means regimens go unreviewed (E2, E3). Agbabiaka et al. (2018) found that 33.6% of older adults use supplements with prescription medications, and one third of those were at risk of adverse drug interactions. Only two participants (P02 & P09) reported a mechanism for periodic professional review (one of them being outside of the Netherlands, and one paying for a private clinic).

Root causes

Four systemic root causes sustain the core problem, each operating at a distinct level of the system.

Regulatory asymmetry permits claims without evidence (R1): Unlike pharmaceuticals, dietary supplements in the EU can make implied health claims without demonstrating efficacy through clinical trials. The regulatory analysis in 2.8 details this asymmetry; E2 confirmed it from daily practice (SQ2). This regulatory gap is the structural foundation upon which confusion is built.

The healthcare system has no role in supplementation (R2): GPs are trained to manage disease, not to review preventive supplementation in healthy older adults. Consultations are too short, supplementation is not insured (some exceptions apply if there is a medical indication/necessity), and the sheer volume of products makes it impractical for clinicians to stay informed (E2, E3). E1 identified physician involvement as “the deciding factor” for supplement purchases in this age group, and E1 noted that women aged 55-75 treat the doctor’s word as “sacred”, yet the healthcare system does not formally support this role (SQ5).

No accessible mechanism exists to verify regimen appropriateness (R3): The most direct cause of regimen uncertainty is the absence of a tool to answer the question “am I taking the right supplements for me?” Blood testing is expensive and logistically burdensome; micronutrient sensing via wearables is years from consumer readiness (E5); the most advanced commercial solution costs €250 - 750 per quarter (Bioniq, 2026). Participants signalled clear willingness to pay for clarity at far lower price points (P01, P06; see 2.6). So there is demand, but nothing on the market answers it.

Supplement effects are inherently invisible (R4): Did improved energy come from the magnesium, from better sleep, or from more exercise? Attribution is impossible without periodic feedback. The participants with the strongest commitment (P03, P06, P09) are precisely those who experienced tangible feedback; for everyone else, "just in case" is the best available motivation. E1 confirmed the mechanism: "when you're confronted with yourself [through blood test results], that's usually a trigger for change" (SQ6).

How the root causes interact

These four root causes form a reinforcing cycle. Regulatory asymmetry (R1) floods the market with unsubstantiated claims, creating a confusing landscape. The healthcare system (R2) does not step in to help users navigate this confusion. No accessible tool (R3) exists to resolve uncertainty at the individual level. And because supplement effects are invisible (R4), users cannot resolve uncertainty through personal experience either. The result: women sustain their routines by hope rather than evidence, and the system provides no mechanism for this to change.

2.9.4. Promising design directions

The cross-cutting themes above, combined with the sub-question findings, suggest four distinct but potentially overlapping design directions. Each direction addresses a different core problem and draws on different parts of the evidence base. The purpose of identifying these directions at the end of the Discover phase is not to select one prematurely, but to make the options explicit so that the Define phase can evaluate them systematically using appropriate design tools.

Direction 1: Adherence and routine support

This direction focuses on the moment-by-moment friction in the supplementation routine: acquisition, storage, preparation, intake, disruption handling, and recovery. It is the direction most strongly supported by the sub-question evidence. Product concepts in this space include physical organisers, smart dispensers, and routine-anchoring objects.

Direction 2: Clarity and personalised guidance

This direction targets the uncertainty and confusion that underpin fragile adherence. Rather than helping people take supplements more consistently, it asks: are they taking the right supplements in the first place? The evidence for this direction is strong: four of nine participants showed signs of regimen uncertainty, only two participants (PO2 and PO9) reported any periodic professional review of their regimen appropriateness, and the supplement entrepreneur identified personalised blood-test-driven consultation as the most credible trust-building mechanism.

Direction 3: Format innovation and ritual integration

This direction challenges the assumption that supplements must be pills taken as a separate activity. Four of nine participants reported physical or psychological barriers to pill-form supplements (PO2 and PO7 with swallowing difficulties, PO1 with taste rejection of collagen powder, PO9 with complex timing requirements for iron). Meanwhile, Silvie Health already produces supplement sachets designed for body and mind, thereby already providing an alternative delivery format.

This direction is potentially the most disruptive but faces regulatory complexity around food supplement boundaries and requires careful navigation of EU food safety regulations.

Direction 4: Empowerment and health literacy

This direction positions supplementation as one component of a broader health understanding, particularly relevant for women navigating the physiological transitions associated with ageing. Rather than optimising the supplement routine itself, this direction asks: how can a system help women 55+ understand their changing health needs so well that they can make confident, informed decisions about supplementation (and their health)?

These four directions are not mutually exclusive. A product-service system might combine elements of any of these directions together. The task of the Define phase is to determine which direction (or combination) is the most appropriate according to the evidence gathered here in the discover phase, and to use structured design tools to converge on a design vision that can guide concept development.

3.

Define

Chapter 3 is the Define phase. This is where the messy findings from Discover get pulled together into concrete design requirements, a design vision, and success criteria for the supplementation system. Chapter 2 opened up the problem; this chapter narrows it down to what the design has to deliver, for whom, and within what limits.

Methodology for the Define phase

In the Define, phase the design problem, direction and goal are articulated. A variety of tools were used from the Delft Design Guide (Technische Universiteit Delft, 2021), in an order where each step builds on the one before it. First, a design direction is chosen from the four candidates in the Discover synthesis, compared with a Harris Profile adapted (originally used for concept comparison, here for comparing directions) so that the choice is explicit and grounded. Second, the problem is reformulated: the emotional layer beneath the routines was surfaced. Third, three personas anchor every later decision to real users from the interview data. Fourth, a journey map extends the six-moment framework from the Discover phase with an behavioural/belief (emotional) and clarity layer, showing where the gaps sit in the routine as it is lived today. Fifth, a future vision sets where Silvie should go by 2031, grounded in a PESTEL scan and stress tested in a “playground” step. Sixth, the problem and design opportunity are laid out. Seventh, a list of requirements turns the goal into testable demands and wishes, organised by desirability, feasibility, and viability.

3.1. Direction selection

The Discover phase surfaced a wide spread of unmet needs across desirability, feasibility, and viability. No single product can address all of them equally, so a design direction must be chosen before concept development: a core proposition that defines what the product-service system fundamentally exists to do and which problems it prioritises. This section documents the reasoning behind that choice. The chosen direction is the filter every downstream step (problem reformulation, personas, journey map, future vision, design goal, and requirements) builds on.

The four candidate directions identified at the close of the Discover phase are compared using a Harris Profile (Technische Universiteit Delft, 2021). The tool is normally used to compare design concepts; here it is adapted to compare directions against three criteria, weighted by importance. Table 8 summarises the scores; the reasoning behind each is outlined below.

Table 8. Harris Profile comparing the four candidate design directions against three criteria: salutogenic alignment (most important), evidence strength, and design opportunity. Scoring: -- = weak, - = moderate, + = strong, ++ = very strong

Harris Profile Design Direction Selection																			
Direction 1					Direction 2					Direction 3					Direction 4				
Adherence & routine support					Clarity & personalised guidance					Format innovation					Empowerment & health literacy				
	--	-	+	++		--	-	+	++		--	-	+	++		--	-	+	++
Salutogenic alignment					Salutogenic alignment					Salutogenic alignment					Salutogenic alignment				
Evidence strength					Evidence strength					Evidence strength					Evidence strength				
Design opportunity					Design opportunity					Design opportunity					Design opportunity				
Scoring scale: -- = weak / pathog, - = moderate, + = strong, ++ = very strong. Criteria are listed in order of importance (most important on top).																			

Three criteria structure the evaluation, listed in order of importance. Salutogenic alignment measures how well the direction builds health capacity rather than merely reducing pathogenic friction. A direction that scores poorly here cannot be rescued by strong scores elsewhere. Evidence strength measures how many participants and sub-questions support the direction, while accounting for whether the evidence reflects genuine user need or research framing. Design opportunity measures how much room the direction offers for original, feasible design work within a graduation project scope.

Direction 1: Adherence and routine support. The evidence base looks strongest here, but that strength partly reflects how the sub-questions were framed rather than the real problem hierarchy. Skipping a day of supplementation is, unlike medication non-adherence, without acute consequence for most preventive supplements, though this is compound specific, so for many users the problem does not feel urgent enough to justify adopting a new product. Salutogenic alignment is moderate: routine support reduces friction but does not build health capacity, and it risks creating dependency instead of empowerment. The design opportunity is limited: the market for organisers and dispensers is crowded, and participants rejected most existing solutions as unnecessary, over-engineered, or autonomy-threatening.

Direction 2: Clarity and personalised guidance. This direction targets the most broadly evidenced gap in the data: women who keep taking supplements without knowing whether they are right for them. Salutogenic alignment is very strong, because clarity about one’s own health needs builds Coherence and Manageability, two of Antonovsky’s three components, and directly counters the guessing that defines the current experience. The design opportunity is strong: no consumer product currently combines health assessment with personalised supplement guidance in a way that is accessible, non-medicalised, and trustworthy, and the expert interviews and participant frustrations confirm that the demand is real.

Direction 3: Format innovation and ritual integration. Format barriers are real but narrow: they affect specific individuals rather than the whole sample, and Silvie’s existing sachets already cover part of this space. Salutogenic alignment is low: a friendlier format reduces conflict between body and product but builds no understanding and supports no autonomy. The design opportunity is moderate at best: format innovation works as a feature inside a broader system, and food-supplement regulation narrows the room to move.

Direction 4: Empowerment and health literacy. This is the most directly salutogenic direction, and it matches the autonomy that participants treated as non-negotiable.

3.1.1. The chosen direction: clarity as the core, empowerment as the trajectory

Based on this evaluation, Direction 2 (clarity and personalised guidance) is chosen as the primary design direction. Direction 4 (empowerment) sits behind it as the long-term trajectory. Elements of Direction 1 (routine support) and Direction 3 (format integration) come in as supporting features rather than core propositions.

As established in section 2.9 and in the profile above: clarity is the deepest and most widely shared unmet need in the sample, it sits closest to the salutogenic framing of this project, and the design space is wide open, with no existing product-service system occupying this position for the target group.

3.1.2. Deepening the problem: from clarity to doubt

The problem beneath the problem

This section makes the second of three passes the thesis takes at the problem: the project brief framed it as adherence, the Discover evidence reframed it as clarity (2.9), and the analysis below deepens it to the doubt beneath that lack of clarity; the section Problem and design opportunity (3.5) consolidates these into the committed problem statement the design goal builds on. The six routine moments mapped in the Discover phase describe what women do with supplements: when they buy, store, take, and evaluate them. A deeper layer of the interview data reveals why they remain locked in these routines, often despite low confidence, no felt benefit, and recurring doubt. A client meeting flagged this as a missing layer: what is the emotional origin of supplementation, and what keeps it going? A close reading of the participant transcripts gives an answer that was not the expected one.

The worry can attach to the supplement

Participants describe supplementation as part of staying healthy, and several frame it explicitly as prevention. The worries they voice, however, rarely concern a specific condition; they concern the supplements themselves: overdosing, unknown interactions, putting something unnecessary or harmful into the body. P01 articulates this most directly: “Omdat ik dacht: als ik die andere er ook bij neem, dan is het misschien te veel” (“Because I thought: if I take the other ones too, it might be too much”). P03 removes supplements pre-emptively when uncertain about safety, P06 stopped taking pre-packaged blends after questioning their contents, and P07 wishes for more professional gatekeeping of supplement safety.

The participant who states most explicitly the “baat het niet, schaadt het niet” logic is P04, who also reports no felt benefit yet commits to lifelong use. A deepening validation round confirmed that this mental model works as a shared cultural script rather than a personal rationalisation: asked about certainty, P04 repeated the exact same phrase and treated it as reason enough to keep going.

Supplementation begins at an age threshold

Across the sample, the initial trigger for supplementation is remarkably consistent: an age threshold, not a diagnosis or symptom. P05, a medical professional, frames it as guideline adherence: “het is volgens mij in de richtlijnen dat je vanaf je 50ste vitamine D suppletie moet gebruiken” (“it is in the guidelines that from age 50 you must use vitamin D supplementation”); P04, P06 and P08 describe they started around this time as well. P03 is the only exception: her supplementation followed a confirmed B12 deficiency, and she is also the only participant who reports a clear felt benefit.

Continuation is driven by obligation and trapped uncertainty, not conviction

Another interesting finding is the gap between confidence and continuation. P01 continues primarily out of obligation, unable to see a difference but feeling she must persist. P07 represents the most extreme case of what might be called the uncertainty trap: she has taken magnesium for years without any perceived benefit, but cannot stop, because stopping would introduce a new unknown: “je weet niet ... zou je je dan nog rotter voelen. En ik ga het dan ook maar niet testen”. This is supplementation sustained not by evidence but by the inability to generate evidence; in the deepening round she described her own posture as “kop in het zand steken en hopen op het beste”.

P04 continues from passive acceptance rationalised by low cost, implying that evidence only becomes worth seeking above a price threshold. P02 and P06 are the exceptions: P02 manages her uncertainty through annual vitamin D testing, and P06 resolves hers by trusting a specific advisor, making explicit in the deepening round that trust in a person fills the gap the medical system leaves open.

The medical system does not meet them where they are

A recurring thread across the interviews is the absence of meaningful medical guidance on supplementation. P06: “je bent niet ziek dus dan ga ik niet” (“you are not sick so you wouldn’t go”). P07 wishes a doctor would tell her what is safe, what is necessary, and what she can stop. P01 described a past experience with prescribed medication that permanently reduced her trust in healthcare. Root cause R2 (2.9) described this gap from the system’s side; these accounts show what it feels like from hers: supplementing on cultural knowledge, family advice, a quick google search on her symptoms, without professional validation.

Reformulating the problem

The findings above sharpen what the design must solve. The women in this sample do not lack a way to take supplements consistently; most already have one that works for them. What they carry is a quiet, persistent doubt about whether what they are doing is right for their body, and no way to resolve that doubt. The four root causes mapped in 2.9 close every exit: the market does not answer the question (R1), professional care does not pick it up (R2), no accessible verification mechanism exists (R3), and felt experience stays silent (R4). Unresolvable doubt then hardens into the patterns described above: worry directed at the supplement itself, continuation out of obligation, and fragile hope.

Validation of the framing

This framing was checked in one in-depth conversation with a participant from the cohort (P01), who recognised the doubt directly and found a trust framing a more accurate description of her difficulty than a feedback framing. Two lighter checks point the same way: the design goal built on this framing was shared in writing with 7 participants (5 respondents), who broadly endorsed it. Neither validates the framing on its own. However, the feeling of doubt and mistrust is really what arises from the lack clarity. The doubt is well supported across the nine interviews and the deepening rounds, the framing is the synthesis around this, and is properly validated by the concept direction in the develop phase.

3.2. Personas

With a direction chosen, the next step is to pin down who the design is for. Three personas (Technische Universiteit Delft, 2021) are built from the interview data so every design decision that follows stays tied to a real user. The first persona is the typical woman in the sample. The second shows the most common coping strategy and where it breaks down. The third is the entrant to the supplementation market seeking evidence.

All three personas describe postmenopausal women aged 55 to 70. This is the window where behavioural change still produces meaningful healthspan gains, and the group is more digitally engaged than older stereotypes suggest. Within that band the personas span three socio-economic positions; here we lean towards the more premium end, with women who are socio-economically positioned to invest in their own health.

Persona 1: Ingrid, Stuck in uncertainty (62)

Ingrid

Stuck in uncertainty



62

Netherlands

Lives with partner

Retired teacher

Moderate health literacy

Walks often

Reads a lot

Sees family weekly

Routine stability

High

Regimen confidence

Low

Trust in professionals

Medium

Need for autonomy

Medium

A reliable routine without conviction

Ingrid remembers, organizes, refills her weekly box. The friction is that she cannot say why she takes most of it, and she does not dare to stop in the fear of missing out on benefits.

Routine in real life

1

Breakfast anchor

Swallows her morning supplements with a sip of tea.

2

Kitchen placement

Pill box and bottles next to the tea tin.

3

Sunday ritual

Refills the weekly pill box while watching TV.

4

When routines shift

Weekends away / eating out break the routine.

5

No travel system

No travel kit, she simply skips when away from home.

Current regimen

Multivitamin

Vitamin D (GP-suggested at ~59)

Magnesium (4 years, no felt benefit)

Omega-3

Glucosamine chondroitin (friend's advice)

Has added several on magazine or friend recommendations.

Where confidence breaks

Accumulated logic

"Baat het niet, schaadt het niet." "Kop in het zand steken en hopen op het beste."

Doubts efficacy

Cannot tell whether any individual supplement is doing anything.

Fear of stopping

Afraid stopping would quietly cost her a benefit she cannot feel.

What good support would do

Give a calm, honest verdict on her regimen

Surface which items have no recorded reason

Not make her feel like a patient or a customer.

Work without daily logging or input.

DESIGN POSTURE

Give Ingrid reassurance or redirection

Ingrid is the average participant in the sample. She maintains a consistent five supplement routine refilled every Sunday, anchored to her morning tea, yet cannot articulate why she takes most of what she takes. She started at around 55 “because you do that after a certain age,” has accumulated additions through a friend’s advice, and continues mostly out of the fear that stopping might cost her a benefit she cannot feel. Her routine is reliable but she is not convinced it does anything. She has a mental model captured by the cultural script “baat het niet, schaaft het niet” that 4/6 of deepening questioning round respondents articulated verbatim, alongside P07’s: “kop in het zand steken en hopen op het beste.” She is grounded behaviourally in P07, with evidence from P01, P04, and overlap with P08. If the system cannot help her, it has failed its central purpose: roughly four of the nine interviewed women sit inside her frame.

Persona 2: Hannie, The trust mediated self manager (58)

Hannie

The trust mediated self manager



58

Rotterdam

Single mom, lives alone

Paralegal, vegetarian

Sceptical of drogist brands

Reads newsletters

Walks as sport

Close to son

Routine stability

High

Regimen confidence

High (borrowed)

Trust in professionals

High (advisor)

Need for autonomy

High

High functioning system built on borrowed certainty

Hannie runs a deliberate, seasonal regimen she designed with a trusted specialist apothecary. It works, but the certainty is borrowed, and if the pharmacist relationship fails, so does her trust in the routine.

Routine in real life

1

Morning drawer

Takes supplements before coffee

2

Custom container

Uses organizer labelled by time of day.

3

Sunday review

15 min weekly refill ritual on Sunday.

4

Travel case

Packs a week’s portions before every trip.

5

Seasonal shift

Adds B-complex in winter; drops products that stop feeling useful.

Current regimen

B-complex (winter)

Vitamin D (higher in winter)

Magnesium

Iron (under review)

Seasonal additions (ashwagandha, etc.)

Reviews the stack 1-2×/year with her specialist apothecary.

Where confidence breaks

Borrowed certainty

“I don’t need 100% certainty, I trust my specialist apothecary.

Advisor dependent

If her specialist apothecary retires or the shop changes staff, her trust and certainty drops.

No feedback loop

Cannot / did not measure whether the regimen is doing what the pharmacist claims. She feels “fine”.

What good support would do

Generate her own evidence to bring to the advisor.

Respect her autonomy, never tell her what to take.

Make her self-experimentation legible.

Use “we noticed” rather than “you should.”

DESIGN POSTURE

Augment Hannie’s advisor, do not replace

Hannie represents the most functional coping strategy observed outside the uncertainty trap: she has outsourced the certainty she cannot produce herself to a trusted advisor at a specialist apothecary. Her regimen of six to eight supplements shifts seasonally, she prepares it on a self designed container system she finds satisfying rather than burdensome, and she will not buy supplements from a drogist. She is high in autonomy and high in perceived confidence, but her confidence is borrowed, and her own deepening response (“Ik hoef geen 100% zekerheid. Advies Apotheker voelt goed voor mij”) makes the mechanism explicit: trust in a specific pharmacist substitutes for the clarity the medical system fails to provide. She is grounded in P06, with threads from P08 and P05’s professional framing. She must be designed for because she would not accept a replacement of authority (at least not easily). A system that augments her pharmacist relationship, producing evidence she can bring to him rather than take from him, will be adopted and defended. Designing for Hannie ensures the concept earns trust rather than demanding it.

64

Persona 3: Sanne, The Evidence Seeking Newcomer (55)

Sanne

The evidence seeking newcomer



55

Netherlands

Partner, teenage daughter

Pharma researcher

High health literacy

Very active

Annual blood panel via GP

Routine stability

Medium

Regimen confidence

High (evidence-based)

Trust in professionals

Medium

Need for autonomy

High

Evidence focused, resists overdoing supplementation

Sanne is just crossing the age threshold that triggered the others where supplementation is usually recommended. She refusesto take things she cannot justify, but she also knows that waiting and seeing what happens isn't a long term preventative health plan.

Routine in real life

1

No pill box

Takes morning supplements with breakfast after her run.

2

Kitchen windowsill

Three bottles on the counter, visible

3

Data check

Reads the research literature before adding anything new.

4

Missed days

Shrugs. Never doubles up.

5

Annual bloodwork

Annual blood panel with specialist, considers bloodwork the backbone of the regimen.

Current regimen

Vitamin D (all year round)

Magnesium

Low-dose omega-3

Stopped multivitamin (weak evidence)

No additions without data

Open to expanding only if a test justifies it. Resists “women

Where confidence breaks

Cultural pressure

Resists her mother’s regimen and “women 50+” marketing on principle.

Slow feedback loops

Annual bloodwork is too coarse to guide adjustments.

Wants to act sooner

Wants a signal when a change is necessary before it becomes a symptom.

What good support would do

Base any recommendations on health data

Recommend the supplements that are necessary only

Give data she can act on herself.

Evolve with her as her body changes.

DESIGN POSTURE

Provide data evidence that deepens as her needs do.

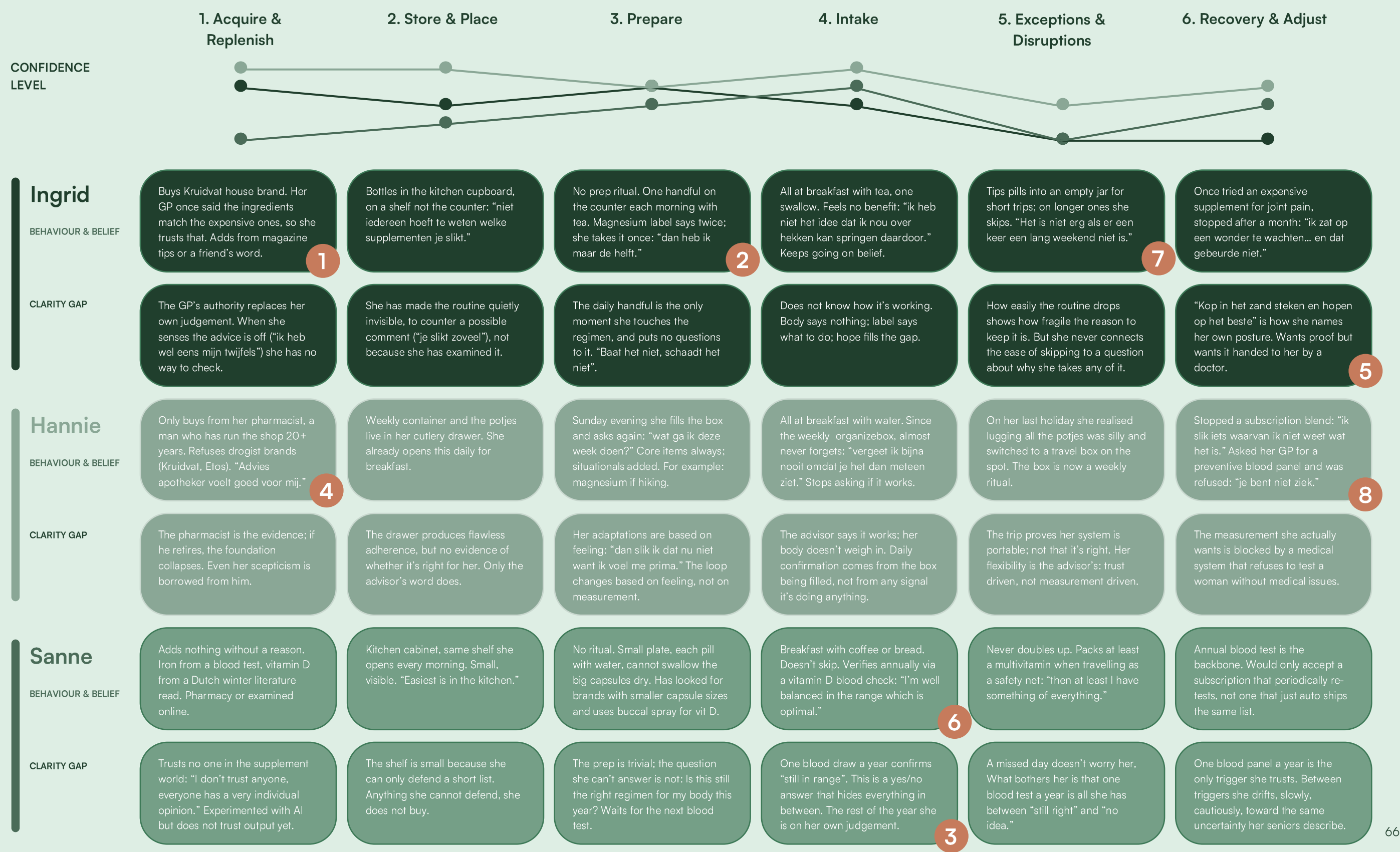
Sanne is the newcomer. At 55 she is just crossing the cultural threshold that triggered supplementation in P01, P04, P06 and P07, but she is resisting the marketing claims, refusing to take anything she cannot justify. Her current regimen is deliberately spare (vitamin D all year since a recent blood test, magnesium after reading about perimenopause, a low dose omega-3), she reads the primary literature before adding anything new, and she has stopped a multivitamin because the evidence base disappointed her. She is grounded in P02 (who assembled her regimen piece by piece through testing and a skeptical reading of the literature) and P09 (who anchors adjustments in annual bloodwork reviewed with a specialist doctor at a private clinic). She must be designed for because she is the credible onboarding story for the product service system; where a system built only around Ingrid would read as late stage remediation, one that onboards Sanne builds its user base ahead of the uncertainty trap rather than after it.

Across the three personas, the design brief is consistent: produce clarity about what the body actually needs, communicated as evidence rather than instruction, delivered with the least possible burden, and capable of evolving with the user over time. Where they differ is in the state of the user at the point of contact: Ingrid already inside the trap, Hannie managing around it, Sanne approaching it, and therefore in the emphasis the system must place on reassurance, augmentation, or onboarding for each of them.

65

3.3. Journey Map

With the persona in place, the next step is to map her actual routine. The journey map extends the six-moment framework from SQ3 by adding an emotional and clarity layer: where SQ3 captured what she does at each moment, this map overlays how she feels and where the clarity gaps sit.



3.3.1. Design opportunities

1

Supplements enter the regimen without evidence

All three women add supplements based on age norms, family advice, or cultural pressure, never based on personal health data. There is no clarity gate between 'I heard this is good' and 'I now take this daily.' The purchase moment is the first design opportunity for intervention.

Acquire - all personas
SQ3, SQ5

2

The routine works but generates no evidence

These women have functioning routines. Pill boxes are refilled, drawers are labelled, bottles are grabbed with breakfast. But none of this activity produces information about whether the regimen is right. The routine could generate evidence. Right now it generates nothing.

Store / Prepare / Intake
SQ3, SQ6

3

There is no signal between 'I feel fine' and crisis

P03's B12 crash is the only feedback signal in the entire sample. For everyone else, the body stays silent. The routine needs a gentle, periodic signal. Not necessarily continuous monitoring, but enough to distinguish 'this is working' from 'this is doing nothing.'

Intake - all personas
SQ5, SQ7

4

Trust is concentrated in one fragile source

Hannie's clarity depends entirely on one pharmacist. If that person retires, the foundation collapses. Ingrid trusts nobody. Sanne trusts data she cannot easily get. The system must create a durable trust source that does not depend on one relationship.

Acquire / Recovery - especially Hannie
SQ5

5

Nobody gives permission to stop

The market says ADD. The body says nothing. The GP says 'you are not sick.' P07 names her own posture 'kop in het zand steken en hopen op het beste.' The most valuable thing the system could do is give her credible grounds to question an item, and a reason to raise it with a professional.

Recovery - especially Ingrid
SQ1, SQ5

6

The evidence users already generate is wasted

P02 tests vitamin D annually. P09 reviews her bloodwork with a specialist doctor. P06 logs in a notebook. Only P09 gets advice from her private clinic on supplementation. The data and synthesis that exists already is not utilized.

Intake / Recovery - especially Sanne
SQ6, SQ7

7

Disruption reveals how thin the conviction is

P07 skips entirely when travelling. 'Het is niet echt een must.' The routine collapses not because of logistics but because, without the home routine anchor, there is no reason strong enough to continue. This disruption shows the gap in conviction.

Exceptions - especially Ingrid
SQ3, SQ4

8

The medical system refuses testing without an indication

P06 asked her GP for preventive blood testing and was told: 'je bent niet ziek dus een bloedtest is niet nodig.'. The design must create an alternative pathway to professional grade clarity that respects clinical boundaries.

Recovery - everybody
SQ5, SQ8

3.4. Future Vision

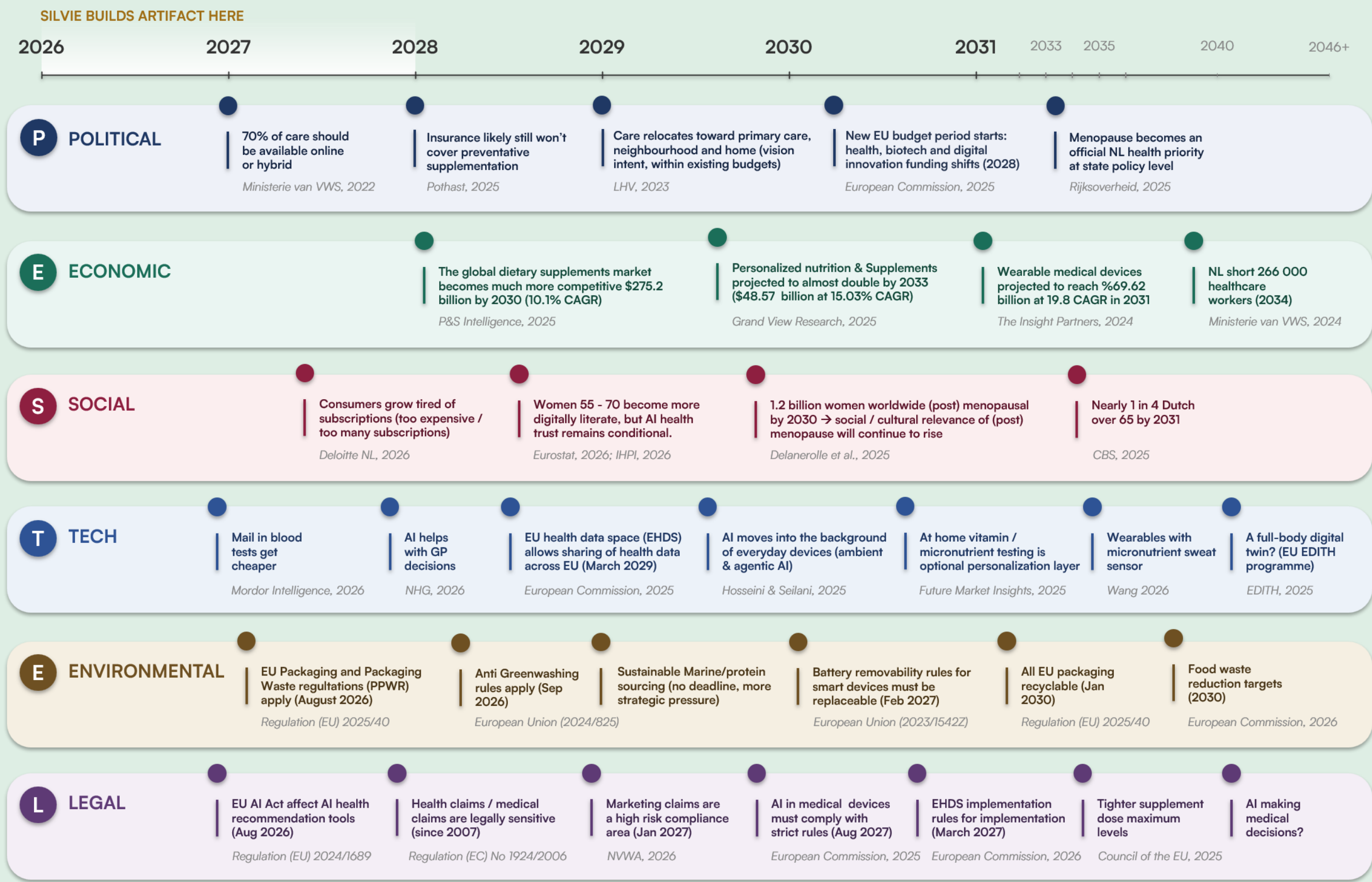


Figure 24. Future vision: 2026 to 2031 timeline across all PESTEL elements, with a compressed view of 2032 to 2046+

The journey map in the previous section shows how supplementation works for these women today, in 2026. This section describes what the future should look like by 2031 (see Figure 24). The method is Future Visioning from the Delft Design Guide (Technische Universiteit Delft, 2021), with two adjustments. Step 1 is set up as a PESTEL scan. Step 2 is a Playground, inserted between the scan and the vision statement to stress test the space with quick experiments in the form of written scenarios. The “vision as future state” step is expressed as a vision with three commitments (Step 3) and translated into a five-year roadmap for Silvie (Step 4).

The five-year horizon is a deliberate choice. It looks ahead just enough to be able to build something within the 2 year timeframe the client has set. Moreover, most of the policy, market and technology shifts that matter here are already funded, already written into law, or already on the market as prototypes. Five years is long enough for those shifts to land, and short enough that the concept work in the Develop phase can aim at them directly. A short outlook section at the end of Step 1 names the bigger pressure that builds after 2031, without asking the design to solve for it. This is where the technologies live that people often invoke when they talk about the future of health (whole-body digital twins, continuous wearable vitamin sensors). These sit far beyond the design horizon. not at its edge. The text below walks through the figure lane by lane, one short subsection per PESTEL pillar. Every claim made on the slide is sourced here.

Step 1. From trends to value drivers (PESTEL scan, 2026 → 2031)

PESTEL (Voros, 2003) is a way of scanning the world along six lenses: Political, Economic, Social, Technological, Environmental and Legal. It serves at the beginning step of future visioning. The scan stays short and serves as a mid-step. Each lens below matches one row on Figure 24 and every claim made there is cited here.

Political (P), what governments have decided

The Political lane has five events worth flagging.

First, by the end of 2026 the IZA (Integraal Zorg Akkoord) requires that 70% of suitable care should be available online or in a hybrid form (Ministerie van Volksgezondheid, 2022). The target was set in 2022. Whether the Netherlands hits it on time is a separate question.

Second, preventative supplementation is likely to stay outside the Dutch basispakket through this horizon. Independer's 2025 review found that 72% of Dutch adults took supplements in 2024, but the basic insurance package only reimburses them in narrow medical cases (a diagnosed deficiency, prescription magnesium, certain pregnancy supplements). Preventative use is not covered (Pothast, 2025).

Third, the LHV Visie Eerstelijnszorg 2030 sets out a 2030 reorganisation of Dutch primary care. Care should relocate toward the GP, the neighbourhood and the home, with a new cross-disciplinary funding title and explicit task-relocation initiatives between secondary and primary care. The Visie is explicit that this happens within existing budget frameworks rather than as a financial shift toward primary care (LHV, 2023)

Fourth, the new EU Multiannual Financial Framework for 2028 to 2034 was proposed by the European Commission in July 2025. Under the proposed European Competitiveness Fund, four target areas include "health, biotech, agriculture and bioeconomy" and "digital transition," and Horizon Europe is proposed at €175 billion (European Commission, 2025). This is a Commission proposal, not adopted law yet, so the framing should be a likely direction rather than a done deal.

Fifth, the Nationale Strategie Vrouwengezondheid 2025 – 2030 was launched on 2 July 2025. For the first time, women's health priorities including menopause became an official Dutch state policy (Rijksoverheid, 2025).

Economic (E), what's shifting in the market and the workforce

The Economic lane has four events worth flagging.

First, the global dietary supplements market is expected to grow from US\$155.9 billion in 2024 to US\$275.2 billion by 2030, at a 10.1% compound annual growth rate (P&S Intelligence, 2025). The category is not shrinking. It is getting more crowded. That is exactly the condition under which it starts to matter whether a brand can stand out by trust and interpretation rather than just by what is in the bottle.

Second, the personalised nutrition and supplements market is projected to grow from US\$15.97 billion in 2025 to US\$48.57 billion by 2033, at 15.03% annual growth (Grand View Research, 2025). The growth concentrates in the part of the market that helps people make sense of their data, not in the part that just sells more pills.

Third, the wearable medical devices market is projected to reach US\$69.62 billion by 2031, at 19.8% annual growth (The Insight Partners, 2024). Consumer biosensing is not hypothetical anymore. The open question is whether the specific signals Silvie cares (specific vitamins etc.) about will be among the ones that reach validated accuracy on a wearable.

Fourth, just past the thesis horizon, the Dutch healthcare system is projected to be short roughly 266,000 workers by 2034 (Ministerie van Volksgezondheid, 2024). This is the underlying reason body-knowing matters at the level of a whole country. The Dutch system mathematically cannot deliver current service levels with the workforce it is projected to have. A shortage of this size means self-directed prevention will be asked of people more often. That is a reason the design has to be worth something to her first, not a reason to move the system's responsibility onto her.

Social (S), how midlife women's lives are changing

The Social lane has four events worth flagging.

First, consumers are getting tired of subscriptions (Deloitte Netherlands, 2026) finds this is partly about the cumulative monthly cost and partly about the cognitive load of managing so many subscriptions at once. For a supplement brand whose typical business model is recurring subscription, this is a real headwind. Future product-service systems will have to earn each renewal rather than assume it.

Second, women aged 55 to 70 will be more digitally literate by 2030. The EU's Digital Decade target is that 80% of adults should have basic digital skills by 2030, and the Netherlands is already among the leaders on this measure (Eurostat, 2025). Their trust in AI for health, however, stays conditional. The University of Michigan's 2025 found that 92% of older adults want to know whether health information comes from a person or an AI, and 46% have very little to no trust in AI-generated information (University of Michigan Institute for Healthcare Policy & Innovation, 2025). The cohort will be more comfortable with the tools and more careful about the source than the stereotype suggests.

Third, by 2030 roughly 1.2 billion women worldwide will be peri- or postmenopausal. The social and cultural relevance of menopause keeps rising, both as a public health priority and as a category in consumer products (Delanerolle et al., 2025)

Fourth, by 2031 nearly 1 in 4 Dutch residents will be 65 or older. CBS confirmed in its December 2025 Kernprognose 2025-2070 that 2025 was the first year in Dutch history with more residents 65+ than under 20, and that share continues to rise (Centraal Bureau voor de Statistiek, 2025).

Technological (T), what's becoming possible (and what is not)

The Technological lane has seven events. The first five sit inside the design horizon. The last two sit beyond it and are included on the slide as a deliberate contrast, because they are often used in industry hype.

First, mail-in blood tests get cheaper. The global direct-to-consumer laboratory testing market is projected to grow from US\$3.99 billion in 2026 to US\$6.48 billion by 2031, at 10.19% annual growth (Mordor Intelligence, 2026). The price point that makes home testing routinely affordable is close.

Second, AI will increasingly help with GP decisions in the Netherlands. The NHG has taken a formal position on the use of AI in primary care, framing it as support for clinical judgement rather than a replacement for it (NHG, 2026). For Silvie this matters because it sets the tone. AI in health is becoming normal in the Dutch system but stays subordinate to the doctor.

Third, from March 2029 the European Health Data Space (EHDS) makes lab results, prescriptions and patient summaries portable across EU member states with patient consent (European Commission, 2026c). This changes the data layer Silvie can build on. A user's records become available to her by law.

Fourth, the way people interact with AI is shifting. Ambient and agentic AI are moving into everyday devices. Agentic AI describes software that takes goal directed action on a person's behalf rather than waiting to be asked. The interaction is moving from apps you open to AI that runs in the background of objects and devices. (Hosseini & Seilani, 2025)

Fifth, at home vitamin and micronutrient testing becomes an optional personalisation layer for nutrition products by 2031. The two pieces converging are direct-to-consumer kit availability and the data infrastructure to do something with the results (Future Market Insights, 2025).

Sixth, just past the design horizon (around 2033), wearables that can read micronutrient status from sweat reach the market. In SQ7 (2.7), multiple technologies demonstrated detection of micronutrient status. However, they remain early research and can not yet reach the market within a 2 year window. Wang et al. (2022) for example, showed real time detection of vitamins B1, B2, B7, B9, B12 and D in sweat, yet it remains early state research.

Seventh, far beyond the horizon (2046+), full-body digital twins for clinical decision-making remain aspirational. The EDITH Consortium's 2025 roadmap for the European Virtual Human Twin describes it as a 10 to 20 year initiative that needs sustained EU funding, common standards and ethical governance (EDITH Consortium, 2025). It is on the slide as a contrast, to make clear that some of the things people invoke when they talk about the future of health are not five year items.

Environmental (En), how packaging law reshapes products

The Environmental lane has six events, all driven by EU regulation.

First, the EU Packaging and Packaging Waste Regulation (PPWR) applies from 12 August 2026 (European Union, 2025). Silvie's sachets, pouches and shipping boxes fall under new design rules immediately.

Second, the EU's directive against greenwashing (the Empowering Consumers for the Green Transition Directive) applies from 27 September 2026 (Directive (EU) 2024/825, 2024). Words like "sustainable," "clean," "eco" or "planet-friendly" will need real evidence behind them. For a brand that leans on trust, this matters more than it would for a brand whose value proposition is purely price or convenience.

Third, Silvie uses marine collagen, omega-3 DHA/EPA and whey protein, ingredients that are increasingly judged not only by their health benefits, but also by where they come from and how transparently they are sourced (Silvie Health, 2026).

Fourth, the EU Battery Regulation requires from February 2027 that portable batteries in products must be removable and replaceable by the end user (Regulation (EU) 2023/1542, 2023). This matters if Silvie ever ships a dispenser, reminder device or connected adherence tool. The design principle is to separate reusable hardware from consumable refills.

Fifth, by 1 January 2030 all EU packaging must be recyclable under PPWR (European Union, 2025). The recyclability deadline gives companies pressure now.

Sixth, by 2030 the EU food-waste reduction targets must be met (European Commission, 2026b). This carries through to how Silvie can source and talk about ingredients.

Legal (L), what regulations now require

The Legal lane has seven events. They draw the edges of what Silvie can claim, sell, and do with AI.

First, from August 2026 the EU AI Act starts affecting AI health-recommendation tools (Regulation (EU) 2024/1689, 2024). Anything that recommends a supplement based on a user's data sits inside that scope.

Second, health claims and medical claims have been legally sensitive in the EU since 2007. The Nutrition and Health Claims Regulation requires that all claims are authorised, substantiated, and entered in the EU Register (Regulation No 1924/2006, 2006). This is not new, but it limits how Silvie can describe what its products do.

Third, from January 2027, marketing claims become a higher-risk compliance area in the Netherlands. The NVWA has tightened its enforcement on online food promotion, which includes supplement claims and influencer marketing (Nederlandse Voedsel- en Warenautoriteit, 2026).

Fourth, from August 2027, AI that is embedded in medical devices and IVDs (in-vitro diagnostics) falls under the AI Act (Joint Artificial Intelligence Board & Medical Device Coordination Group, 2025).

Fifth, the EHDS implementing acts start applying from March 2027, with the first wave of cross-border data exchange from March 2029 and a second wave for medical imaging, lab results and discharge reports from March 2031 (European Commission, 2026a). Each milestone gives Silvie more data to potentially work with, under consent.

Sixth, just past the thesis horizon, the EU Council in December 2025 formally called for harmonised maximum levels for vitamins and minerals in food supplements and fortified foods (Council of the European Union, 2025). The likely consequence is tighter dose caps across the EU in the late 2020s.

Seventh, the open question for the 2046+ horizon is whether EU regulation will ever permit AI to make clinical decisions without a human in the loop. The AI Act currently requires human oversight for all high-risk medical AI (Regulation (EU) 2024/1689, 2024).

Pulling the six lenses together

Policy is moving toward prevention, patient-held data, and women's-midlife-health priority. The supplement market is large and growing, but it is also getting more crowded, and the value is shifting from the product itself to the layer that helps people make sense of it. The target group is demographically dominant, more digitally literate by 2031, but still careful about whether they trust AI for health. Sensing, AI, and ambient interfaces are consumer-ready for general signals by 2031, but not yet for the specific micronutrients Silvie cares about. Packaging law and health-claim law both tighten in the same window. The scan is consistent with the design intent. Silvie can win by becoming the trusted interpretation layer on top of a supplement market that is already there, by staying aligned to GPs and pharmacists, and by being able to stand up to the AI Act and PPWR rules from day one.

A short outlook beyond 2031

Two events sit just past the thesis horizon but matter for the framing. By 2034 the Dutch healthcare system is projected to be short roughly 266,000 workers (Ministerie van Volksgezondheid, 2024). This is the underlying reason the body-knowing posture of this thesis stops being a wellness preference and becomes a system-level need. Further out, the technologies that could in principle do more of the sensing remain research-grade through 2035 and aspirational through 2046+. Naming this gap is an active design argument. The technology is not around the corner. The design therefore has to do the right thing with the signals that are actually available now.

Step 2. The playground

Step 2 is a playground that stress-tests imagined futures and edge cases. It consists of six written scenarios: the key takeaways are kept here as a short list.

The worst possible outcome

Everyday interaction stays invisible and low-interface. Notifications, dashboards and streaks are not more value. The everyday touchpoint should be as small as the job allows.

The worst possible outcome

I wrote the worst possible supplementation service for a woman of 55+, then inverted each bad feature.

The anti-Silvie is one generic "women's daily" pill, or worse yet, a bland bad tasting drink or annoyingly sticky powder that ignores her personal body needs. It's a maximum upsell: unlabelled pills/powders, big marketing claims that EFSA has rejected, an app that shames you when you did not take your supplements, regardless of whether you actually took them or not. Every supplement pill is individually shipped, and shipping is a hassle: the pills arrive too late / not at all half of the time. They are directly dispatched from China, no tracking on the package. Does not fit through the postbus. It's obnoxious packaging too: triple layer cardboard with plastic cover screaming "ANTI AGEING" along with claims on your health. Graphic design screams for attention, logos are everywhere to constantly remind you that you got it from Silvie. The supplements are overpriced, amounts are not noted, it's contaminated with heavy metals, carcinogenics and hormones that make you sick and actually age more. It's just below a threshold where you don't fully notice anything though, making you second guess yourself and just keep taking it. Many attempts and discounts on the website try to lure you in, and without you noticing you subscribed to a twelve month contract with phone only cancellation outsourced to India customer support or a very badly made AI tool, where you are only able to call on Mondays from 6-7 in the morning. Your data is not safe: it's sold to insurers and beauty brands, anyone that can help Silvie turn a profit.

The formulation never updates, no visibility for the GP, many fillers that are not disclosed on the packaging and have interactions with other drugs, becoming a major health risk.

Inversion of the worst

Each of those bad features gives me an inversion. Most of them are predictable. A personal blend based on her actual body rather than a cohort guess. Minimum effective intake rather than maximum upsell. Something she is willing to put in her body: neutral or pleasant, not sticky or bitter. Every pill named, dosed, and traceable to its source, with the amount of each ingredient printed plainly on the pack. Only EFSA-authorised claims on the label. Reminders that are supportive and accurate, not shaming. Reliable Dutch delivery that actually fits the postbus. A transparent, European supply chain with tracking. Pharmacy-grade quality with third-party testing and documented safety margins. Calm, understated branding rather than a box that shouts for attention, and a single logo where it belongs instead of scattered across everything. Fair pricing shown up front. No dark-pattern discounts and no hidden contracts: a month-to-month subscription she can pause or leave with one tap from any channel, at any time of day. Her data stays with her, and she decides what to share. The blend updates when her body or the evidence moves. A one-page summary her GP can see, if she chooses to share it. Full disclosure of every ingredient, fillers included.

Five inversions surprised me, and I keep them as explicit design commitments rather than implicit hygiene. Minimum effective intake. Silvie is explicit about recommending as little as possible, and occasionally recommends nothing. The default industry incentive is to sell more. A product that disciplines itself to sell less becomes trustworthy on contact. Interface-light by default. The industry assumes more interface is more value: more notifications, more dashboards, more streaks, more reasons to open the app. A product that trusts the woman trusts her not to need it shouting at her every day. Silvie's everyday touchpoint is as small as the job allows. Richer views exist when she asks for them, but the default is quiet. Pause as a first-class feature. Subscription businesses hate pause because it hurts retention. A product that believes in the woman's agency has to make pausing effortless, and the effortlessness is itself the legibility of trustworthiness. If leaving is hard, staying does not mean much. "Not for you right now" as a valid outcome. A service that sometimes tells the woman she does not need anything this month, or that something she was taking can stop, is more credible than one that always finds something to suggest. The credibility compounds over time.

Proactive interaction checking. The industry assumption is that supplements are benign enough for drug interactions to be the GP's problem. They are not. A large share of women 55+ already take prescription medication for blood pressure, thyroid, cholesterol, mood, or bone density, and some very common supplements interact with those drugs. Silvie treats interaction checking as her own job, not the huisarts's, and does it before suggesting a regimen rather than after a problem appears. The worst-case above made this impossible to leave out. These five contradict normal supplement-industry incentives, which is exactly why they are worth naming as commitments in the proposition rather than leaving them as implicit design hygiene.

The mandatory medication case extreme

Proactive interaction checking. Many women 55+ are already on prescription medication. Silvie does the supplement-drug interaction check itself (or partners with existing platforms like Examine.com before suggesting anything.

The mandatory medication case extreme

I then imagined a 2031 in which the Health Council's (Gezondheidsraad) vitamin D guideline for women 50 to 70 now receives prescription and insurance reimbursement. Then, it becomes medical: adherence will need to be monitored, non adherence is noted in the patient file, and the consumer becomes a patient.

In this case, the dose is no longer voluntary. The design would shift from "help her decide" to "help her comply." Price would move from her wallet to the insurer's, which is a different business model entirely. The pharmacy would become a channel for sales, not a competitor. She would be a patient, and Silvie would be executing her GP's prescription.

This makes it obvious where Silvie actually can play a role right now. It is not at the mandatory end, where the system has decided for her. Silvie can act where the 55+ woman in the Netherlands still has full agency and low confidence in what she takes.

The extreme also means that whatever Silvie recommends might have to follow what the health Council advises and recognizes as beneficial and necessary: vitamin D for women over fifty, calcium for bone maintenance, B12 in specific cases. All the extra "fluff" and newer science then needs to be fundamentally grounded in science in order to convince people that it could actually be beneficial for them. The question then also becomes: how do you prove this? What suffices as enough evidence for women of this age? The original contribution of Silvie can still partly be the regimen, but it's the interface and interaction that moves a woman from informed but overwhelmed to calm and acting. The job is not necessarily invention of a recommendation, the job is **closure of a decision gap**.

The risky assumption

Every thesis rests on something it has not yet proven. The one assumption in Silvie that, if wrong, would require a full redesign is this: **the 55+ woman wants to understand what she is taking**. The entire evidence-based clarity mindset is built on that. The named pills, the reason on the jar, the dashboard, the traceable sources all presume that understanding is what she came for. What if she does not. **What if the cognitive load of supplement decisions is exactly what she wants the service to lift off her shoulders, and what she calls "clarity" is really "a trusted person decided for me and told me so."**

To make the question concrete: Marianne, 64, retired public prosecutor in The Hague, has had enough of reading things. Her GP has known her for twenty years and she defers to her entirely. If Silvie would send her a dashboard, she would not open it. When Silvie explains why she is taking vitamin K2, Marianne thinks, I do not need to know why, just tell me the jar is empty on Friday and get me a new one. What she wants is a small plain container, or better yet, a magic all in one pill, or no pill at all to swallow. If a pill, then refilled automatically, with her GP's approval. She wants confidence through delegation, not through understanding necessarily. She does not care and prefers to have time for "more important" things.

If Marianne is an example of a larger market share than I assume, then the assumption collapses. Understanding becomes a feature the user filters out. The product that wins is the invisible pharmacy subscription. Silvie would need to pivot from "evidence you can read yourself" to "evidence your doctor has already read for you.". Same underlying mission, very different product.

Riskiest assumption

The riskiest assumption is that the 55+ woman wants to understand what she is taking. One persona flipped this. She does not want to understand. She wants the decision lifted off her. This is kept as a risk to monitor, not as something to resolve.

The anti supplement persona

What if we define somebody who would refuse Silvie on principle?

I call her Hanneke. She is 62, a retired biology teacher from Leiden who cooks from scratch, swims twice a week, and has read more food science for pleasure than most GPs read for work. Her mother took a cabinet full of vitamins every morning and was still diagnosed with cancer at 71, which left Hanneke with a deep belief that supplements are sold on fear. She is not sick, not tired, and not frightened of ageing. She sees the supplement industry as profiting from insecurity, and "healthy ageing" as a marketing category strikes her as a polite way of selling anxiety to women who do not need more of it.

Silvie, from Hanneke's point of view, is another subscription that assumes she is deficient. Above all, she hates "synthetic", mass produced stuff and finds it "unnatural". Nature has led our bodies to evolve in certain ways, and we have been eating food that was grown in the ground or we caught and cooked an animal. "Evidence based" reads to her as protective cover for commerce.

Any more convenient packaging is still packaging she did not ask for. Subscriptions feel like an extra stab in the back in which more and more supplements would be forced down her throat, and money out of her wallet.

The exercise made explicit what I had been leaving implicit: **Silvie's positioning assumes the woman already believes supplementation is a legitimate category**. For Hanneke that assumption does not hold, and no amount of good design can cross it. The useful version of Silvie for her would be an honest one-off audit that could return the answer "your diet is enough, nothing to add." That is not what I am designing. Writing Hanneke down makes my scope explicit rather than pretended universal.

The no motivation persona

The Discover chapter is populated with women who already pay attention to their health. To stress-test the proposition on the other side I constructed one who does not. Annelies, 58, works at a housing association in Utrecht. She eats fins, walks the dog, sleeps fine. She owns no tracker and has no view on magnesium. Her operating assumption is that her GP will tell her if something needs attention, and that supplements are a niche hobby somewhere between crystals and expensive kitchen knives.

Silvie is invisible to her. She would scroll past the ad. If a relative gave her the Silvie packages she would say thank you and shelve it. If her employer handed it out during a health check she would open it once, find it "a bit much," and never return.

Is Silvie for her? In the current framing, no. Silvie assumes the woman is already paying attention and the salutogenic framing assumes she wants to. Annelies does not. Designing around her would dilute the product for the women who are engaged, and the women who are engaged are still a very large group.

Should Silvie be for her. The honest second answer is: perhaps, but only through a relay. The route to Annelies is not a direct-to-consumer message, it is being handed to her by someone she already trusts (GP, daughter, pharmacist, employer). The design question then becomes whether Silvie can hold attention for someone who did not choose her, which is a different product. For this thesis I choose to design clearly for the activated woman and to note, rather than build, the relay path. Writing Annelies down makes the scope decision deliberate.

The anti supplement persona

Another assumption flipped by this persona: the woman already believes supplementation is a legitimate category. Outcome: synthetic is viewed as bad. Products need to be "natural". The most honest thing Silvie can do for the anti supplement person is to tell them that a supplement is "Not for you right now". For the people that do supplement: "there is no recorded reason for this one, worth asking about" (within what the regulations allow).

The ideal picture

What does "good" or "ideal" look like? Every constraint lifted, before filtering out ideas on feasibility, desirability or viability.

Anja, 63 wakes up in the morning, she had an incredible sleep, as all the pillars of her health are perfectly aligned. One pillar is supplementation. On this front. **She does not have to think about what to take, when to take it, or why.**

Continuously, her nutrient status and supplement needs have been monitored, and dosage of any supplement have continuously been entering the bloodstream (in some way) to ensure all her levels are optimal. All the basics and micro deficiencies are covered, and the newest science that is safe to administer, is implemented immediately. Trust is already there, as any medical professional has praised Silvie as the go to solution for preventive health. In fact, Silvie has replaced the GP completely: It has a more accurate picture of her physical wellbeing than any human could have, and knows more science and human compassion than any human could offer her. She goes to Silvie's platform with any questions about her health. She doesn't even have much questions however, because nothing is wrong, and she completely trusts the process.

Silvie will always follow the latest science, and adjust her supplement intake based on her personal data: the more data is gathered daily the better. Silvie integrates with all of it: biomarkers, skin health, X health. Silvie is not only a supplement company, it is also a blueprint on how to live healthily, and Anja follows this blueprint without motivation issues.

Preferably, Silvie owns most sensing technologies, but if not, Silvie integrates with any health sensing technology seamlessly and uses its data to give the best optimisation of Anja's health as possible. The element of choice is gone: the body tells Silvie what is needs, and Silvie gives the solution as invisible as possible. **She trusts and chooses the algorithm over any human, including her own guesses and judgement**. The sensing technologies senses she is about to be sick before she notices anything, and automatically adjust dosage based on this. Matter of fact, whenever she has caught a flu, she bounced back much more easily then she used to in her twenties.

Processing of her data happens safely, completely with her permission, and is integrated and recognized by the Dutch (and any countries) healthcare system as the golden standard. Not only in nutrients is everything aligned: all the other health pillars have a plan: diet and exercise are all perfectly aligned, she simply has to follow along. All these technologies for sensing and autodosing are very well matured, safe, and very effective. The efficacy has been proven in literature, and this has made Anja trust Silvie even more. As she feels sharp, energetic and powerful, she has recommended Silvie to all her friends because she likes it so much.

The system is completely "free" for her: it's in the governments interest to have a healthy population, and this system has caused the population to age healthily and has prevented disease. This value has been recognized and therefore, insurers were very keen to adopt this and government has subsidized everything.

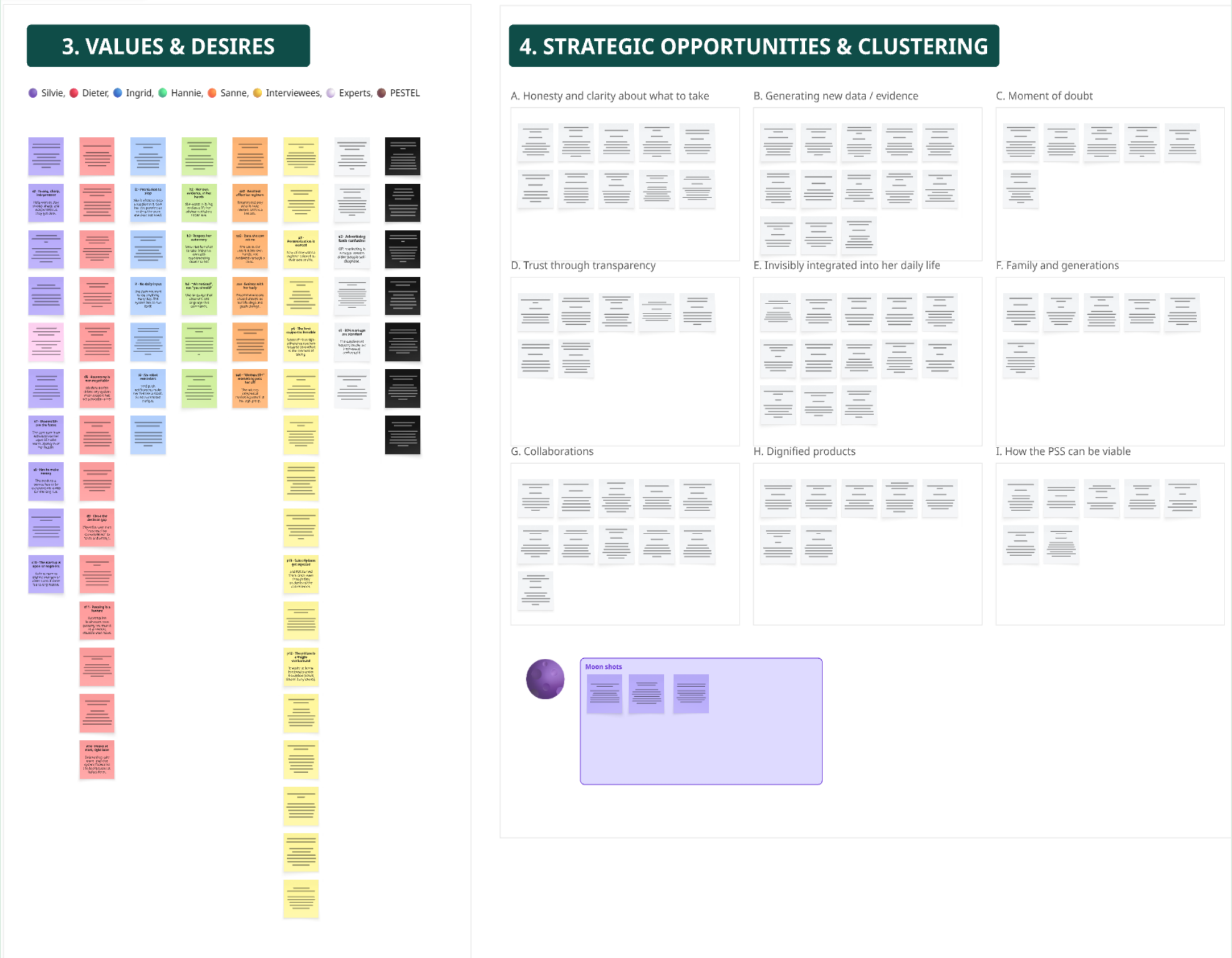
The only choice that remains for her is how much "effort/dedication" she wants to put into her health. Most barriers for her to pick up healthy habits have been removed wherever possible. Without her even noticing it, any plan that Silvie generated has also been made easy for her to follow. Silvie has made a model on her behaviour and can predict at what rate she can adjust, and can track/see her progress.

As Silvie has all this data: it's almost a digital twin of her physical and mental health: therefore it can accurately predict how her body will react to any changes. It's very accurate, and has no trouble keeping her bodu at an optimum. Silvie gets out of her way, and does not hold her attention, she has identified herself as a healthy person and is willing to put in the effort. Silvie provides her with the right steps and makes those steps easy.

The ideal picture

The ideal picture is too far into the future and unrealistic, but here the goal is to strive for a complete digital twin of her so that Silvie can do fitting prescriptions and so that she does not have to doubt. Silvie would integrate fully with Dutch PGO's and read/write data from there.

Step 3, 4, 5: Values → Strategic opportunities / clustering → future vision



3.5. Problem, scope and boundaries

Here, we converge into the problem the design aims to aid in solving, and the scope and boundaries the design has to respect.

THE PROBLEM

Dutch women aged 55-70 who are actively engaged in managing their own health carry a quiet doubt whether what they do for their health works for them. It is a doubt of knowing what their body needs.

The behavioural consequence is visible. Where the information to make a sound judgement is inaccessible (cost, time, effort) or unclear (wrong source, mixed advice, generic guidance), decisions about what to start, continue, or stop default to “baat het niet, schaadt het niet”: if it does not help, it does not hurt.

DESIGN SCOPE AND BOUNDARIES

This thesis does not propose to resolve the full problem. Rather it proposes a focused intervention inside it: a design that creates a specific occasion in her current life where her own observations count as evidence, next to the measurements the design can gather and the supplement decisions she is already making. The scope is set by what Silvie can realistically build and launch in the roughly two-year product cycle.

Functionally, the design consists of a few elements to be given form through ideation in the Develop phase: a periodic moment where evidence is collected and a way of surfacing patterns across her own observations to give her grounded information about her body. Ultimately, she should be able to interpret these patterns and make her own decisions about health interventions and their efficacy.

The instrument behind the evidence moment is deliberately left open here; choosing it is Develop phase work, within the feasibility constraints set by the requirements.

One instrument is scoped out in advance: blood-based measurement. Even though it looks like the most direct answer to her doubt. Consumer finger-prick micronutrient tests would make the product an in-vitro diagnostic under the EU IVDR, with certification demands beyond a two-year horizon. Moreover, both finger prick micronutrient test and mail-in laboratory testing is commoditised, placing Silvie in competition with diagnostics providers. The GPs (E2 and E3) consulted indicated that micronutrient testing rarely needs to happen more than periodically. The cost, the prick, and the postal logistics are real barriers for the user, and steering supplement decisions on blood values tips quickly into medical territory (diagnosing disease), away from the salutogenic position this thesis argues for.

What can be delivered within the constraints of this project is alternative ways of providing evidence (not a verdict) that allows her to judge whether a health intervention works for her or not.

3.6. Design requirements

With the design problem, future vision and scope properly set, the requirements turn them into concrete, testable constraints using the List of Requirements method (Technische Universiteit Delft, 2021). This method is used as without it, there would be no justification for choosing between design proposals. Requirements are classified as demands (must be met) or wishes (used as differentiation criteria when comparing concept proposals). Each requirement is intended to be valid, operational, non-redundant, concise, and practicable.

The requirements are organised along three pillars: Desirability (does it address users’ values and needs?), Feasibility (can it be built and brought to market?), and Viability (will it sustain itself over time?). Each desirability requirement is annotated with its primary 6C salutogenic dimension (Reduces Complexity, Reduces Conflict, Reduces Chaos, Fosters Coherence, Fosters Civility, Ensures Coercion-free).

Within each of the three pillars, cards are sorted by priority for the design (D1 is the most important, colour is darkest). Inside each card is a reference to the evidence from which the requirement was derived (a subquestion from the Discover phase, something a participant has said, a Future Vision regulation or constraint).

3.6.1. Desirability requirements

D1

DEMAND

The product must increase women’s confidence in whether a health intervention works for them or not.

The central problem the product should solve

Coherence

Problem statement

2031 vision

D2

DEMAND

The product must be salutogenic

It focuses on what creates health, rather than purely what is wrong /causes disease. Interactions should be clear and legible (supporting comprehensibility), low in cognitive and physical burden (supporting manageability), and aligned with the user’s own health goals and identity (supporting meaningfulness).

All 6C

D3

DEMAND

The product must feel dignified to the user.

Trust is earned through dignity, especially in a distrusted category. It must avoid clinical, medical and ageing cues and must not feel medicalising.

Civility, SQ5

D4

DEMAND

The product must let the user reach the source and reasoning

The product has rigour: The link from recommendation to source stays inspectable.

Reduces Confusion

SQ1, SQ2, SQ5

D5

DEMAND

The product must show honesty about certainty, proof and patterns surfaced.

Without visible uncertainty the rigour is performative.

Reduces Confusion

Participant interviews

D6

DEMAND

The product must protect her autonomy

Descriptive, not prescriptive: it shows her her own data and leaves the judgement to her, protecting autonomy and staying clear of medical advice. It does not make decisions for her.

Coercion-free

SQ4, SQ5

W1

WISH

The product should make the user's progress known to her

A record she can look back on vs one moment in time.

Coherence

W2

WISH

The product should fit an existing moment or ritual in the user's life.

Existing-cue anchoring is the strongest adherence finding.

Coherence

W3

WISH

The product should match the cadence at which the user is able and motivated to interact with it.

Respecting her natural rhythm, daily or not. Hard to test.

Coercion-free

SQ4, SQ6

W4

WISH

The product should be considered burdenless enough that the user willingly keeps using it over time.

It should not become another chore. Motivated daily input is welcome.

Reduces Complexity

W5

WISH

The product should require as little digital literacy as possible to understand and use.

Accessibility for this group

Reduces Complexity

C5

CONSTRAINT

The product must be single handed operable with readable typography and low force interactions for women 55-70

Demographic

GPSR

3.6.2. Feasibility requirements

W6

WISH

The product should be able to adapt and grow with her over time

Allows for extension to other health pillars without being rebuilt.
Allows for personalisation.

Coherence

Future visioning

W7

WISH

The product should remain on the wellness side of the EU MDR.

Client preference, not a hard line: medical-device classification is acceptable if the evidence justifies it.

MDR 2017/745

Client preference

W12

WISH

The product should be feasible to produce and bring to market within about two years.

Client preference.

Client preference

C1

CONSTRAINT

Stays within the EU AI Act low risk tier: any AI is assistive, explainable, logged, human reviewable.

Reg. (EU) 2024/1689

C2

CONSTRAINT

Privacy by design under GDPR Article 9: explicit consent, minimised collection, local-by-default storage, user control over sharing.

GDPR

C3

CONSTRAINT

Uses only EFSA-authorized wording for any claim about a supplement's effect.

Reg. (EC) 1924/2006

C4

CONSTRAINT

Safe physical product for older adults, with a risk assessment that explicitly considers 55-70 users.

Reg. (EU) 2023/988 (GPSR)

3.6.3. Viability requirements

W10

WISH

The product should remain adaptable for the next, more digitally comfortable cohort of users.

The 55-70 of five years from now is more digital.

Coherence

Future vision

EHDS aware

W8

WISH

A general practitioner should regard the product as serious and credible.

Civility

Future visioning

IZA

W9

WISH

The product should augment healthcare professionals

A fitting solution next to the healthcare she has access to. It does not compete or overrule, it bridges.

Civility

E1, E2, E3

W11

WISH

The product's cost to the user should be defensible relative to the benefit she receives.

The test is willingness to pay for the benefit.

P01, P06

viability

4

Develop & Deliver

This chapter covers the Develop and Deliver phases. It opens with ideation and the convergence on three concept candidates, and with the Weighted Objectives Method used to choose between them. The candidate carried forward, a wall clock for the bedroom or kitchen, was built as a working prototype and evaluated with participants and a general practitioner. It failed. One question in the session showed that everything it offered could live on the phone. That failure is where the problem gets restated, and the chapter follows the turn from a clock that reports to a pendant that confirms. It closes with the prototypes built to answer what was still open, and with the final design of the Silvie Pillar and the service system around it.

The Discover phase closed with a problem framed around supplementation: women of 55 and older want to do the right thing for their health, doubt whether their choices work, and lack trustworthy, personal feedback. The Develop Phase exists as to develop ideas and deliver them to the stakeholders involved. Requirement-making and ideation started from that framing. However, through interviews and co design, the framing shifted twice.

Methodology for the Develop phase

The Define phase converged to a future vision, a single problem and a list of demands and wishes with a constraints checklist. The Develop phase is set on diverging and opening up ideas to solve the problem through the Lotus Blossom Method (Digital Society School, 2026) and How To's (Technische Universiteit Delft, 2021), before it converges on a solution through the weighted criteria method (Technische Universiteit Delft, 2021). The list of requirements, future vision, and participant feedback acted as a guide in validating and choosing the final design.

4.1. Ideation

The sections below present the ideation here as a sequence, but the process itself ran in cycles: ideation returned repeatedly to the problem statement, the requirements were revised several times along the way and framings were checked and co-created with participants.

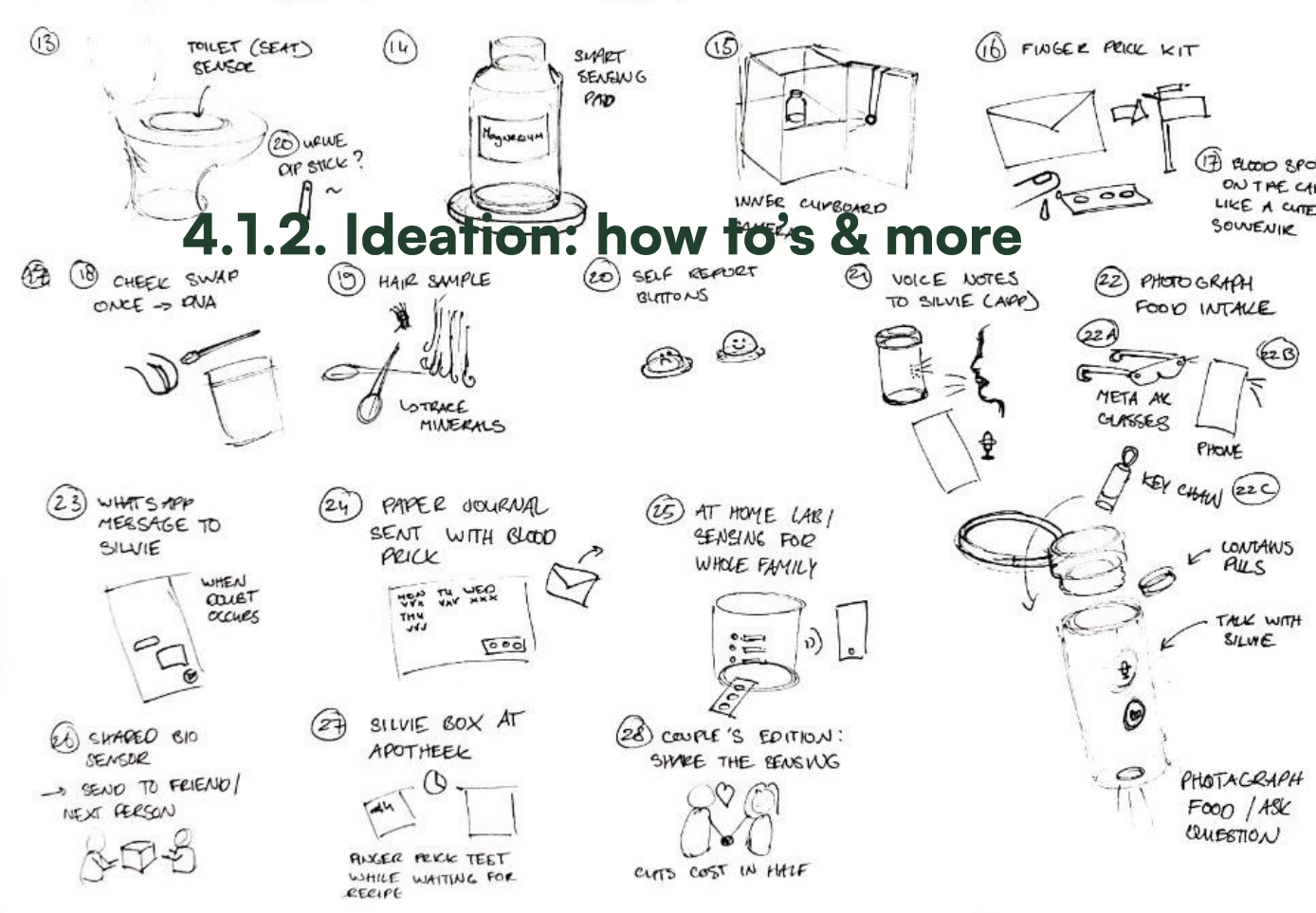
4.1.1. Ideation: Diverging with the Lotus Blossom

To ideate how we can solve the problem, the Lotus Blossom methods was used: the problem at the centre, surrounded by eight themes, each theme expanding into eight sub themes. The resulting 64 cells were reduced to 26 ideation questions and prioritised into three tiers, separating concept defining questions (whose answers change what the artefact is) from implementation questions. This prioritization was supported by an early pass over the ideation themes together with the client. This resulted in three tiers of prioritization, with each tier less concept defining. Tier 1 holds seven ways of solving (part of the) problem. These were reformulated in how to's to ideate on.

T1 1. Teach her what to notice/pay attention to in her body	2. Give her vocabulary for body signals (mood, energy, sleep)	3. Help her tell signal from noise in body sensations	1. Hold an annual review on her birthday	2. Send a Sunday card each month with one reflective prompt (e.g. 'What has your body been telling you this month?')	T1 3. Anchor self observation ritual to existing habit and/or supplement taking moment	T1 1. Own insights have the same status / weight / seriousness as biomarkers	T2 2. Ask what she noticed before showing any data	3. Include her observations as valid data in any conversation with healthcare professionals
T3 4. Daily short prompts (energy today?, sleep last night?, what feels good?)	A. BUILD HER BODY LITERACY	5. Send weekly tiny lessons on reading her body	4. Hold a quarterly coach call with a human	B. BUILD RITUALS OF SELF OBSERVATION/REFLECTION	T1 5. Pause at the moment supplements are empty: refill or not?	4. Keep both her view and the data, if they differ (find reasoning for this together with her)	C. VALIDATE HER OBSERVATIONS / INSIGHTS	5. Use language: you noticed X, the data shows Y
6. Guide embodied awareness exercises (body scan, breath, meditation)	7. Share case studies of other women interpreting their bodies	T3 8. Show her how to recognise patterns over months	T2 6. Hold a pre decision conversation before any health change	T1 7. Facilate reflection / observation (journaling, voice notes etc) periodically on your own health (progress)	T3 8. Give her a list of her observations for apotheek/GP/expert visits	6. Let her revise her own observation framework annually	T3 7. Observations + biomarkers same chart	8. Name felt evidence as a real category alongside measured
T3 1. Give opposing context when ads/false marketing reaches her	2. Collect and present trusted options so she does not have to research	3. Show transparency on why any product is recommended	A. BUILD HER BODY LITERACY	B. BUILD RITUALS OF SELF OBSERVATION/REFLECTION	C. VALIDATE HER OBSERVATIONS / INSIGHTS	T1 1. Measure the body (Test blood, sweat spit, HRV, sleep, temperature etc)	T1 2. Surface patterns (both of measured data, and link between measured and own observations)	T2 3. Capture functional measures (grip strength, sit stand, gait speed)
T3 4. Simplify: the fewest supplements for the desired outcome	H. REDUCE WELLNESS NOISE	5. Cross reference against research databases such as ConsumerLab and Examine.com	H. REDUCE WELLNESS NOISE	PROBLEM: Dutch women aged 55-70 who are actively engaged in managing their own health carry a quiet, persistent doubt about their own ability to know what their body needs. OPPORTUNITY: Not only giving her the information necessary to make a sound judgement: help her re-trust her own knowing of her body.	D. PAIR HER OBSERVATIONS WITH MEASURED DATA	4. Compare to previous results (over time) / baseline	D. PAIR HER OBSERVATIONS WITH MEASURED DATA	T3 5. Explain each biomarker in plain language (comprehensibility)
6. Hold an annual review on what did not work for her	T2 7. Provide opportunities to stop taking something / doing a health intervention that is not really working well for her	8. Use trust signals labels tied to actual evidence (NZVT, GMP etc.), and / or educate on what these labels actually mean	G. OFFER BEHAVIOURS, NOT PILLS	F. CONNECT DECISIONS TO HER VALUES	E. SURROUND HER WITH PEOPLE WHO LISTEN	T3 6. Show honesty about certainty/proof: (for example visual confidence intervals not single numbers)	T3 7. Gather other health data / integrate with other health platforms: Google/Apple Health, Fitbit, PGO etc.	T2 8. Add a "what does this NOT tell you" sidebar to every view
T2 1. Nudge a lifestyle change before any new supplement (from other (more important) health pillars: sleep, diet, exercise, mental health (social))	2. Offer a 30 day (or other amount of time) stop trial	3. Recommend / facilitate resistance training and protein intake	T2 1. Clarify her values in onboarding (what does ageing well mean?)	2. Periodically revisit values (twice a year?)	3. Frame each decision against her stated values	1. Offer a monthly / on demand human coach call	T1 2. Give her an artifact so that she can share her own observations comprehensibly with a health expert	3. Have an expert periodically review her observations and her psychological state, not just the data.
4. Bundle / promote diets (mediterranean/ MIND)	G. OFFER BEHAVIOURS, NOT PILLS	T3 5. Plan habits --> getting rid of major bad habits first, before adding new habits	4. Support her identity work for this life stage	F. CONNECT DECISIONS TO HER VALUES	5. Prompt: what does "mijn gezondheid is eindelijk van mij" mean to her?	4. Provide community: a peer group of women going through the same challenges, buddies etc.	E. SURROUND HER WITH PEOPLE WHO LISTEN	5. Involve family/partners: make shareable summaries / do couples challenges / couples support / involve daughters
6. Suggest "sense of purpose" practices (journaling, mentoring)	7. Suggest / facilitate (yoga, breath, walking)	8. Built in rule: try one habit before one pill	6. Bring the future / prediction consequences of her decision to the now. Be a realistic mirror of her behaviour. Teach her to think in long term behaviours.	T2 7. Connect each decision to Antonovsky's sense of coherence: does it make sense (comprehensible), can she do it (manageable), does it matter for her (meaningful)?	8. Surface when a decision conflicts with her stated values	6. Light WhatsApp (or other platform) check ins from Silvie	7. Pair her intergenerationally (with younger person / older person)	8. Run Silvie ambassador program (women teaching women)

Figure 26. Lotus Blossom method

HOW MIGHT WE CAPTURE EVIDENCE? 2

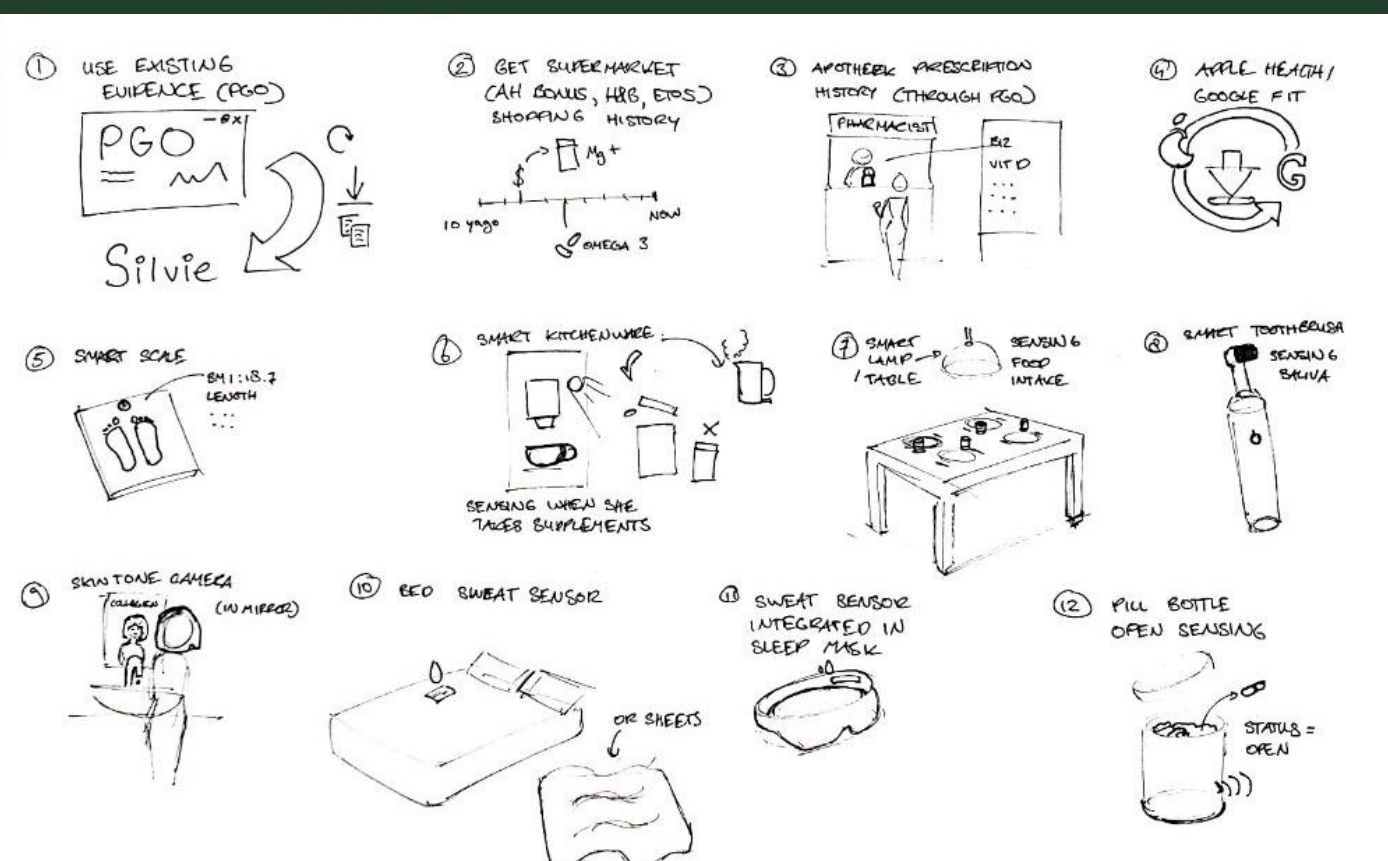
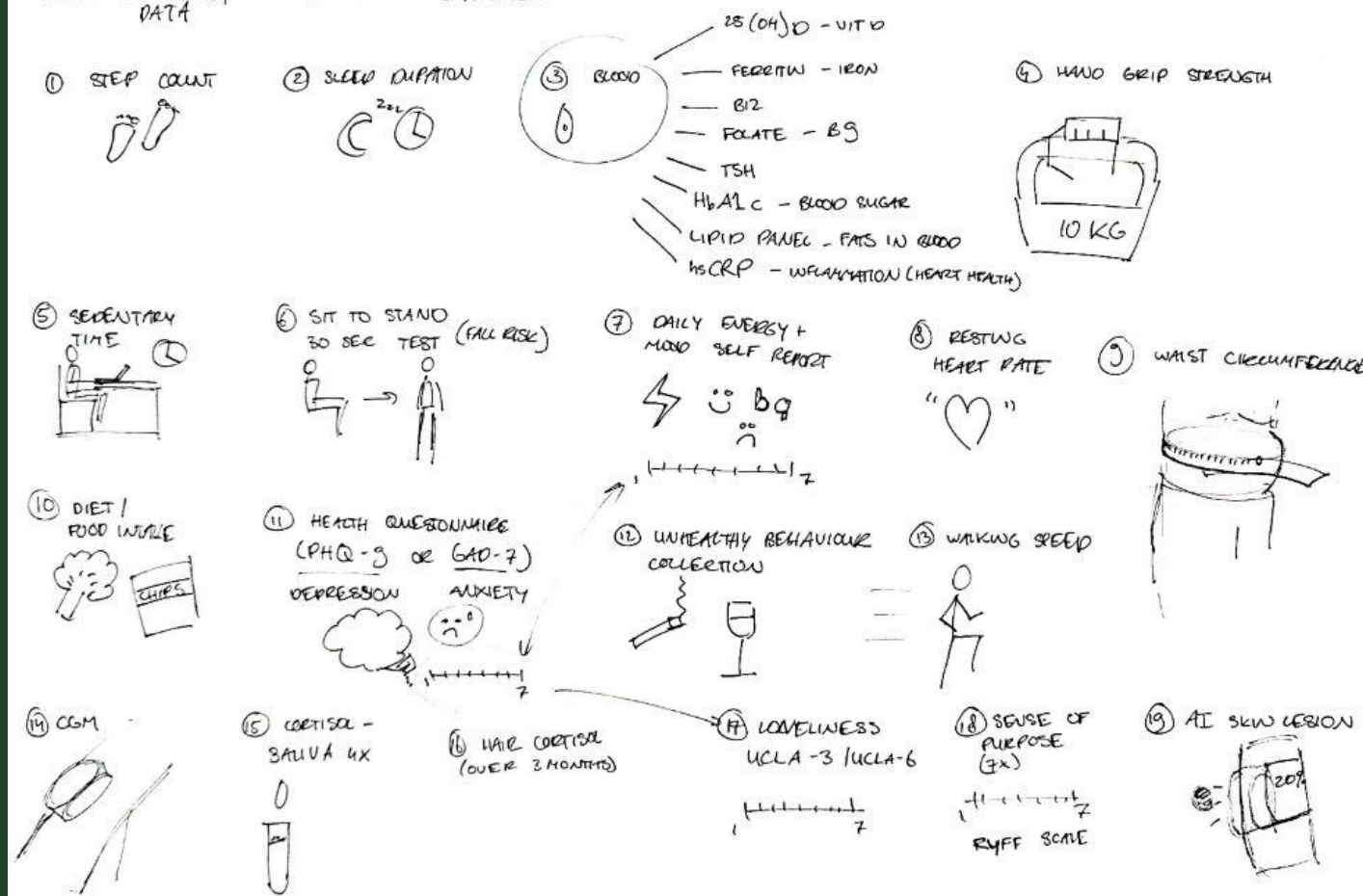


4.1.2. Ideation: how to's & more

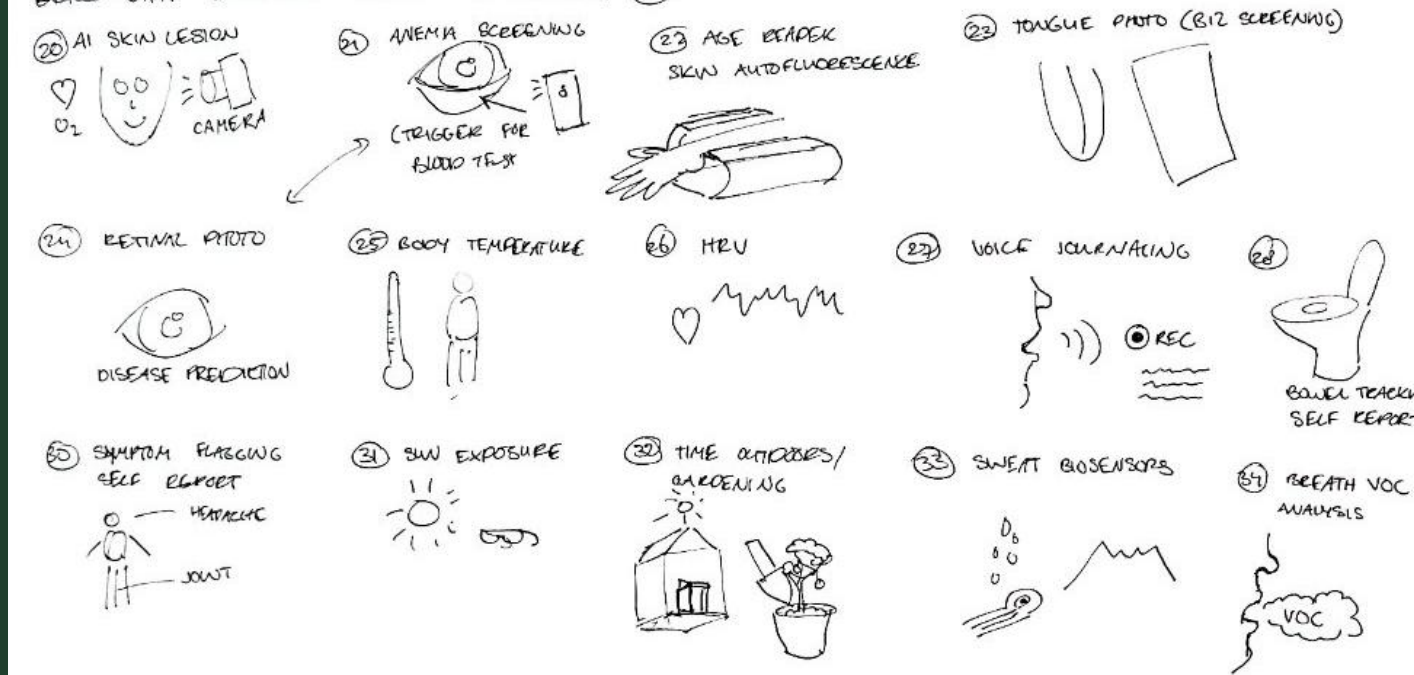
Each tier 1 question was shaped into a "how to" and received its own ideation, each assisted with roleplay through her day or analogies with existing products. Quick desk research fed where ideas needed grounding: which measures matter most for women aged 55 to 70 and at what cadence, which daily habits the participants themselves named as anchors, and what alternative sensing for vitamin D and B12 can and cannot do. Each tiny research sprint followed with picking ideas worth carrying forward.

How to's... & more

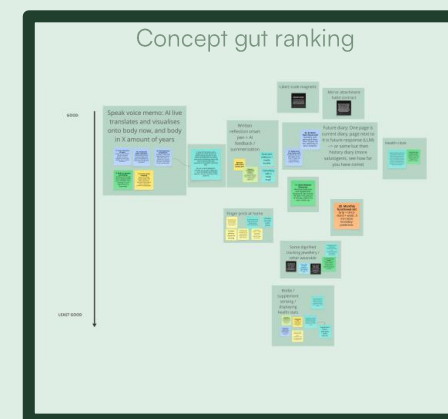
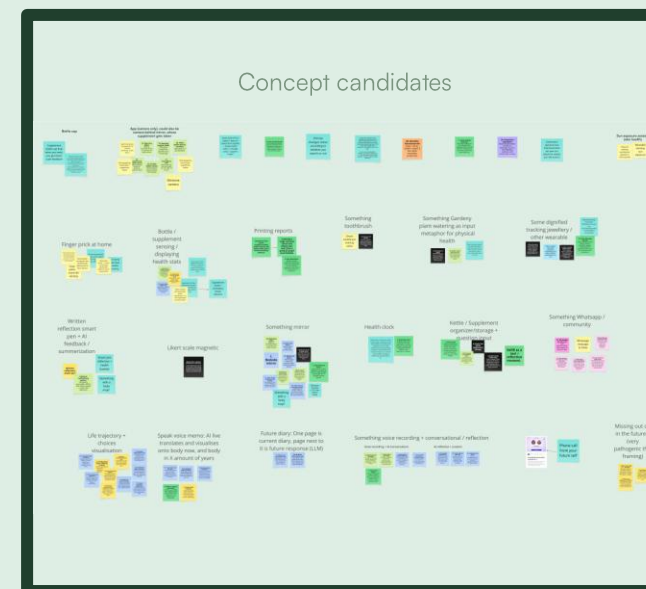
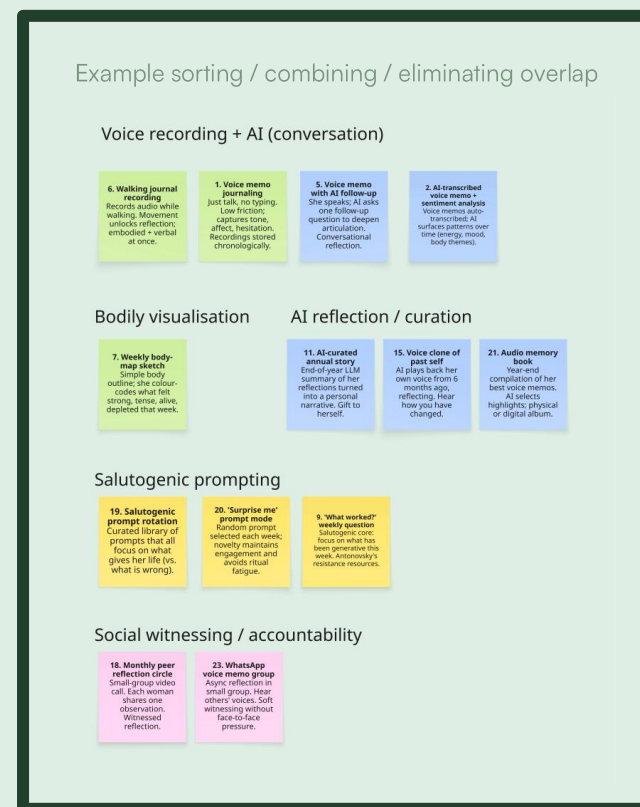
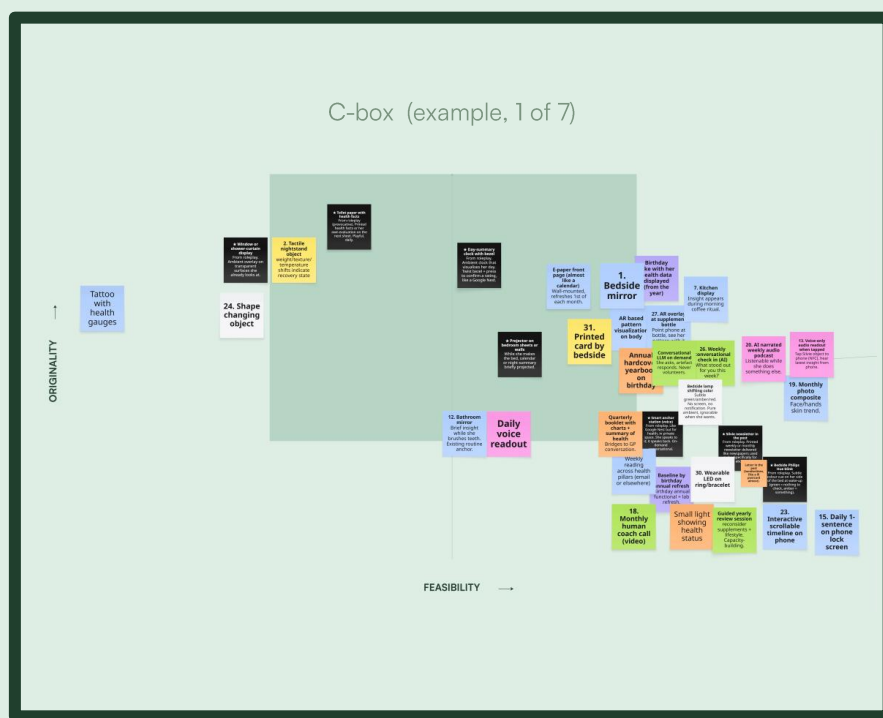
WHAT EVIDENCE/ IS USEFUL TO GATHER?



WHAT EVIDENCE IS USEFUL TO GATHER? (2)



4.2. Converging on concept candidates



WOM

Some of the how to's ideas were eliminated by logic, some of them were chosen through a C-box (Technische Universiteit Delft, 2021) in which the ideas were sorted on originality against feasibility. Those ideas in the "green zone" were then selected to be clustered.

These "green zone" ideas (per how to) were clustered on similarity / or early indication of a concept feature.

From all how to's, different ideas were clustered together into concepts candidates

The concepts received a gut feeling ranking from good to bad. From those ideas eliminated, the plusses, minuses, and interesting elements were preserved (PMI method, (Technische Universiteit Delft, 2021)). These could later be integrated into other concepts. In parallel, the weighted objectives method as a more methodic concept selecting tool, which narrowed final concepts down to 13.

4.3. Concept selection with the Weighted Objectives Method

To evaluate the 13 concepts left from previous converging, the weighted objectives method was used (Technische Universiteit Delft, 2021). Here, we compare concepts by giving each design requirement weight, and scoring the concept on each requirement. The concept was scored against six demands and twelve wishes created in Chapter 3. The weights sum to 100, with the demands carrying 60 points and the wishes 40. Every concept passes the constraints described in section 3.6 Scores run from one to ten and express best case potential: a concept is judged on what it could become, not on how far it is worked out today. Table 9 holds the full matrix with all scores and weighted totals. The 60 points on the demands and 40 on the wishes follow the status of the two classes in Chapter 3, where a demand must be met and a wish only separates proposals. Within the demands the points descend with the priority order of the requirement cards, from 14 on D1 down to 8 on D5 and D6. The weights are a judgement about relative priority. They were set before scoring, and applied to all 13 concepts. The weighting was shown to the client as the reasoning for which concepts to carry forward.

Table 9. Weighted Objectives

ID	Requirement	Weight	C1a Sensing platform	C1b Display on bottle	C1c Packaging display	C2 Likert slider	C3 Mirror contract	C4 Soma Clock	C5 AI diary	C6 Body- map reflection	C7 Body Atlas (pen+booklet)	C8 Bedside dispenser	C9 Functional Kit	C10 Finger- prick test	C11 Wearable jewelry
D1	Quiets her doubt about knowing what her body needs	14	4	6	6	3	3	8	8	6	8	3	7	9	7
D2	Works salutogenically: it focuses on what creates health	11	5	6	7	6	7	9	8	6	9	4	8	4	6
D3	Feels dignified	10	8	5	8	6	6	8	9	7	9	3	7	2	8
D4	Source and reasoning reachable	9	4	6	6	5	6	7	8	8	7	4	8	9	5
D5	Honest about certainty, proof and patterns	8	3	8	7	5	4	8	8	7	8	3	6	9	4
D6	Protects her autonomy	8	4	4	6	6	5	8	7	8	9	3	7	5	4
W1	Makes her progress known to her	5	7	8	7	9	8	9	10	8	9	7	8	7	9
W2	Fits an existing moment or ritual in her life	5	8	8	6	8	7	8	6	5	7	8	5	3	7
W3	Matches the cadence she is able and motivated to keep	3	8	7	6	7	5	10	6	6	4	7	4	5	8
W4	Burdenless enough to keep using over time	3	9	9	8	9	5	8	8	8	3	8	5	7	9
W5	Needs little digital literacy to understand and use	3	8	7	9	8	6	7	6	5	6	6	6	5	7
W6	Adapts and grows with her over time: allows other health pillars s / personalisation	5	4	3	6	5	9	9	9	8	8	3	6	7	5
W7	Stays on wellness side of the MDR	3	9	8	9	9	9	9	4	6	9	7	7	3	8
W8	Producible and launchable within about two years	3	6	5	8	7	6	7	5	5	7	5	9	3	4
W9	Adaptable for the next, more digital cohort	2	7	7	6	7	6	8	8	7	6	6	7	7	8
W10	A GP regards it as serious and credible	3	5	7	6	4	3	5	5	7	7	6	9	7	4
W11	Easy for a healthcare professional to review her regimen (when consented to)	3	6	7	6	5	4	7	8	9	9	5	8	9	5
W12	Cost defensible relative to the benefit she receives	2	8	4	8	8	8	6	3	5	4	3	8	4	5
Weighted total (max 1000)		100	561	617	678	588	567	799	755	679	775	440	701	607	619
Rank (1 = best)			12	8	6	10	11	1	3	5	2	13	4	9	7

Highlighted columns = chosen concepts: C4 Soma Clock (health clock), C7 Body Atlas (pen + booklet), C9 Functional Kit

The top three results sit close together. The Soma Clock, an ambient clock face that quietly shows the rhythm of her day, ranks first at 799. The Body Atlas, a guided reflection booklet written with a smart pen, ranks second at 775. The AI diary, a paper diary that writes back to her with an evidence anchored response, ranks third at 755. Here, changing one factor on a heavily weighted requirement moves a total by a lot of points. So the top contenders are all very close. Therefore, the top contenders are selected on what makes them different.

The Soma Clock is selected as its evidence moment is mostly passive (the user does not have to write or measure anything for it to work). The Body Atlas is selected as well. The AI diary is not selected as a separate concept, because both of its working mechanisms, the reflective written record and the written response, already live inside the Body Atlas. Selecting both would test the same mechanism twice.

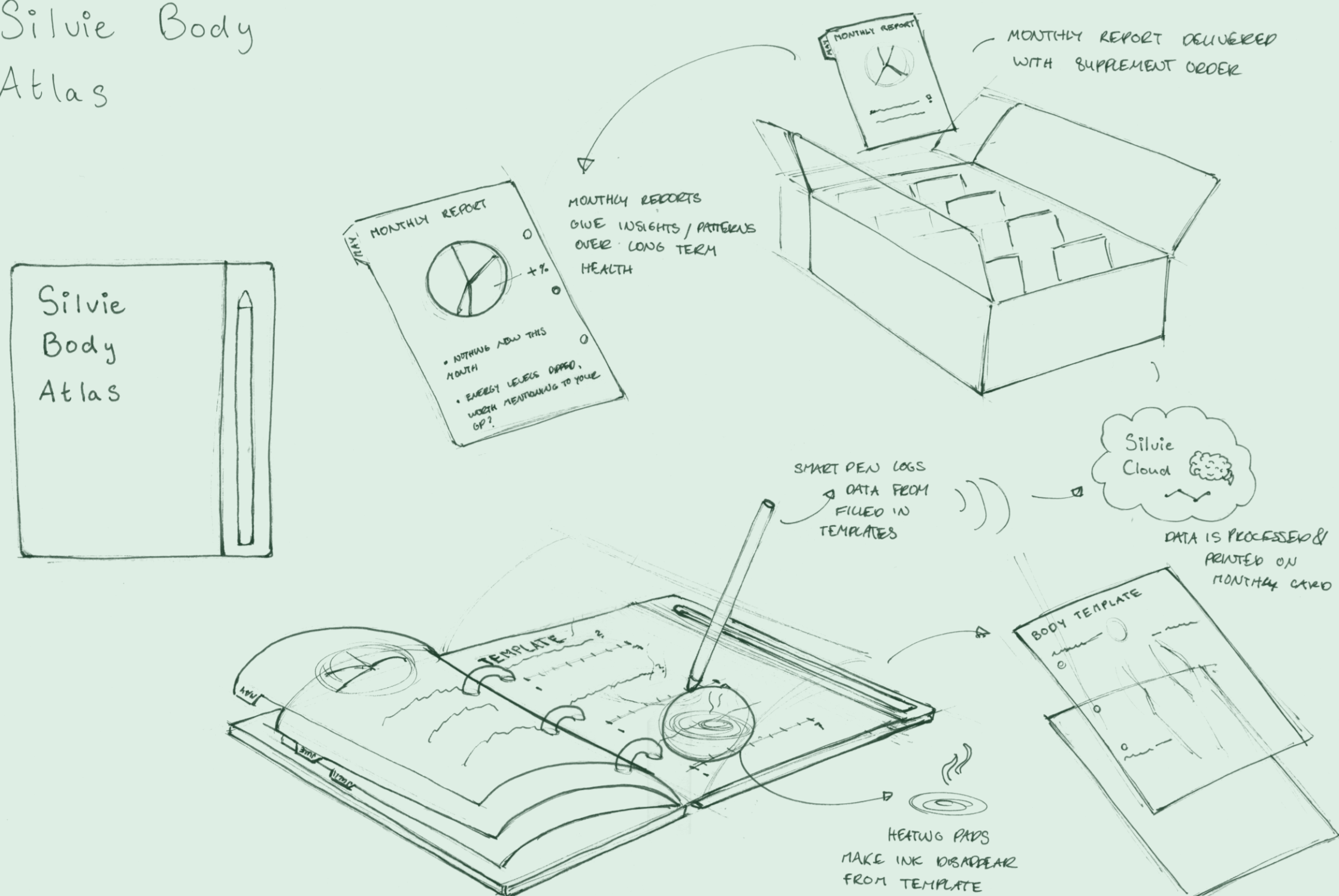
The Functional Kit, a set of simple physical self-tests such as grip strength, ranks fourth at 701 and is selected as the third concept.

The weighted objectives method narrowed 13 concepts to a short list. D1 carries 14 points, so one point of score on that row moves a total by 14, against a gap of 24 between first and second. That is not a stable enough margin to select on. What separated the three carried forward was the effort the user would have to put in order to receive evidence.

4.4. The three concepts

4.4.1. The Silvie Body Atlas

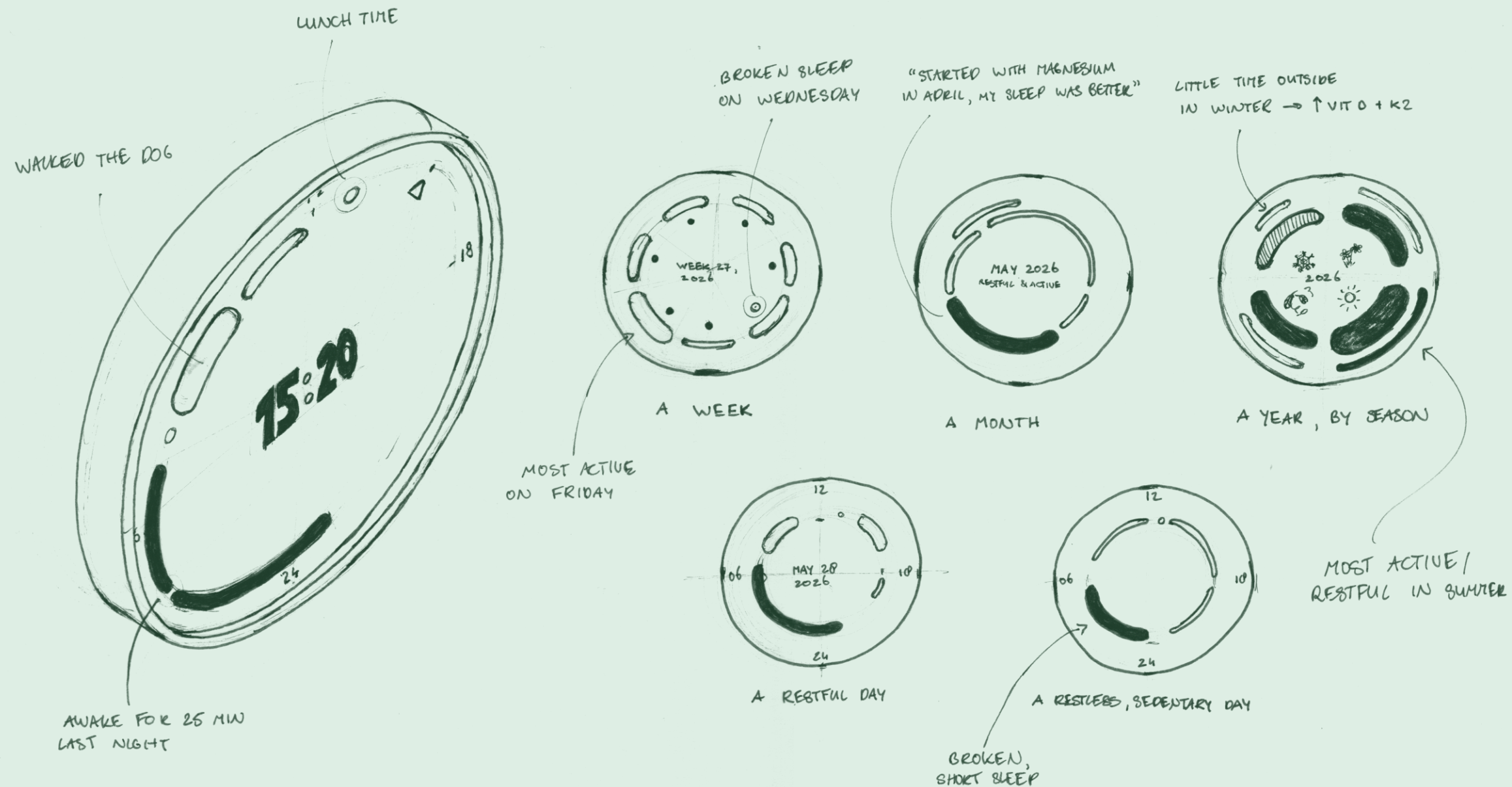
Silvie Body
Atlas



A small booklet she keeps over time: short wellbeing check-ins, reflection prompts, and signs of common deficiencies. She fills in a page in her own handwriting; the accompanying pen records what she writes without asking anything digital of her. With her next Silvie shipment, a small printed page comes back showing the shape of her health over the past period. The Atlas treats her own observations as a primary data source with the same status as measured values, builds the verify capability through evidence she produces herself, rides the delivery rhythm Silvie already has, and grows into a record she keeps for herself or brings to her GP when something looks worth discussing. The record belongs to her, on paper, with the intelligence in the page that comes back rather than in a screen.

4.4.2. The Silvie Soma Clock

SILVIE SOMA CLOCK

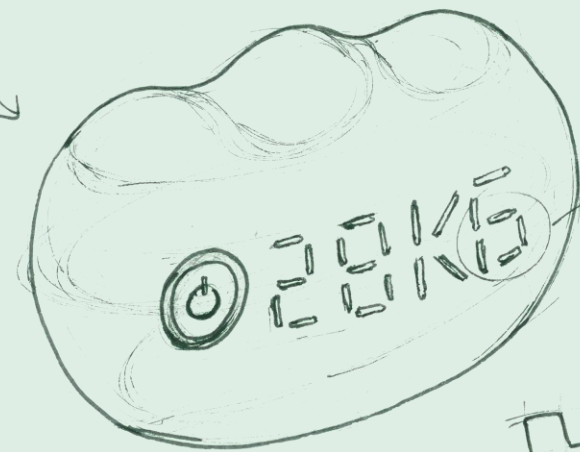


A clock for the bedroom or kitchen wall that passively shows how she has lived, on a 24-hour face: long stretches of sitting, how she slept, time spent outside, with views across the day, week, month, and year. The data comes from her phone and the devices she already owns, so there is nothing to log for the user; the clock integrates data from existing services such as Apple Health. The guiding idea is that it is a calm, ambient object in the home rather than one more screen asking for attention. It makes the evidence moment ambient, and it shows without judging or notifying.

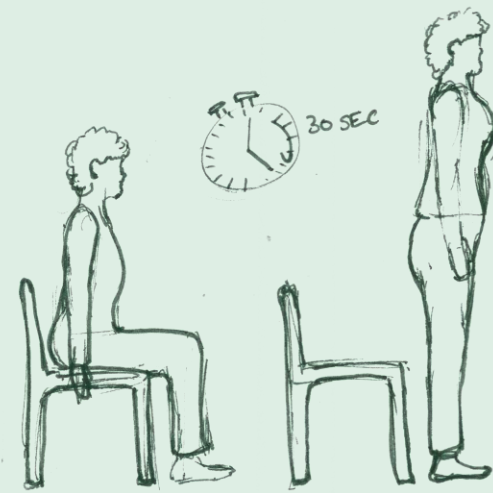
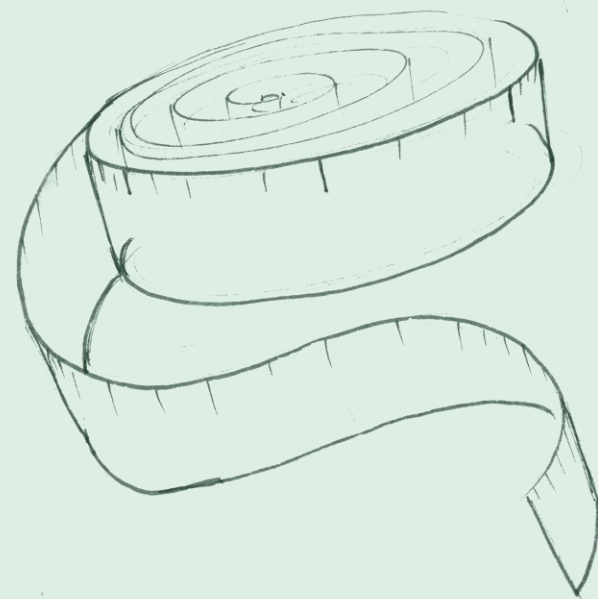
4.4.3. The Silvie Monthly functional measurement kit

MONTHLY FUNCTIONAL MEASUREMENT KIT

GRIP STRENGTH



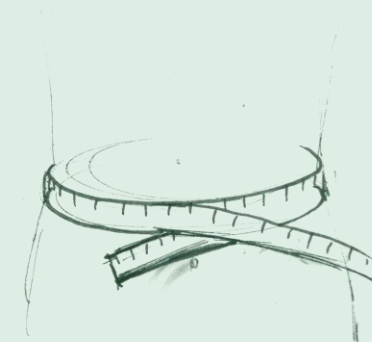
DISPLAYS STRENGTH IN KG



SIT TO STAND - 30 SEC



GRIP STRENGTH



WAIST CIRCUMFERENCE



A short monthly check, occupying around three minutes of time. It includes the tools necessary to do functional measures of how the body is holding up with age: grip strength, the sit to stand test, and waist circumference. These are the capacities Silvie's supplements and exercise plans are meant to support, so the Kit makes those claims testable with evidence she produces herself, at home, at no clinical cost. This is the evidence layer without blood measurement. Here, progress becomes visible and stopping or changing something could gain a more credible basis than having no information whatsoever. It is not a diagnosis, but a measure of function. Therefore, it stays deliberately on the wellbeing side of the medical line.

4.5. Concept evaluation and selection

The three concepts were taken back to users and to the client before one was carried forward. Five participants provided feedback on which (if any) spoke to them the most, and what they would change.

A pattern split by age. The older participants preferred the reflective Body Atlas and, tellingly, wanted room in it for their own notes, recording how major life events such as the loss of a friend had shaped their health. Younger participants divided between the monthly functional kit and the Soma Clock. Across the five who expressed a preference, two chose the Body Atlas (both older), two the Soma Clock, and one the functional kit. None rejected the others outright; each could see herself using more than one. Something the participants noted was keeping up motivation over time. Of the functional kit, one noted, “I would be less motivated if I saw I was declining, but I would still do it out of curiosity.” Of the Soma Clock, participants asked where the clock would get its data from. Upon explanation that the data is drawn from the user’s own phone with their permission, there was acceptance.

The client evaluation reinforced the direction. All three concepts were seen as viable. The functional measurement kit was judged the easiest to realise as it was simply a collection of already existing tools (dynamometer and a body measuring tape). This concept was therefore parked as something that can be added at any time rather than the thesis design. The way in which the Body Atlas’s collected participant reflections / filled in templates was considered unnecessarily costly, and cost and use of technology could not justify the added value over alternatives. From participant feedback, the added value was a physical interaction rather than an app, regardless of its faster feedback. The client also asked to weigh a dignified smartwatch for older women, yet upon considering his suggestion, the Weighted Objectives Method placed it below the leading concepts. Moreover, beyond the scoring, Silvie would be competing directly against established brands such as Apple, Samsung, Garmin or Google.

The Soma Clock was chosen, on one condition (by the client): that the data it would need can actually be obtained. Gathering the data is possible through the user’s phone through Apple HealthKit / Android Health Connect, requiring a one time setup in a Silvie app that the user then never has to touch again. The disadvantage is that to gain insights for metrics such as sleep, the user would need other smart devices that work with Apple HealthKit or Android Health Connect.

Most importantly, when considering the downsides that could not easily be designed away from each of the concepts, the most important deciding factor between these concepts was the user’s long term motivation to use; the Soma Clock was the only concept that did not require active data input by its user, thereby not relying on motivation to collect data.

4.6. Soma Clock Concept desirability validation

This chapter describes how the desirability of the concept was tested. This includes the salutogenic voice and display: “you’ve done enough”. It tested the framing and narrative of the concept and its reason to exist: whether or not potential future users saw the added value above existing market solutions. Moreover, here, we validate the design of the interaction and tested it against the requirements set up in Chapter 3. The concept was tested with 4 women and one general practitioner (huisarts).

What the evaluation tested

To obtain the findings, semi structured interviews were done of which the research protocol is described in Appendix N. The participant thought aloud and gave their critique on prompts, along with pre/post questionnaires on agency and grip on health (all formulated to test the design requirements).

Wizard of OZ prototype

A wizard of OZ prototype was made to validate the interaction with the concept. The functional prototype consisted of 9.7-inch e-ink panel (Inkplate 10) driven to display the prepared clock faces, in a printed housing sized so the round face reads as a wall clock rather than a screen. The faces are switched manually Wizard-of-Oz style through the connection with a laptop. The different faces shown, with feedback by the participants can be found in *Figure 29*.

Clock system architecture

The clock displays three rings: Daylight, Movement, and Sleep (from inside to outside). Meant to be hung up in the home, users could get a day, week, or month overview of these metrics, as a sort of reflection of their day. The clock senses nothing itself. The signals it shows, movement and sitting, sleep, and time spent outside, are read from the user’s phone through Apple HealthKit on iOS and Android Health Connect on Android, with explicit permission. Time outside, is inferred by combining leaving the home Wi-Fi and geofence, the phone’s activity recognition, GPS location, and the weather service’s UV index for the hour and location. This has been done before by apps such as Sola (App Store, 2026). And if one owns an Apple watch, a more accurate “Time in Daylight” exists. A small Silvie app handles a one-time setup and granting of permissions, after which the user never has to touch it. Nothing is recorded on the device, and the clock describes only.

Wizard of OZ prototype

Alongside the clock, a set of written framings of the problem was put to participants (on Miro), to find which they recognized themselves in. The one that landed with almost all of them was a life spent caring for others, with their own health taking a lower priority as a result. It is read here as how they explain the gap between knowing and doing rather than what causes it.

Figure 27. Participant filling in post session sheet.

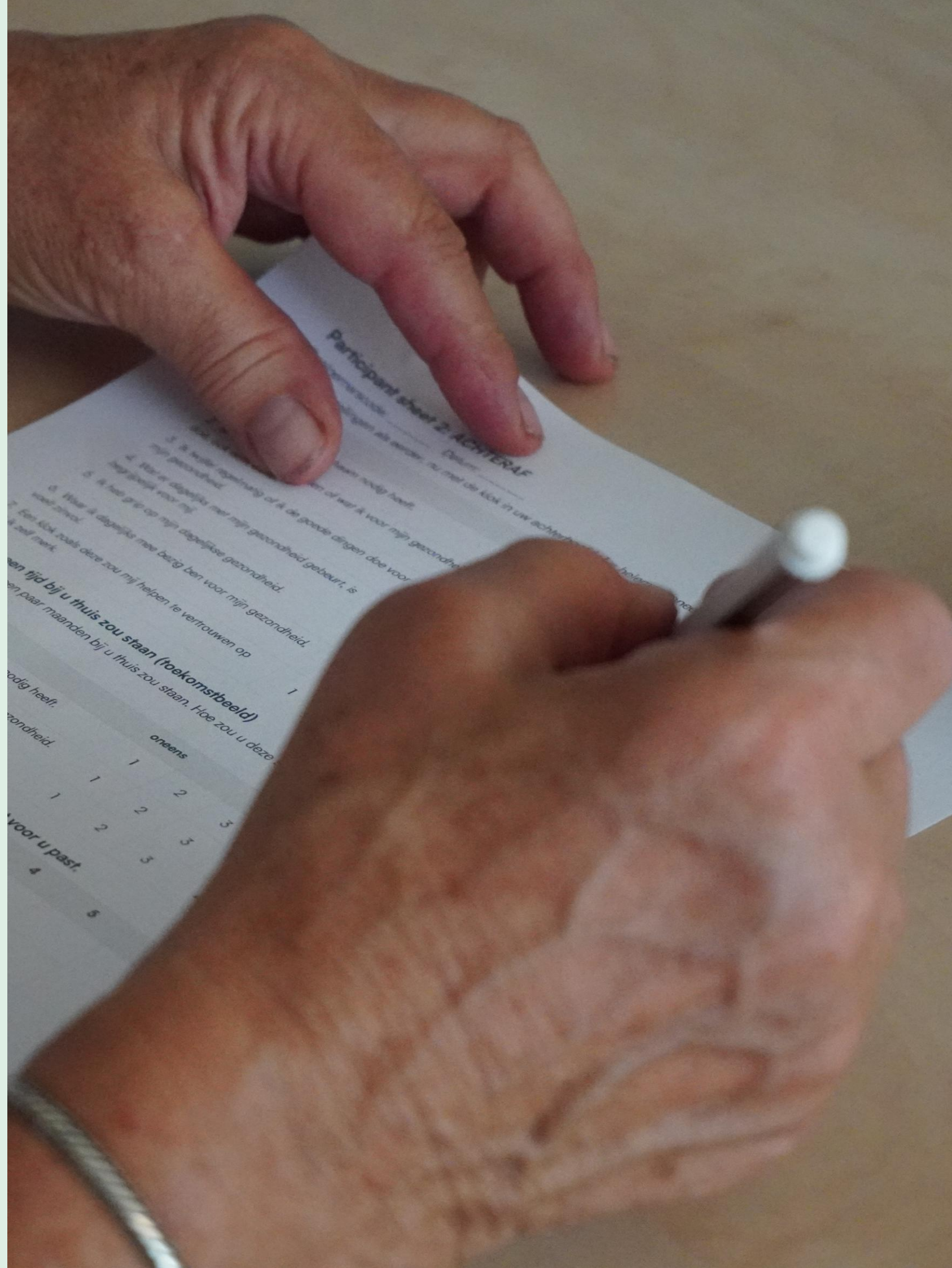


Figure 28. Participant interacting with the Soma Clock prototype



"Ik neem aan dat dat het slapen is. Ik zie 3 ringen."
(P01)
"Ik zie niet in hoeverre dat genoeg is of te weinig
of te veel." (P01)



A

"Misschien alleen die slaapstreep is anders. Die is
dunner." (P10)
"Deze lijkt ietsjes dunner dan wat die was. En deze
lijkt iets lichter." (P11)



B

"Op vrijdag heb je heel slecht geslapen. Dat zou ik
er nu uithalen." (P11)
"Dan heb ik hier minder in de zon gezeten. Slaap
is hier niet helemaal goed." (P10)



C

"Dit is voor een afstandje niet leesbaar. Als dit op
de muur hangt, dan kan ik dit niet lezen." (P11)
"Ik kan ze allemaal lezen." (P10)



D



E

"Dan is het een soort dooddoenertje. Voor een
standaardopmerking word ik niet per se blij." (P11)



F

"Daar heb je wel wat aan." (P10)
"Dan gaat het over mij. En niet over ons vrouwen."
(P11)
"Te vaag. Wat u voelt is mogelijk te wijten aan
deze segmenten in het patroon." (P01)



G

"Oh, niet naar mijn arts doorsturen, naar mij." (P10)
"Ik zit er niet op te wachten als mensen zelf geen
problemen ervaren dat mensen dan allemaal met
dit soort rapportjes op me afkomen." (E2)



H

"Dat is de marketing van koop en werk aan je
buitenkant. Maar met dit klokje is het terug naar
de basis." (P01)

Figure 29. Soma Clock Faces shown to participants on the Wizard of Oz Prototype, with quotes from participants

4.6.1. Findings

The clock was tested with four women (P01, P04, P10, P11) and a general practitioner (E2). The evaluation tested the story, the voice, the faces, the place of the doctor, and assessed the concept against the requirements.

The object did not explain itself

None of the four named all three rings unprompted at the silent first read. Sleep was recognised first and most often ("Ik neem aan dat dat het slapen is. Ik zie 3 ringen," P01), movement followed once explained, and daylight was not something they understood from the clock face. The fade out gradient meant to indicate the current time was not understood by three of four. Once understood once, all participants could find and reason changes from face A to face B (less sleep, different movement etc.). On an A3 paper, three different clock sizes were printed to test legibility. It split the group along eyesight: P10 could read everything at sizes 14 to 16 centimetres (smallest sizes), while P11 could not read any from across the room: "Dit is voor een afstandje niet leesbaar. Als dit op de muur hangt, dan kan ik dit niet lezen." Her point: "Bij dit soort producten wordt vergeten voor wie het is. Bij 55 tot 70 is zicht een heel groot probleem. Dus als je iets gaat maken wat we allemaal niet kunnen lezen, dan kan je het net zo goed weg doen."

The salutogenic voice is well received

Keeping messages generic ("Wat u merkt komt vaak voor bij vrouwen van uw leeftijd", face E) is not appreciated: P11 called it "een soort dooddoenertje", which makes the requirement: "dan gaat het over mij. En niet over ons vrouwen." Faces that are gentle but provide no content were rejected too: P01 wanted "harde cijfers en een directe tip" and P04 wanted a "stok achter de deur". Yet the same P04 confirmed that acknowledgement works: "aan het eind van de dag wil je, als je het hebt gehaald, een soort compliment krijgen van: hé, goed bezig. Het is heel kinderachtig, en ook al is het een machientje, toch werkt het." The sufficiency line ("you're doing enough") was appreciated and felt like it contrasted how the wellness industry currently markets: "Dat is de marketing van koop en werk aan je buitenkant. Maar met dit klokje is het terug naar de basis." (P01)

Dignity

Because the clock only described and never judged, every woman invented the judgment herself: targets, percentages, a coach. "Ik zie niet in hoeverre dat genoeg is of te weinig of te veel" (P01). Only showing the metrics was chosen to protect dignity, and although having a moment of realization was said to bring about more awareness of what they do to their bodies, it missed a next step; there was a need for advice, a form of help or a positive encouragement.

The link with healthcare

"Ik zit er niet op te wachten als mensen zelf geen problemen ervaren dat mensen dan allemaal met dit sort rapportjes op me afkomen." The general practitioner (E2) had no objection to a woman bringing a pattern report to the consult, but it would only help the patient, not the practitioner: a sleep and movement overview adds little information: if a patient tells her that she has been sleeping bad, she usually knows, and she does not need a device to tell, and a report from this device does not tell the practitioner why. E2 feared that having a device like this that would recommend people visit the doctor would only cause more pressure on healthcare. Participants drew the same line from their side. They would never want a report sent without their consent: "Oh, niet naar mijn arts doorsturen, naar mij. Want dan lijkt het net een soort medisch dossier te worden" (P10); "sommige mensen willen niet alles delen met hun huisarts, die willen dingen verstoppen" (P01). Only P11 wanted the print, and strictly for herself. A report would only exist for a conversation she chooses to start. However, E2 did find the concept itself good: "Op zich wat ik zo zie is eigenlijk een fantastisch instrument voor mensen die met hun leefstijl aan de slag willen".

The questionnaire results

The pre and post sheets (Appendix H., six statements, 1 to 7, repeated with the clock in mind, plus four semantic scales) mostly confirmed what the conversations said louder. Scores started high, 4 to 6: these women already agree that they know what their bodies need, which is the quiet headline, because it means knowledge was never the gap. In the post interview sheet, where they had to imagine how they would rate themselves once owning the product, the scores moved up a tiny bit, but not drastically: none more than one point. The semantic scales placed the clock midway between clinical and homely, clearly at respectful and for everyone rather than just for the elderly, and on the apparatus side of furniture piece. With four sessions this remains a direction, not a statistic.

Nobody called the clock clinical or betuttelend when asked to scale it on the forms. The worry the semantic scales were built for, and having guests over in the home and them seeing the clock were not found to be an issue. The nearest miss was P01 reading it as an appliance: "iemand die nu binnenkomt die zegt: oh ja, thermostaat staat te hoog." The clock did not die of indignity. It died of redundancy.

The phone substitution question killed the concept

One question, killed the concept: if this same information lived on the phone, does the clock still add anything? Three of four moved the interaction off the wall inside the session. "Op telefoon. Nee, dan is een klokje niet nodig" (P01). "Je moet constant geconfronteerd worden met het feit dat die klok er is. En wat heb je bij je? Dat is je telefoon" (P04). "Als het op de telefoon kan is dat wel zo praktisch. Als app" (P10). The one yes, P11, chose the wall for legibility and the fact that is was not something she could easily lose; a display size argument rather than a product argument.

4.7. The problem, restated

The problem framing of this project did not move once, it moved continuously. Throughout the project the framing was reformulated, root causes were dug for, and reframings were put in front of participants session after session, until the digging itself met its limit. The intermediate framings are documented in chapters 2 and 3 and are not repeated here; what follows is the reasoning that ended the search.

The first realisation concerned stakes. The case made in chapter 1 still stands: taken consistently and correctly, supplementation has documented benefit, and more healthy years is worth designing for. What did not stand was the assumption about where the difficulty sits. The adherence framing borrowed its urgency from an adjacent literature: a missed or wrongly taken dose can cause real harm. For supplements that analogy quietly breaks. The participants confirmed it from their side: supplementation is a small part of their day and a small part of how they think about their health, most had long settled it into a stable ritual, and support tools like dispensers solved a problem they did not experience. The goal was still right, but adherence was not where the problem sat. Designing better adherence support would have meant polishing a solution to a problem where polishing would be a nice to have at best, and unnecessary at worst.

The second realisation concerned the market. Where real friction did exist, convenience and composition, Silvie's daily sachet format had already absorbed most of it, and the remaining territory is crowded: several competitors already combine blood testing with personalised supplement delivery in convenient and even travel formats, at premium prices. Another entry there would leave Silvie undifferentiated. The route offered no competitive ground to stand on.

What remained, and kept returning in interviews, was doubt. Women doubted whether what they took was right for them, and whether it did anything at all, because for most supplements the effect cannot be felt. The exception proves the rule: where an effect is dramatic and noticeable, as with medically indicated B12 injections, doubt disappears. Doubt implies missing information, and part of that gap is structural: general practitioners are reluctant to test blood values in the absence of illness, so the guidance that could settle the question is withheld.

There is an honest answer to doubt, and it is evidence. Told what her body actually needs, and shown what changed, she would not have to wonder. That answer requires measurement, from blood or from a sensor. Going this route would mean competing with existing blood kit providers, or integrating technology that would tip into the medical, and the technology is still far out from giving an honest n=1 answer. The honest answer was out of reach and the dishonest one was refused.

Every concept that followed is an attempt to be useful without measuring inside the body. The Soma Clock, the Body Atlas and the Functional Kit each proposed a different substitute for evidence: a rhythm she could see, a record she wrote herself, and a simple test she could run. The clock was taken forward and did not survive its evaluation. What survived it was its voice rather than its body.

The way out came from returning to Silvie's core. Silvie's mission is not selling pills; it is being a catalyst on the path to healthy ageing, in which evidence-informed supplementation is one element of a preventive lifestyle alongside movement and, for women of this age specifically, strength training, with documented benefits for muscle retention and later-life independence. Seen from that core, the problem participants actually voiced stops being a supplement problem at all. They know, roughly and well enough, what a healthy week looks like. They do not lack knowledge, they lack the action: the gap sits between knowing and doing, across all the behaviours that make up that preventive lifestyle. That gap is a designable problem.

4.7.1. The knowing-doing gap and its history in this group

In this group the gap has a history. These women have spent their lives caring: children first, then work, and for many who have stopped working, now their parents. Caring for others is not a closed chapter but an ongoing one, named in plenty of sessions as something that snatches a large chunk of her day. Their own care did not disappear from the list; by default, it got a lower priority, and it still does sometimes. What is scarce is not the time but the energy and permission to spend some of it on herself.

Two findings sharpen the frame. First, the promise culture of this generation. They were raised on keeping their word: "Ik ben opgevoed met het idee dat als je iets belooft, dan moet je het ook doen. Het gekke is dat dat niet werkt als ik het aan mezelf beloof, want dan stel ik het gewoon uit" (P11). A promise to herself must borrow the binding power of a promise without borrowing its guilt. Second, the behaviour itself should be something she actually wants, something she enjoys: "Alleen maar opgeruimd, en dat is helemaal niet bevredigend. Want ja, dat is gewoon geen leuke activiteit" (P10); "ook omdat ik dat natuurlijk leuk vind, want anders zou ik dat niet doen" (P11). Thinking to oneself that they "have to" do it, as a sort of duty, does not survive a busy week. Enjoyment sometimes does.

4.7.2. What is at stake

At this age, daily preventive behaviour can still make a difference: certain behaviours can extend the years lived in good health, which is precisely Silvie's mission, women with the energy and capability to do what they want to do. The context gives it urgency. The Netherlands is greying: by 2040 a quarter of the population will be 65 or older (Centraal Bureau voor de Statistiek, 2024). Care is already short of hands: the projected shortage of care and welfare workers runs toward 266,000 in 2034 (Ministerie van Volksgezondheid, 2024). Staying healthy will increasingly land with people themselves.

4.7.3. From supplements to healthy behaviour

Within that frame, the scope of the project widened deliberately. Supplements, the entry point of the assignment, turned out to be one healthy behaviour among many, and participants' real intentions varied widely: walking, sleep, rest, social contact. The concept focuses on the mechanism all of those share, a small promise kept, and supplementation remains one promise type among the rest.

4.7.4. Lowering the bar

The title of this thesis is a position statement against the direction health products and industry have taken. Regardless of whether a device targets elite athletes with 'strain scores' (WHOOP, 2026c) or the general public with 'close your rings' (Apple, 2026) the underlying philosophy of the wearable industry remains the same. Health has become a performance culture: measured, scored, benchmarked, and marketed, especially toward younger consumers, as a state of perpetual insufficiency. There is always another metric to optimise; even rest is no longer a reprieve from this cycle, but rather 'active recovery' (WHOOP, 2026b) that is quantified and scored. It is a culture focused on constantly pushing limits, rather than a support for stable baseline well-being. In that culture, lowering the bar is not a fitting approach. This thesis argues that for this group of women, it is exactly the right thing to do.

Measuring is not neutral: tracking an activity makes it feel like work and lowers the enjoyment of doing it (Etkin, 2016), so the instrument built to improve the behaviour starts to damage the relationship with it. Autonomously motivated behaviour (choice and enjoyment) is maintained, while controlled regulation (driven by obligation) is short lived (Ng et al., 2012). Missing a single day does not disrupt habit formation (Lally et al., 2010). However, self-blame after a minor slip up often leads to complete abandonment, whereas self-compassion actively promotes healthy behavioural maintenance (Sirois et al., 2015). Tracking health as a scored performance creates a pressure that works against the sustainable psychology required for active ageing.

The pressure of 'personal quantification' directly drives abandonment; users have been found to discard devices once motivation drops or data tracking becomes burdensome (Attig & Franke, 2020). Digital health tools experience a median abandonment rate of 70% within the first 100 days. A driver of this is the sheer magnitude of effort demanded from the user; studies indicate that "burdensome data entry" and the daily time commitment required for tracking consistently lead to abandonment. Furthermore, "fading motivation" and the cognitive friction of complex interfaces cause users to disengage entirely. (Kidman et al., 2024)

This thesis argues for future designs to optimise for the smallest viable behaviour that actually happens and lasts. An illustrative example: getting this age group to move only a little makes a significant difference in mortality. Mortality benefits of physical activity for older women are steepest at the low end (4,400 steps per day) and levelling off well below the 10,000 step industry standard (Lee et al., 2019). For certain behaviours, focusing on the smallest steps consistently can capture a larger possible margin of health improvements.

The women in this study do not reject measurement outright: P11 describes the current industry posture as coercive: "Sommige apparaten maken het heel dwingend". P08 declines a smartwatch: "ik wil niet voortdurend mijn slaap meten", and, as a clinician, names the pitfall of quantification: "patiënten die eindeloos bijhouden hoeveel meters ze lopen en hoeveel watt." Both participants ask for a longitudinal view so they can understand a slip up. P01 refuses app tracking: "dan voel je je helemaal als een robot", but wants "harde cijfers en een directe tip", yet two other participants seem to be somewhat motivated by the gamification of health.

What these women reject is feedback that passes judgement rather than explains (E2), monitoring that is continuous rather than retrospective (P04), and a displaying information to others rather than private (P11). Guilt is not a durable mechanism; it exhausts itself, and the device goes in the drawer. Measurement-first design does not fail because it measures. It fails because it sets the bar at a height that guarantees a verdict, and then delivers that verdict daily.

For the women in this study, lowering the bar means lowering three bars at once:

1. The bar of the number of behaviours tackled: trying to optimize multiple behaviors simultaneously introduces planning friction that undermines commitment (Dalton & Spiller, 2012); focusing on a single, achievable routine change is far more effective. P04: "dat je laag begint [...] ik kan me voorstellen dat één intentie om mee te beginnen misschien wel genoeg is."

2. The bar of judgement: when the larger goal fails, devise smaller sub goals. P11: "moet je het anders aanpakken? Of moet je jezelf meer tijd gunnen? [...] Misschien red je het niet in één keer, drie keer per week. Misschien moet je het opbouwen." The appropriate response to a missed target is a smaller target, with those smaller targets adding up over time. An idea that closely aligns with the core idea of the book Atomic Habits (Clear, 2018).

3. The bar of permission: the one specific to this generation. Firstly, entitlement is not the missing ingredient: "ik vind dat ik tijd voor mezelf mag nemen, maar ik doe het niet omdat ik heel veel andere dingen dan belangrijker vind" (P11), permission to prioritise it is. P04: "tijd voor mezelf is er relatief weinig; dat is niet om te klagen, maar het is gewoon zo", and P08, asked whether a lifetime of prioritising others applies to her, answers "ja, dat geldt ook zeker voor mij," adding that many women her age are giving informal care to ageing parents. P01 states it explicitly: "als vrouw, en dat is echt zo, is je aangeleerd: je houdt je bek en je zorgt voor anderen. En je loopt binnen de lijntjes en je dient." Secondly, the behaviour must belong to who she wants to be (Ng et al., 2012). P01 names the mechanism herself: "wat ik zeg is eigenlijk intrinsieke motivatie krijgen", and "trouw zijn aan mezelf en mezelf op de eerste plek zetten, dat is de eerste stap die je moet doen als je serieus wil veranderen." If she wants it strongly enough, an identity shift needs to take place: she needs to identify as someone that allows herself to prioritise the promises she made to herself, and that promise must belong to who she wants to be.

The salutogenic lens ties the three bars together. Pathogenic design watches for what deviates from a norm; salutogenic design starts from where she is and asks what generates health next (Antonovsky, 1979). The three components of the sense of coherence match with onto the stance directly: one thing at a time keeps it comprehensible, a smaller step at a well timed moment keeps it manageable, and a behaviour that fits who she wants to be and what she allows herself, keeps it meaningful. Lowering the bar is salutogenesis made operational: the bar is set at the height at which health is actually generated, and the promise is set at a size at which it is actually kept. It is lowered not out of low expectations of these women, but out of high respect for how behaviour actually starts.

4.8. Same voice, new body

4.8.1. What the clock hands over

The clock was about awareness: "so this is how much I really moved today." What survived the clock was not that ambient mirror but its voice and signature sentence: "you have done enough". Calm, reflective, and personalized. The new concept had to offer added value above the phone (unlike the clock) and put that voice to work differently, in a different form.

4.8.2. Choosing the form

TU Delft's faculty of Industrial Design Engineering is known for its methodology. To choose a new form, a variety of familiar methods could have been used (How to's, SCAMPER etc.). However, per recommendation of the supervisors (Stefan Persaud and Gianni Orsini), it was time to follow design intuition, to "kick the ball ahead", and to think of "what if's": what if it could intervene or nudge you to do healthy behaviour at the right moment, what if it could coach you on the spot? What if we integrate it invisibly into something that women wear every day already?

These "what if's" led to exploring 6 alternative forms: a watch, bracelet, ring, pendant, glasses and earring. These alternatives were gauged with participants during co creation sessions with 4 participants. Potential forms and integrations were explored: earrings with a coach that could speak to you, smartwatches that looked dignified, similar to their own, with the addition of simple notification and confirmation mechanisms, and bracelets and rings with the same. Glasses and earrings were discarded as objects that not all would consider wearing (at all or daily). Rings were perceived as fragile and watches/bracelets were a close second to the pendant. The pendant won as it was something that felt more personal, close to the heart.

This step was not a study. The alternatives were put to participants verbally, in conversations that started during the last clock sessions, when it was already becoming clear that the clock would not hold. No guide was written for it and no appendix holds one.

The bar shape came out of one of those conversations. A participant was shown a drawing of the pendant as it then stood, much larger as it carried a light sensor. Browsing jewellery together afterwards, a slim bar pendant came up that she liked far better, and it was the most enthusiasm the form had drawn from anyone. An enthusiasm that was later shared by everyone.



Figure 30. Quick sketch of a concept that was shown to a participant

4.8.3. The pendant concept, in six steps

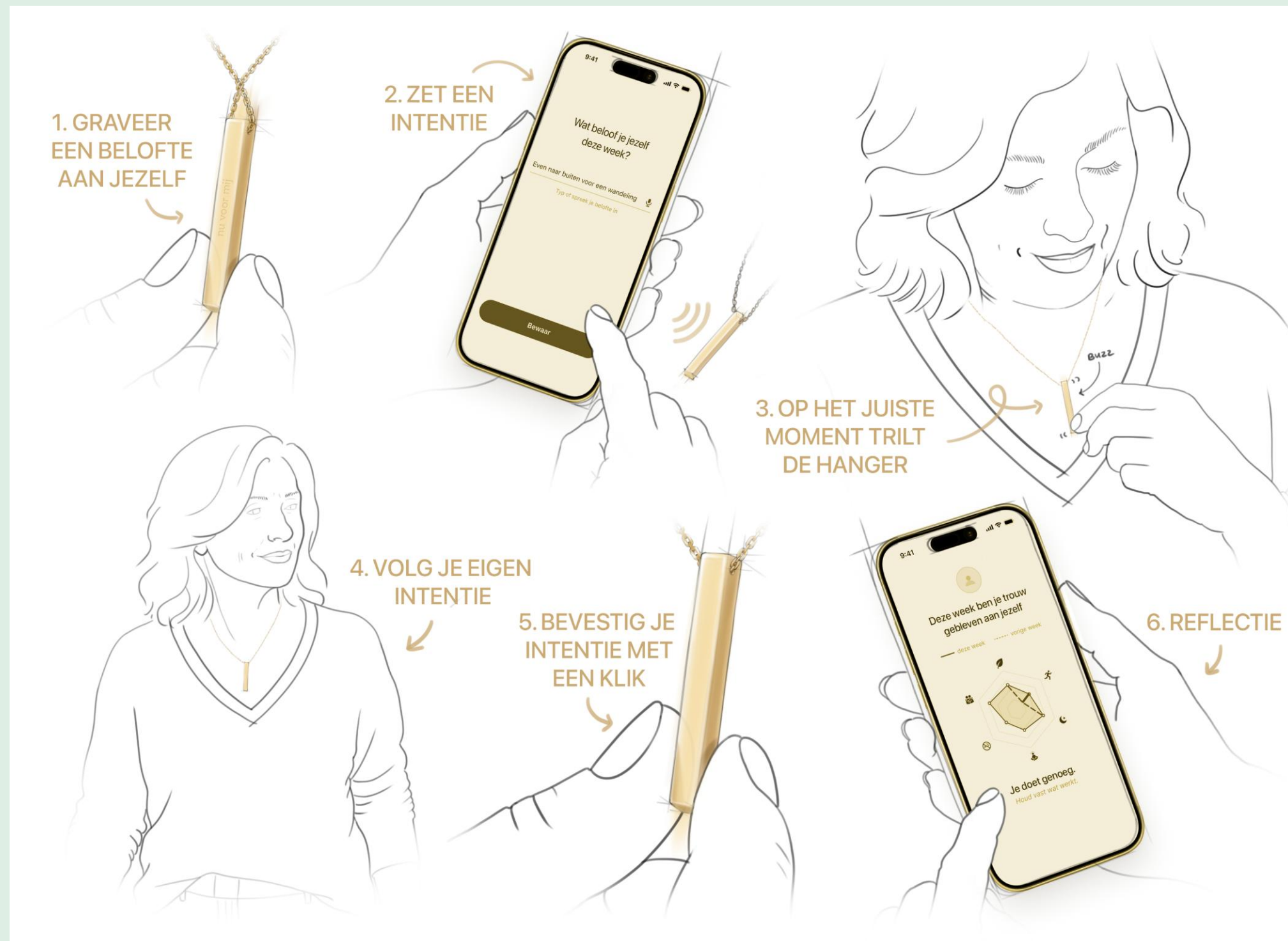


Figure 31 Pendant concept scenario drawings as they were displayed to the participants, 6 steps from engraving till weekly reflection

Storyboarding (Technische Universiteit Delft, 2021) was used so participants could react to the interaction with the concept itself, and so desirability could be gauged before anything was built.

1. A promise to herself, a quote, an emotional connection that is meaningful to her, a vow, engraved in the jewel as a motivational backbone.
2. The user sets a promise to herself in the accompanying app for the coming week.
3. A gentle vibration at a well timed moment notifies her that it is time to keep the promise she set herself.
4. She follows her promise and does the healthy behaviour she set out to do.
5. A squeeze on the pendant confirms it happened.
6. At the end of the week, a reflection that closes with the sentence the clock handed over: "je doet genoeg".

The reactions were positive enough to produce unprompted intent to buy, which none of the three earlier concepts had drawn. "Ik ga hem kopen als jij hem gaat verkopen. Ik denk echt oprecht dat ik er heel serieus over nadenk om dit te gaan dragen. Dat meen ik echt" (P04). "Ik moet heel eerlijk zeggen dat ik hem erg leuk vind" (P11). "Ik vind het concept van dat iets op je lijf gaat trillen en dat je jezelf daardoor een boodschap doet waar je aan herinnerd wordt. Dat vind ik wel heel grappig" (P08). "Het is een mooie reminder" (P10).

The same sessions produced the requirements that the functional prototype was then built to test. Most were folded into existing requirements when the list was revised in 5.2, and only the water resistance clause survives there as a separate entry, N2. Haptics only, no light and no sound: "een lichtje zien anderen ook, en een trillinkje is alweer alleen voor jezelf" (P11). The confirmation must not trigger accidentally (P11). It has to work when the phone is elsewhere, and survive water, because jewellery is not taken off for the shower or the sea (P11). And one promise to begin with rather than several (P04).

Participants also asked for something the scenario did not offer: that the jewel keep what has already been achieved. "Dat je jezelf zou kunnen belonen, dat je er een steentje in doet, dat het echt de vertegenwoordiging wordt van je commitment" (P04). That wish became the milestone layer described in 4.10.2.

Two things in the scenario did not survive the sessions unchanged. It uses *belofte*, *doel* and *intentie* interchangeably across the six steps, a slip participants noticed. P04 already pointed at the difference in this round: "doel, dat kan frustrerend zijn als je je doel niet haalt, en een intentie niet halen, dat voelt wat zachter."

4.9. Prototyping

The prototypes in this project were research instruments rather than steps toward a finished product. Each one was built to test requirements, or to test desirability, feasibility or viability. Each prototype made a specific question answerable: whether a confirmation squeeze can be sensed through a wall, whether a vibration on the breastbone reads as calm, and what would be a preferred vibration pattern and strength, whether the size and material choices of the pendant and charging dock were appropriate, whether the charging dock material and sizing were desirable, whether the interaction with both the app and pendant and charging is understandable / user friendly, whether the object can be manufactured, and whether it can be serviced years later by someone who did not design it. The answers are reported in the validation chapter (Chapter 5); what follows is what was made, and what each thing was built to answer.

The sensing sandwich

Using capacitive gap sensing, the testing sandwich was built to prove that a squeeze can be read as a change in capacitance across a closing gap, before any of it was folded into the pendant.

The functional pendant

The same principle on a chain, with the capacitive gap sensing and vibration feedback integrated in the prototype so that it could be worn and felt by participants. Built so participants could feel the buzz where it would really live, compare strengths and patterns that were changed live in the code, and feel the confirmation buzz with a squeeze.

The app

Prototyped as different scenarios in Figma to test whether the app was coherent (comprehensible, manageable, and meaningful), user friendly and had the correct tone of voice. Participants read the screens aloud and they were adjusted and rewritten throughout co-creation sessions so that the app was made to fit participant wishes more accurately.

The pendant charging dish

In three sizes, with material renders alongside. Built to settle size (does it fit other pieces of jewelry that participants wear daily?), placement in the home, and material. Built also to test whether participants could place the pendant in the charger blindly (to simulate charging the pendant at night).

The manufacturing feasibility production model

A complete CAD assembly in the way it would be made, including materials, machined outer shell, injection molded inner halves, lid, seals, retaining plate, contact screw and the electronics stack. Built to verify whether all parts necessary to deliver the interaction could fit in this form factor, whether it could be assembled and manufactured. Built to be specific enough to be audited, quoted and criticized by real manufacturers. Every assumption that could be replaced by an answer was put to a supplier: the cell, the custom cell, the motor, the molded parts and the titanium shell.

The service model and the service sheet

A printed pendant at enlarged scale (4x) with lid (same CAD model), plate and screw, and instruction sheets in the format the watch trade already reads. Built to test whether either the user or the jeweler could do a battery replacement so that the pendant does not become obsolete when its battery dies, it was made to be viable in the long run. Engraving service and stone setting personalization feasibility and price were also tested.



Figure 32. 3D printed models on Bambulabs printbed

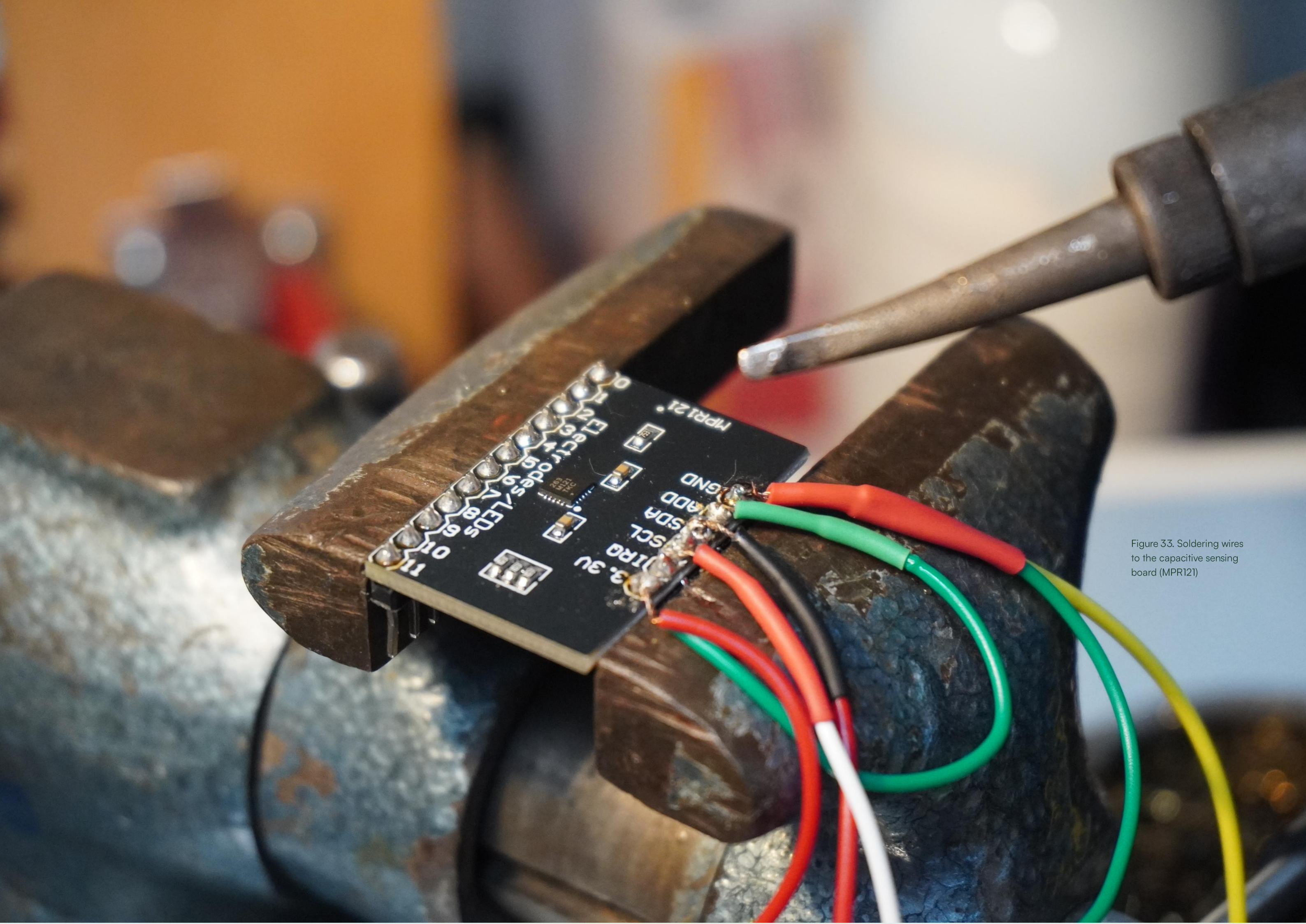


Figure 33. Soldering wires to the capacitive sensing board (MPRI21)

4.9.1. Reading a squeeze through a closed wall

The interaction of the confirmation of a promise fulfilled depends on one a squeeze through a metal wall that can be measured from inside the device. The pendant does this with capacitive gap sensing. The outer wall (outer shell) is the moving plate of a capacitor and is electrically connected to ground. The sensing electrode sits on the inside shell at a fixed distance (0.125mm), and the air between them is the dielectric. Squeezing the pendant bends the wall inward by a few micrometres, the gap narrows, and the capacitance rises.

Why this method of sensing

The method was chosen by its ability to be repaired: the pendant has to inevitably open for a battery change, and the inner assembly has to leave the outer shell in one piece, which means nothing may be bonded to the inside of the wall. That single constraint removes most of the alternatives like strain gauges or piezoresistive sensors (they would have to be glued to the wall), like Google and HTC shipped in the squeeze phones (Google Research, 2019; iFixit, 2017a, 2017c), and iFixit reports that those sensors are close to impossible to remove without destroying them (iFixit, 2017a). Load cells, force sensitive resistors and pressure sensors all need something to carry the movement of the wall into the sensor, and are thereby unsuited as alternatives too. Ordinary capacitive touch on the outside surface does not work either, as the pendant is constantly touched by skin as it rests on the breastbone. Inductive sensing is the only other alternative, yet it would require more space for a coil and a more conductive material than titanium.

Where this has been done before

Capacitive gap sensing inside a sealed metal body is not novel. Apple uses it in the AirPods Pro stem (Apple, 2024). Texas Instruments sells an evaluation board (Texas Instruments, 2017).

Which plate is grounded

If the metal shell itself were the sense electrode, the capacitance of a finger and of the wearer's body would swamp the tiny change caused by bending the shell. With the shell grounded, it screens the electrode instead, which has much less parasitic capacitance: the only thing the electrode can see is the wall in front of it, and the only thing that moves that wall is force.

Wall thickness

Deflection of the outer shell walls scales inversely with the cube of the wall thickness, so thickness dominates every other variable: halving the wall multiplies the movement by eight. The wall is therefore as thin as the rest of the object will allow (0.6mm). In conversations with manufacturers (see Chapter 5), a lot speaks for increasing wall thickness: machining a thin wall over 43.67 mm length, polishing, PVD and engraving, and compressing a seal against it all argue for more material. The wall thickness is the single most contested dimension in the design, yet also the one that cannot be tested without building or finite element analysis. Discourse is still ongoing between manufacturers, but locally thinning is a possible solution to this problem.

The gap

The smaller the gap, the higher the sensitivity. Texas Instruments describes 0.1 mm as the optimal spacer thickness and states that sensitivity falls away rapidly beyond 0.5 mm (Texas Instruments, 2017). The gap in this design is therefore pulled in as far as the tolerance to slide the inner assembly in allows (0.125 mm).

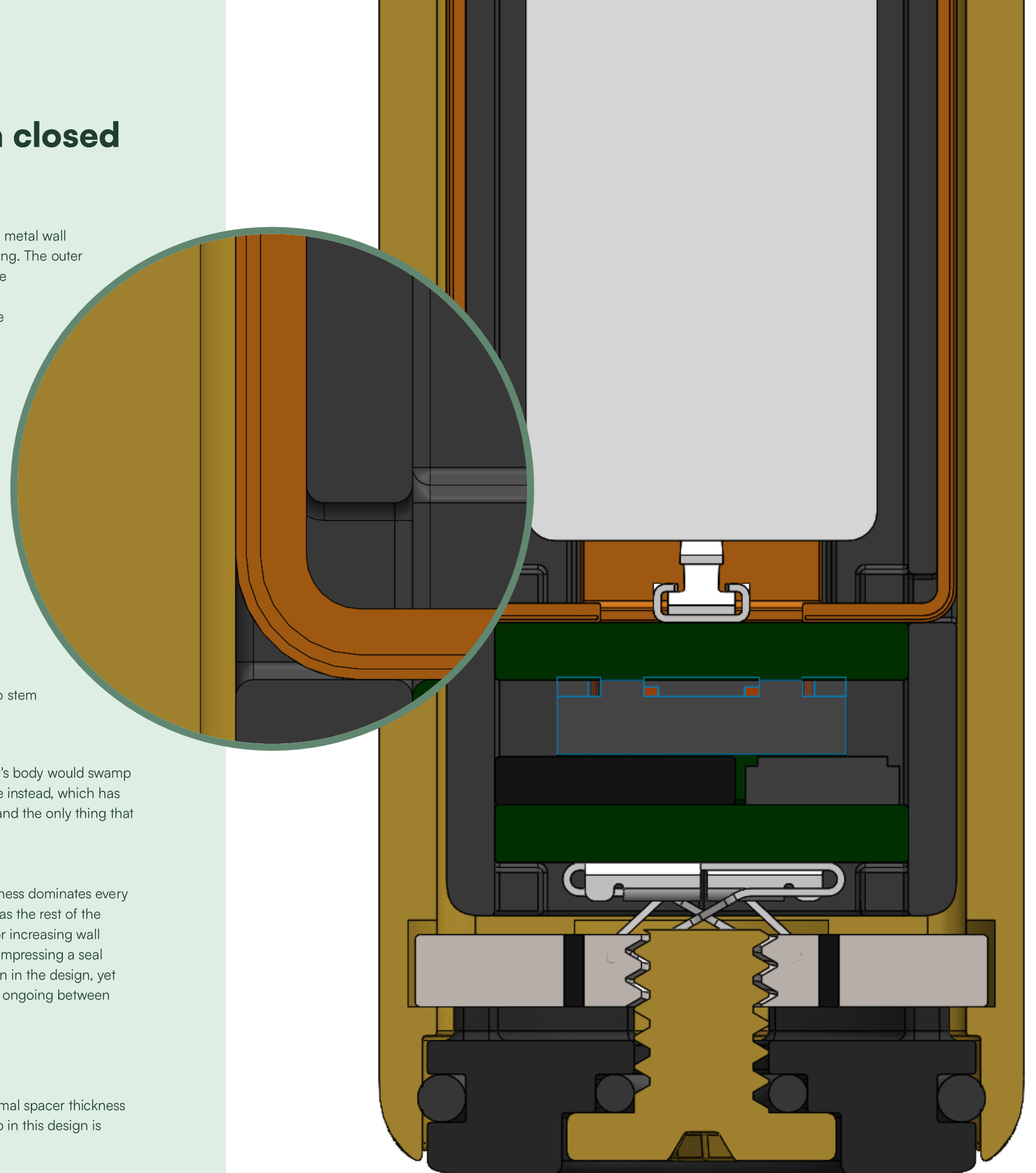


Figure 34. Cross section production model pendant. The flex cable (orange) is distanced 0.125mm from the outer shell inner wall (gold)

Material choice

How far the outer shell wall moves under a given force is determined by the stiffness of the material, and titanium's is 1.7 times less stiff than stainless steel, given more deflection, which in turn is a gain in signal. Moreover, there is more elastic range as its yield strength is higher, and for a wall that is squeezed several times a day, this matters: the metal fatigues less. A wall that fatigues easily would shift the sensor's baseline, and that is the failure this choice guards against.

Sensing the squeeze

The MPRI21 is a touch controller rather than a capacitance meter, and was used because it was the only suitable part available without a lead time. It reports a count, not a capacitance. The board's firmware converts between the two from the charge it injects, $C = (I \times t \times 1024) / (3.3 \times n)$, so results are reported in picofarads.

Figure 35 shows five consecutive squeezes in the functional prototype (see next chapter). At rest the electrode measured 20.9 pF, with the detection threshold 1.7 pF above it. Two deliberately light squeezes reached 22.4 and 22.5 pF and do not trigger a confirmation buzz. Three ordinary squeezes reached 23.1 to 23.5 pF and do trigger a confirmation buzz. The baseline holds still through all five squeezes, which is the drift compensation following slow change while refusing to follow a press.

The flexible PCB's hold only the electrodes and connect straight to the PCB that holds the capacitance sensor, thereby eliminating potential parasitic capacitance as much as possible. The electrodes sit on the outside of the inner shell. The production design uses two electrodes on opposing walls whose signals must both rise before a squeeze counts (to eliminate accidental trigger further).

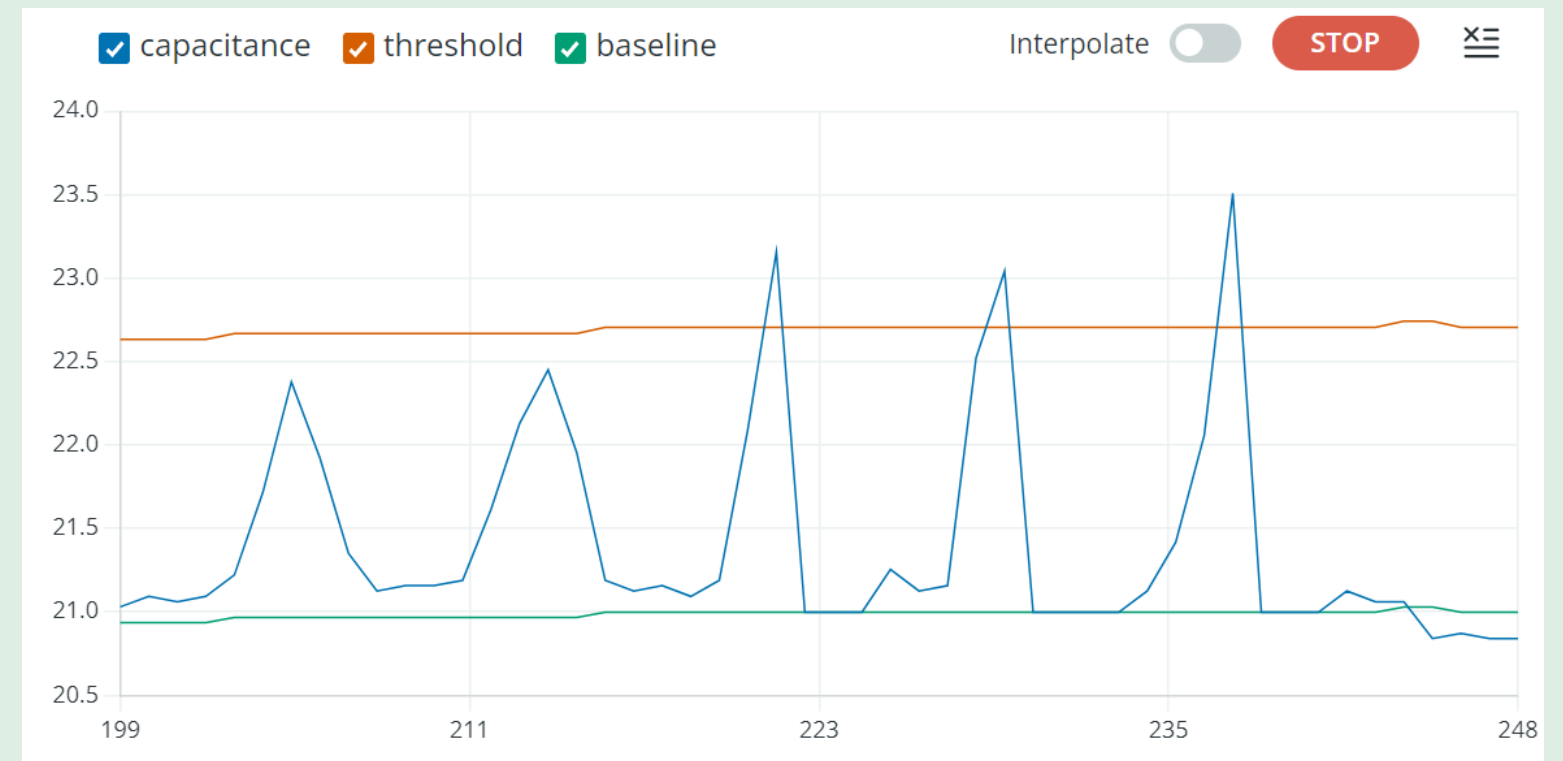


Figure 35. Five squeezes plotted by the functional prototype. X axis = picofarads, Y axis = sample number, total time plotted here is 4.9 seconds

What is left to validate

What was not validated is the deflection with the final production material and shape. The squeeze was tested with a plastic wall with copper tape, which deflects more, while the pendant titanium wall is stiffer, which would reduce the signal. The question could be settled either through finite element analysis or by squeezing one machined part. What supports the choice in the meantime is that the production sensor, a TI FDC1004, resolves capacitance changes far below one femtofarad, while the change measured in the prototype was in the order of picofarads, several thousand times larger.

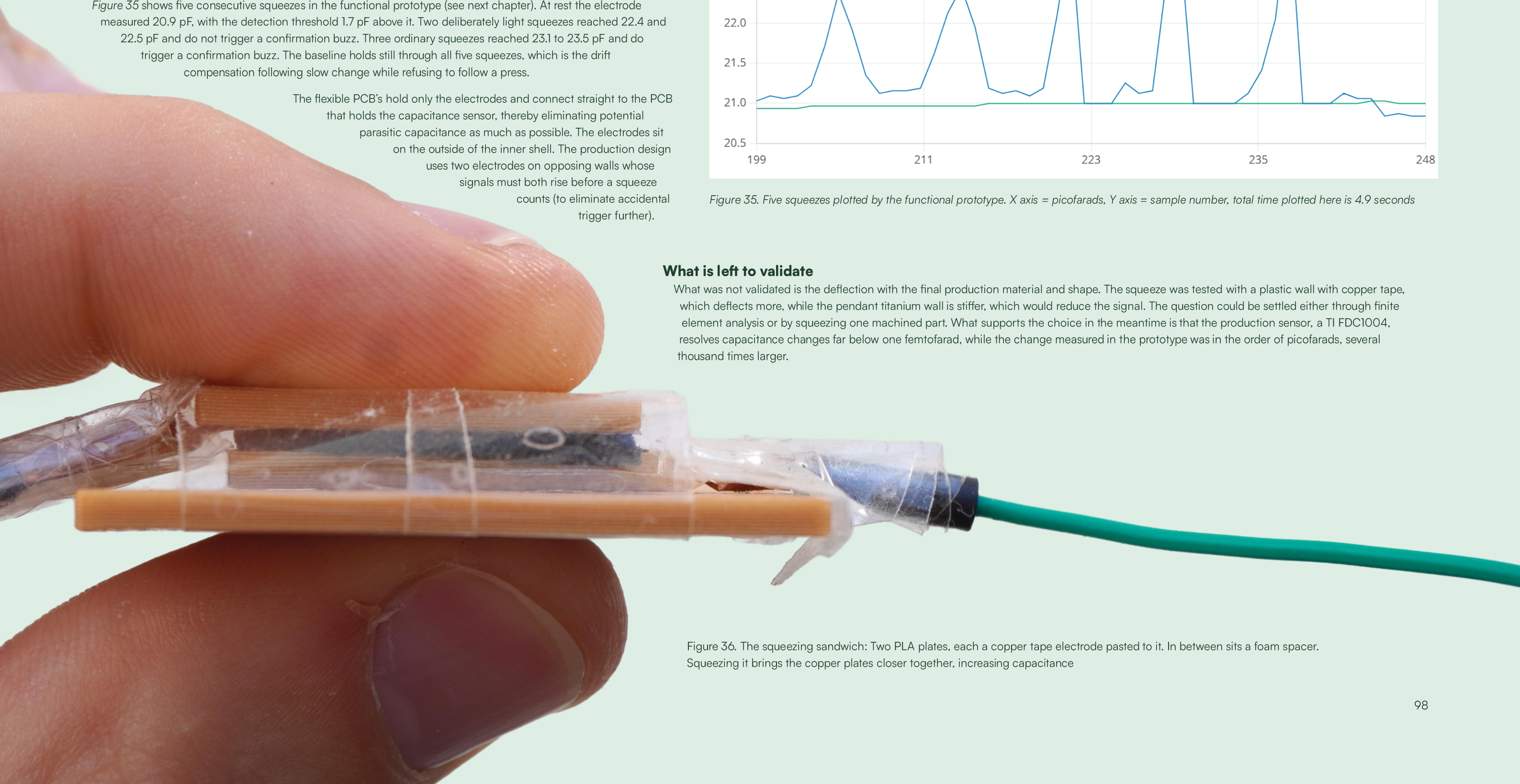


Figure 36. The squeezing sandwich: Two PLA plates, each a copper tape electrode pasted to it. In between sits a foam spacer. Squeezing it brings the copper plates closer together, increasing capacitance

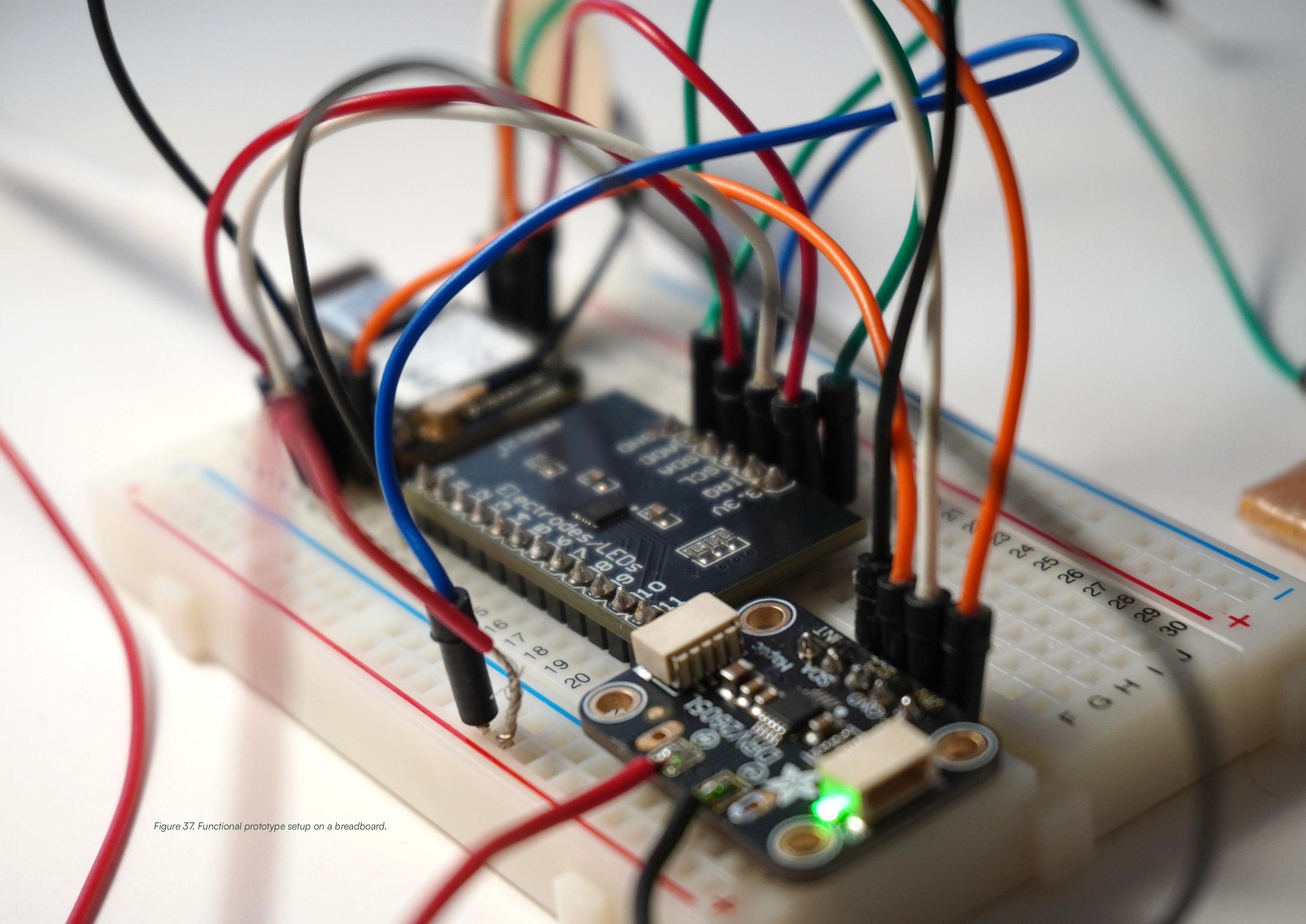


Figure 37. Functional prototype setup on a breadboard.

4.9.2. Functional prototype setup

The functional prototype runs on a Seeed XIAO ESP32-S3 with an Adafruit MPR121 capacitive controller and an Adafruit DRV2605L haptic driver driving an ERM motor (HYY4Z08V000-L45, 2.0-3.4V). The MPR121 is a capacitive touch controller rather than a precision capacitance gap sensor. See Appendix K. for the code.

For anybody trying to reproduce this setup: the failure that cost days to fix was that both breakout boards ship at the same I2C address. The fix is to cut the presolder on the back of the MPR121 between the ADD and GND pin. The ADD pin was then connected with the 3.3V pin.

The final prototype moved out of the breadboard into a printed housing that holds the controller (see Figure 39), both boards, the motor and the sensing plates in the pendant's own proportions, on a chain, so that participants could wear it and feel the vibration on the breastbone rather than in the hand.

The pad on the right is the “sandwich” (see Figure 38): two copper plates held apart by foam spacers, where the outer plate stands in for the titanium wall and the inner one is the sense electrode. Squeezing compresses the foam, the gap closes and the capacitance rises. One electrode couple was wired, which was enough to prove the principle. The production design replaces all three boards and uses two sense electrodes, both working against the outer shell as their shared moving plate, so this diagram documents the research instrument that produced the measurements rather than the product.

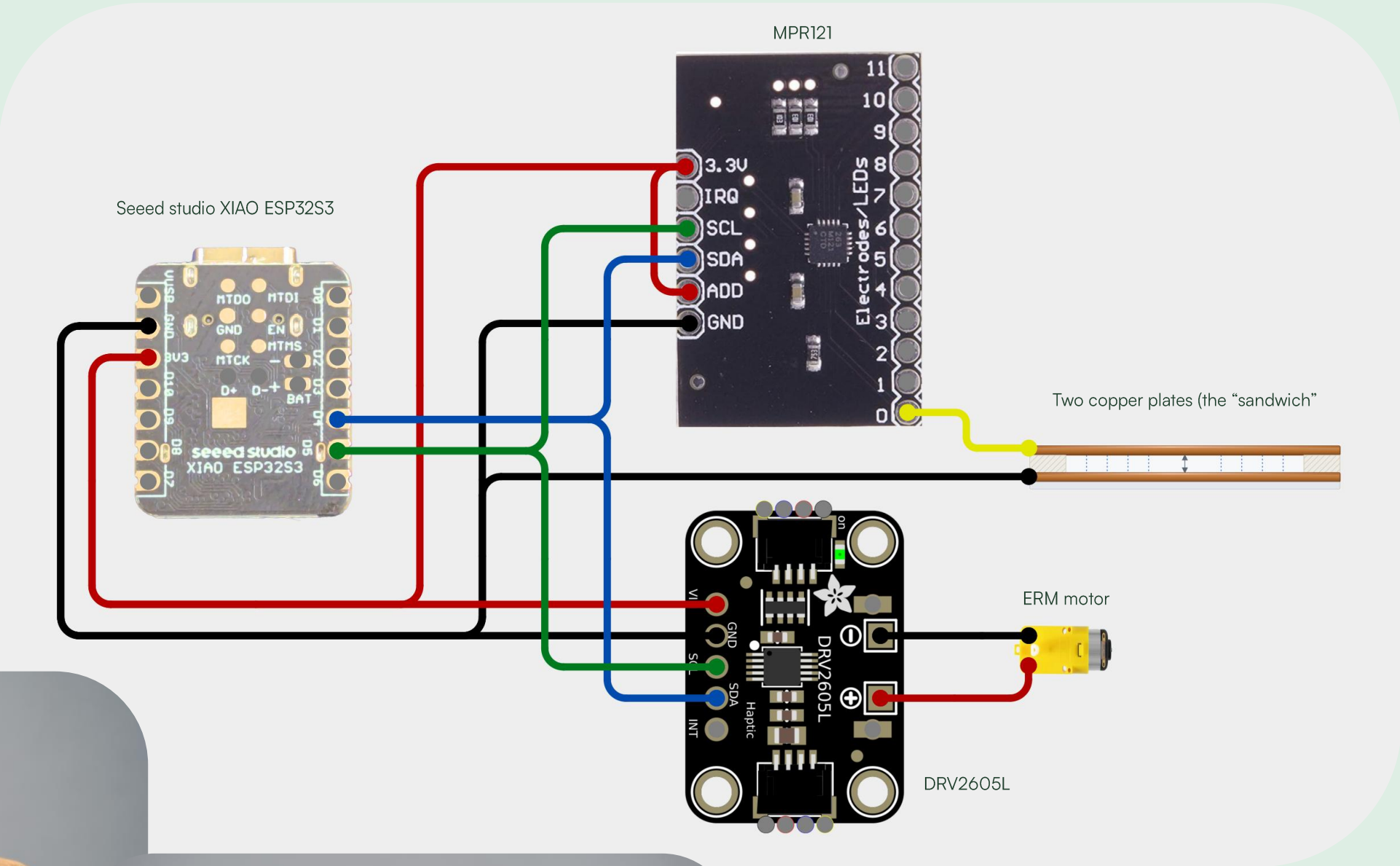


Figure 38. Functional prototype wiring diagram

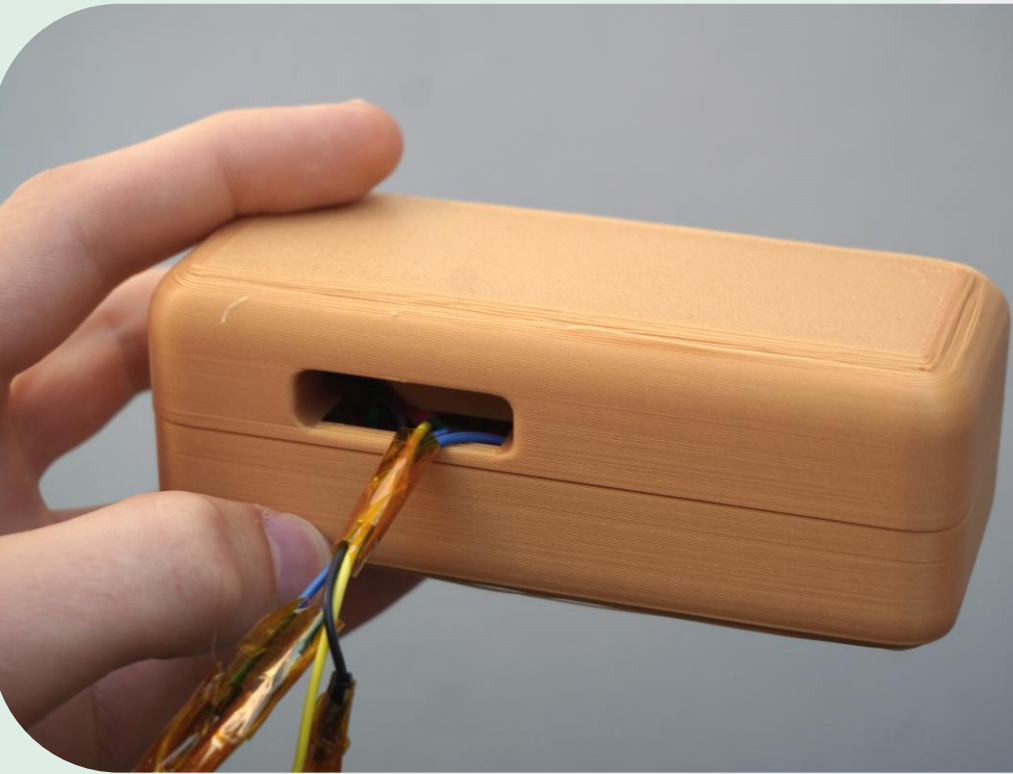


Figure 39. The printed housing that made the electronics wearable (closed)

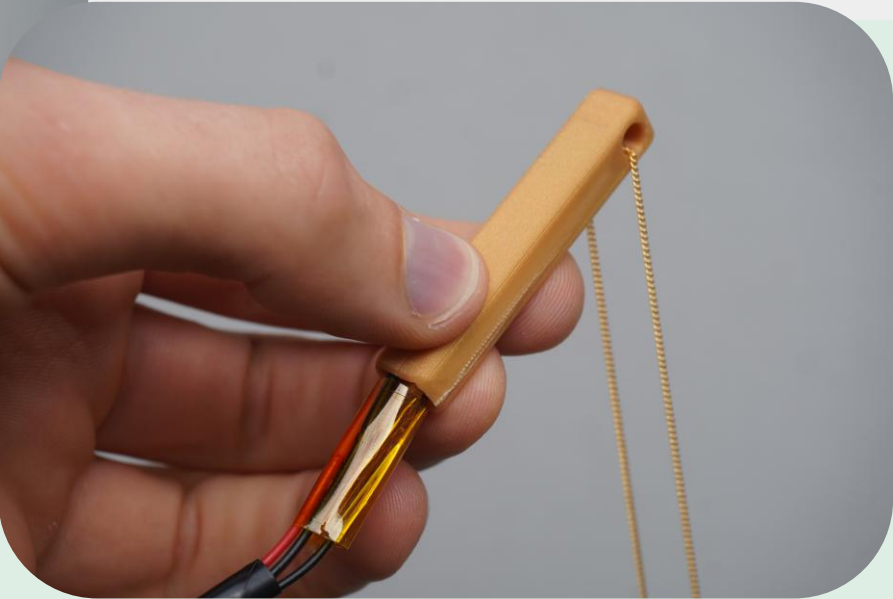


Figure 40. The pendant, slightly enlarged to fit the wiring and prototype motor, squeezing on the sides gives a confirmation vibration



Figure 41. The printed housing that made the electronics wearable (open)

4.9.3. Two parts, five jobs

At 6.7 mm wide, parts must share functions to optimally use the space available.

What each part does

The titanium shell is the circuit ground, and that single role covers three things at once: the negative contact for charging, the grounded plate the squeeze sensor measures against, and one half of the antenna. The screw fastens the lid and carries the charging voltage while the pendant stands in its dish. It does nothing else, and it is isolated from the shell by the moulded lid it passes through.

Polarity

The shell is ground and the screw is positive, for safety rather than convenience. The shell is the entire outside of the product. If it carried the supply voltage, laying the pendant on a metal surface would short it, and skin would sit permanently against a live conductor. Ground is the safe thing to expose, and the screw is energised only while the pendant is docked.

Keeping the two apart

The retaining plate is built as two conductors with an insulating ring between them: an outer ring meeting the shell for ground, and an inner threaded core that the screw enters, so the two nets reach the boards through separate spring contacts. The construction is the same as the barrel connector on a laptop power supply, where the outer sleeve is negative and an insulated centre pin is positive.

Ground and antenna on the same metal

An antenna needs two conductors, because the radio has to push current onto one and pull it off the other. Here they are the titanium shell and the ground layer of the circuit board, and since the shell is by far the larger of the two it does nearly all of the radiating. This is the ordinary arrangement in small radio products rather than an unusual one, where the chassis is the main radiator rather than a separate antenna part, like modern smartphones.

The contradiction is that the shell must also be circuit ground. If it were simply wired to the board's ground, the radio would have both of its terminals on the same node and nothing would radiate. The two are therefore joined through one small inductor, which behaves as a wire at direct current and at the 25 kHz the sensor uses, and as a high impedance at 2.4 GHz. The shell is a single node with the board for the battery, the charger and the sensor, and a separate conductor for the radio. Because radio frequency current runs on the outer surface of the shell, the electronics inside stay shielded from it.

Limitations of this design

This architecture is assembled from established parts and it has not been verified to completely work together other than fit. It has not been reviewed by a radio engineer, and it needs to be further prototyped. The radiating efficiency of a gold plated titanium bar worn against a body is unknown and needs to be tested further in a fully assembled pendant. Moreover, the chain is electrically continuous with the shell, which makes it part of the antenna and makes the tuning depend on which chain the wearer chooses, so isolating it with a non-conductive material at the connection point is to be further explored. Antenna design is a specialist discipline and this project did not include one. After all, this is not the final product, and it remains a prototype. This technology exists in a similar form factor (such as the Aura Ring), and thereby, a comparable product like this pendant should be able to be manufactured at this scale.

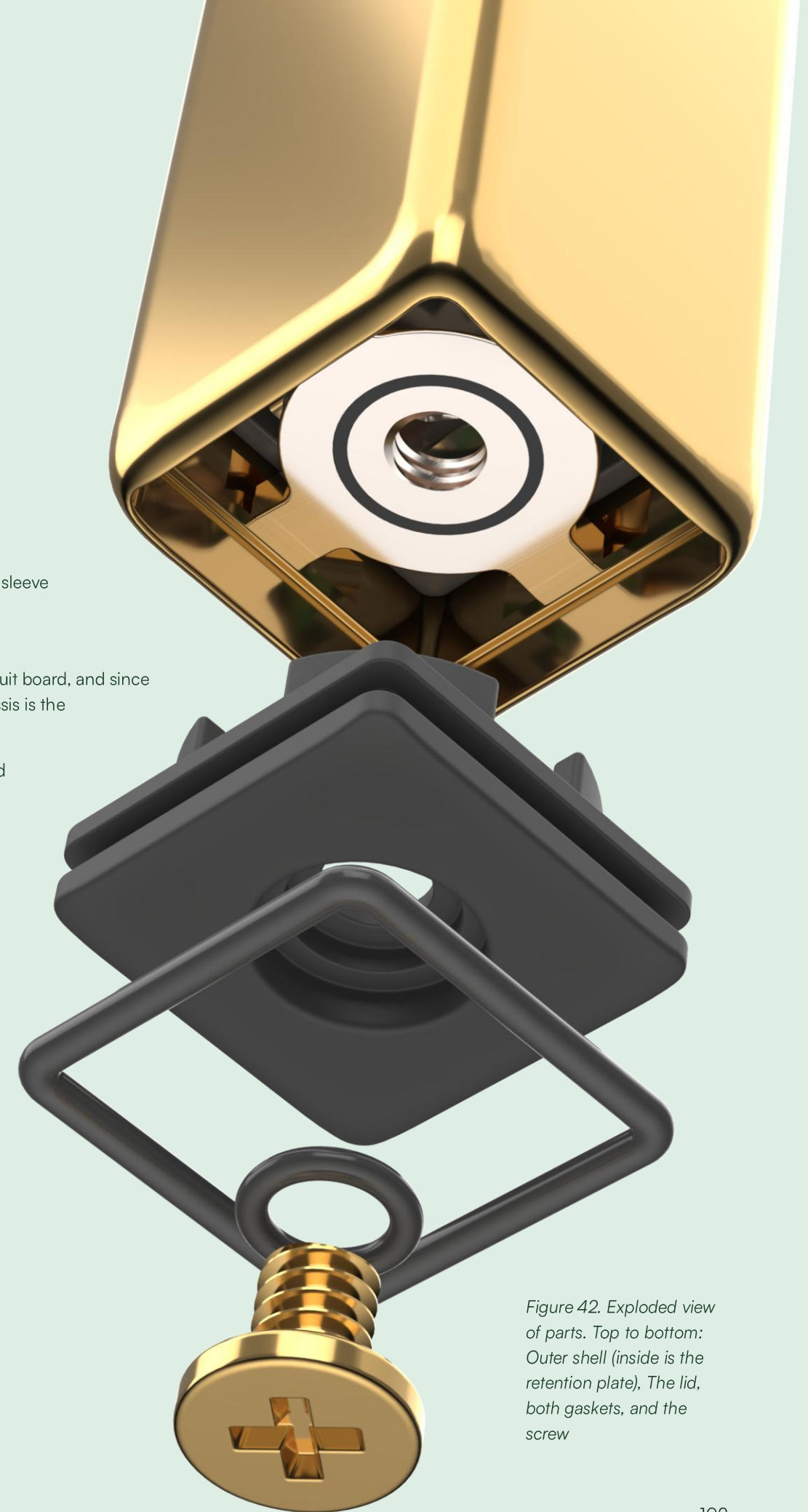


Figure 42. Exploded view of parts. Top to bottom: Outer shell (inside is the retention plate), The lid, both gaskets, and the screw

4.9.4. Charging by standing it in a dish

The pendant charges by being stood upright in a jewelry dish like charging dock. As participants described likely charging the device in their bedroom, the charging has to be able to be done at night (near dark), so the charging port sits at the middle so that it can be found easily while approaching from any angle by hand. The charging dish contains space for other jewelry the user would wear daily.

To aid in ease of charging, a magnet sits under the well of the dish (see *Figure 43*). The retaining plate inside the pendant is machined from stainless steel, which is magnetic, so the magnet pulls the pendant down into the well and holds it there, taking care of the last millimeter of alignment. The well is a shallow funnel, so the pendant only has to be dropped roughly into the right place. Spring loaded contacts in the base then meet two surfaces: the outer shell, which is ground, and the head of the screw, which is the positive input. Because the pendant and charging entrance are symmetrical, orientation does not matter.

Designing against the chain

A dish with exposed contacts and a metal chain in the same dish is a short waiting to happen. The measures against it: the charging cavity is relatively deep so that the chain cannot hit the contacts, the dish stays electrically dead until it recognizes a pendant rather than a random conductor (such as the chain), and the current is limited so that it does no damage. Regardless, the dock charges at voltages that are not dangerous to touch. The BQ25100H component is the charger and a TPS7A02 regulator feeds the 15 mAh Panasonic CG-320B pin cell, with charging and regulation split across two parts because no single part small enough could be placed.



Figure 44. Pendant charging in a charging dish

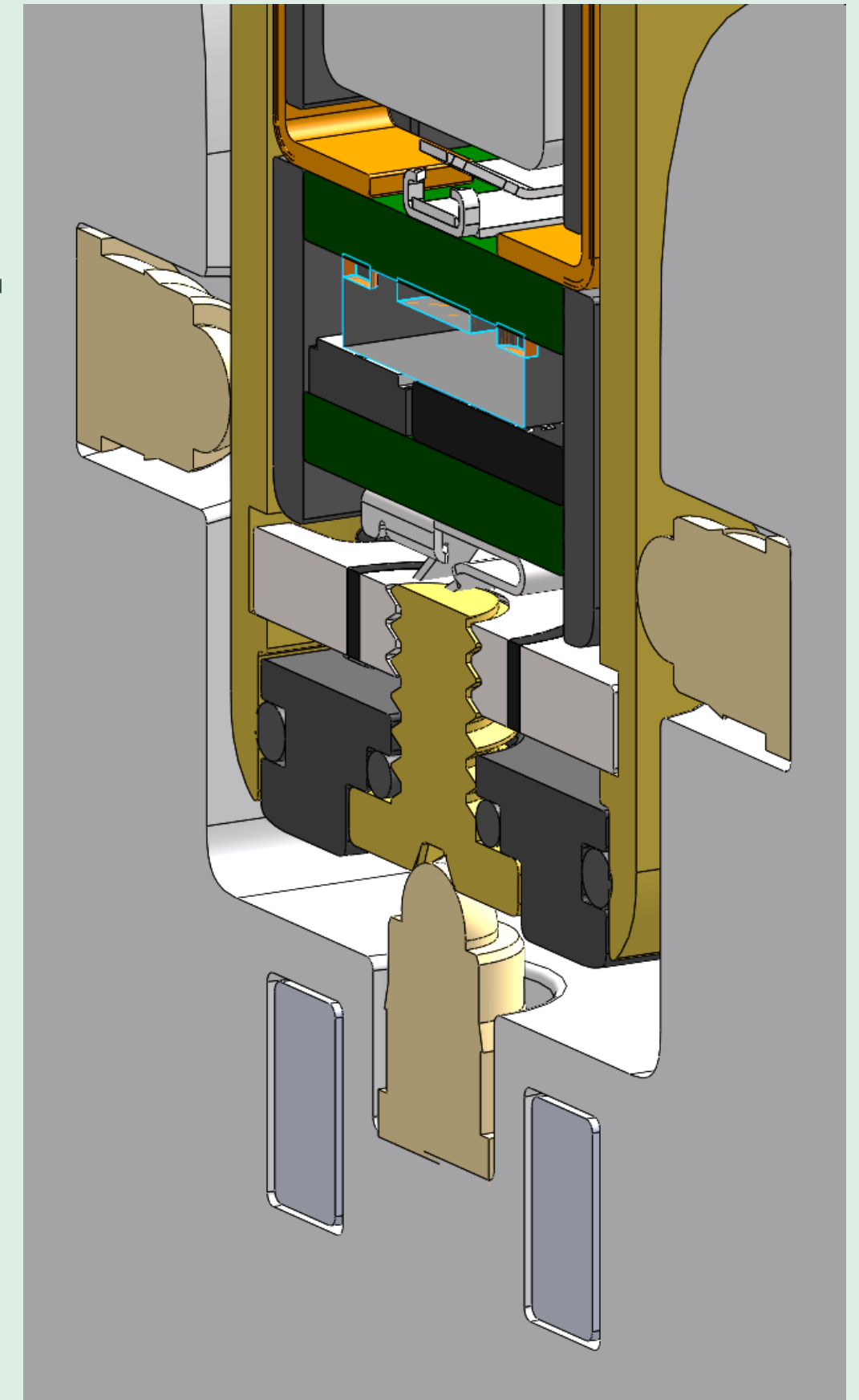


Figure 43. Cross section through the dish and the docked pendant. Magnet under the well, the retaining plate inside the pendant. The pogo pins make contact with the screw head and shell, and the screw makes contact with the spring leaf contacts that are attached to the PCB.

4.9.5. Fitting the electronics into 6.7 millimeters

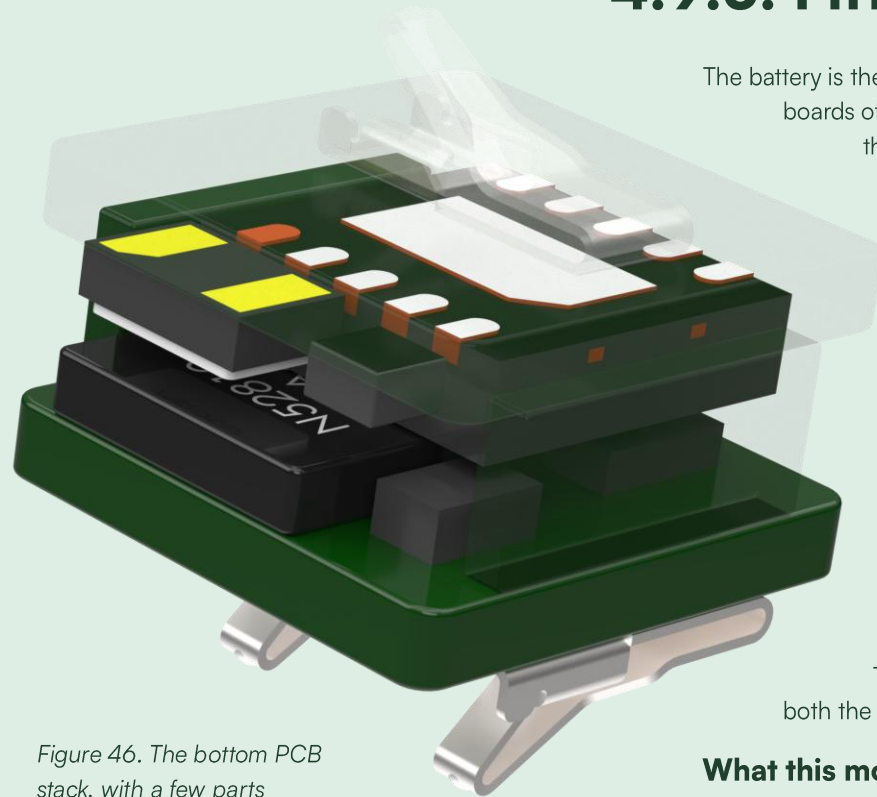


Figure 46. The bottom PCB stack, with a few parts transparent so the PCB components can be seen

The battery is the largest object in the pendant and it occupies the middle, so the electronics are split around it into three boards. Two double sided boards of 4.5 by 4.5 by 0.6 mm sit at the lower end, joined by castellated rails so the pair behaves as one. They carry the radio, the sensor, the charger and the regulator, together with the leaf springs that hold the cell. A third board sits at the upper end directly beneath the motor, carrying the haptic driver, and the leaf spring that holds the other end of the cell. A flex cable runs the length of the battery to join the two PCBs, and the two electrode flexes for the capacitive gap sensing connect to the stacked pair at the lower end.

That split is not only a packaging decision. Keeping the haptic driver at the motor keeps the motor leads short, so the flex passing the battery carries a two wire bus and power rather than the switching current that drives the motor. The electrode flexes and the motor flex are kept separate for the same reason, since joining them would have run the noisiest signal in the assembly alongside the most sensitive one.

All the parts are catalogue items. A Nordic nRF52810 holds both the processor and the Bluetooth radio. A TI FDC1004 reads the capacitance, a DRV2605L drives the Precision Microdrives 304-015 motor, a BQ25100H charges the cell through the screw, and a TPS7A0233 holds the supply steady as the cell drains, which matters because a capacitance measurement is only as trustworthy as the voltage it is measured against. Two crystals sit alongside them: a 32 MHz one that gives the radio its timebase, without which it cannot hold the frequency tolerance Bluetooth requires, and a 32.768 kHz one that keeps time while the pendant sleeps, for energy efficiency. A TPD1E05U06 diode protects the exposed screw contact against static discharge, and TE 2329497-2 spring fingers carry both the cell connections and the ground and charge paths to the retaining plate.

What this model does and does not establish

The inductors and passives are not modelled. The parts that decide whether the electronics fit are the large ones, and those are placed with correct scale from manufacturers' CAD models. The smaller parts (such as the capacitors and resistors that every chip needs around them) would fill the spaces in between rather than define it. The model therefore establishes that this set fits the form factor with catalogue parts. It does not establish that this is the layout that will be built. A production board would be laid out by a specialist, and at this size it is likely to differ from the one shown here. If this layout still proves too small, then other alternatives could be considered, such as placing a PCB alongside the battery (isolated by Kapton or foam).

4.9.6. Keeping the inside dry

As the pendant is a piece of jewelry, users will likely want to wear it swimming, showering etc. Therefore, two silicone seals close the pendant: a squircle shaped rubber ring of 4.5 x 4.5 x 0.5 mm snapped around the lid, pressing into the outer shell inner wall, and a smaller 2.2 x 2.2 x 0.4 mm in diameter ring under the head of the screw. Both are replaced at every battery service, which is ordinary practice at a jeweler and the reason the service kit contains seals and a dot of grease (see following chapters). No water resistance rating (IP rating) is claimed in this report: a rating requires a pressure test on real parts, which a jeweler (E6) consulted in this project offered to perform yet has not been done.

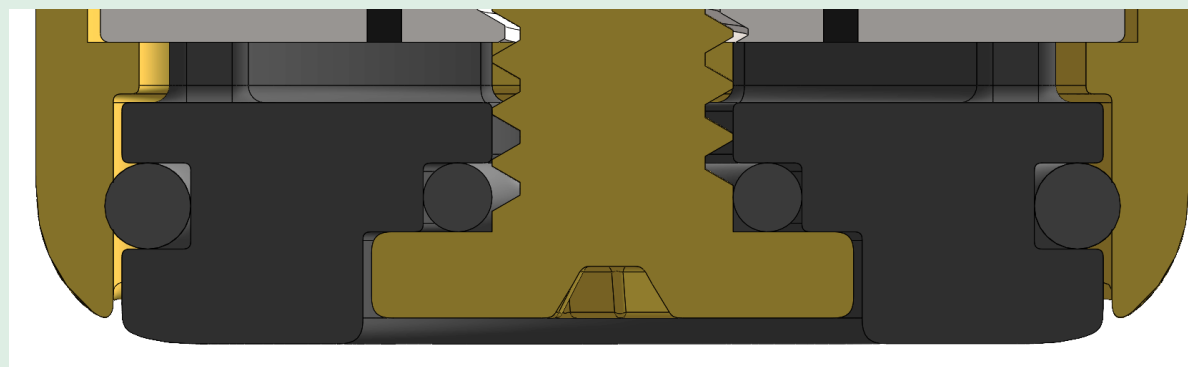


Figure 47. Cross section view of pendant showing the seals.

4.9.7. What changed along the way

The production model went through several revisions driven by answers from manufacturers. An example of which is the custom cell in order to minimize the sizing of the pendant. The exchange established that the required pulse current for the vibration motor was incompatible with their pouch cell sizes, which sent the design back to the catalogue Panasonic cell it now uses (which can provide the correct pulse current with a safety margin). Other changes include the contact between retaining plate and PCB beginning as a pogo pin being replaced by spring contacts to save space. As for the retention plate and lid locking mechanism, the manufacturer identified the internal groove as difficult to machine in a thin-walled tube, three alternatives were developed in response, and the geometry is being resolved with a supplier.



Figure 45. The three boards. The stacked pair at the lower end with its castellated rails and battery springs, the driver board beneath the motor, the flex that joins them along the battery, and the two electrode flexes.



4.10. The final design: the Silvie Pillar

This section describes the result as it stands. Engineering detail, evidence and numbers follow in chapter 5. The design consists of the pendant itself, the “Silvie Pillar”, the app, and the charging dish. The service blueprint and battery service system complete the interaction with the full product service system.

4.10.1. The pendant

A titanium bar of 6.7 by 6.7 by 43.67 mm mirror polished and PVD coated in gold, worn on a chain. Two of its walls are 0.6 mm thick and flex by a few micrometres when squeezed, which is the entire interaction: one deliberate press, along the side, confirms that the promise was kept. The pendant hangs at the height of the breastbone where the vibration is felt, with a twist clasp, which needs less pinch force and less precision than a spring ring. The back face carries an engraving, a milestone chosen by the wearer once she keeps her promises to herself. It becomes a private mark that only she can read.

The Pillar in numbers

Size: 6.7 by 6.7 by 43.67 mm.

Mass: About 5.2 g without the chain (from the CAD assembly).

Material: Titanium, mirror polished, gold PVD over a titanium nitride interlayer (nickel free)

Sensing: Two walls have capacitive gap sensors. The walls oppose, and are 0.6mm thick.

Input: One squeeze along the side, read capacitively through the closed wall.

Output: One haptic pulse, felt on the breastbone.

Cell: Panasonic CG-320B pin cell, 15 mAh, replaced by a jeweller.

Battery life: About 3 days per charge at the fastest response setting, about 6 days at a slower one, and about 10 days if the sensor only listens after a prompt.

Electronics: Three boards around the cell, carrying the radio, the capacitive sensor, the charger, the regulator and the haptic driver.

Charging: Upright in a dish, contact through the screw head and the shell.

Waterproofing: Designed for shower and sea. Not yet measured or rated.

Specifically not in it: A biometric sensor, no screen, no speaker, and no cloud needed for the promise itself.

Figure 48. Real size and gold look. Photo by author, pendant made to look gold by OpenAI. (permission to use OpenAI was granted by participant)

4.10.2. The app

The application is presented here as scenarios to show what happens to a promise over time. Five scenarios follow a single promise through its whole life. She sets one promise in her own words, typed or spoken. She chooses the rough moments at which she wants to be reminded, and the system finds a good one inside them. When a week does not work out, the app offers three ways forward, continue, pause or let go, and proposes a smaller version of the promise rather than a verdict. At the end of the week a reflection shows what she did in her own terms, compared with herself and nobody else, and closes with the sentence the clock handed over: je doet genoeg. There are no cumulative numbers on the home screen, no streaks, and no weekly totals unless she asks for them.

Because the pendant is not on her neck at every hour of the day, the application is also where the promise lives while the jewel is off. The language is positively oriented (health generating): A promise can wait, rest, become smaller or be renewed, but it never breaks. The tone is adjustable in the settings menu, because the sessions split cleanly between women who want softer words and women who want plainer ones. The application was reviewed and rewritten with participants in Dutch, and every word was carefully chosen, therefore it is not shown in English but in Dutch here.

Making a new promise

She writes or speaks one promise in her own words, and chooses the rough windows in which she wants to be reminded, as well as the period in which she wants to try to make this promise work, how often she wants to be reminded per day and vibration strength. The system finds a workable moment inside those windows, and asks for the permissions it needs only at the point it needs them.

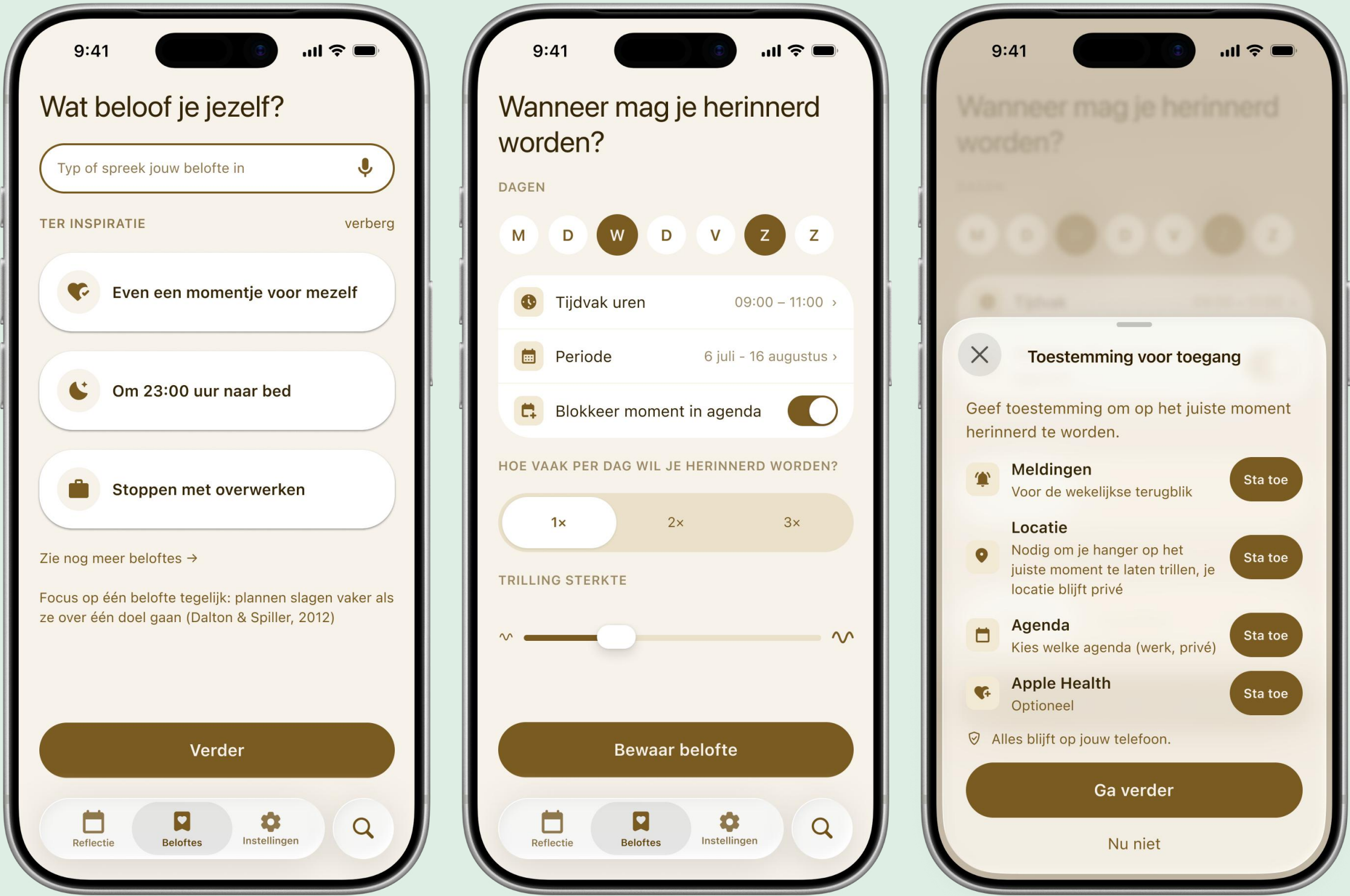


Figure 49. Promise setup in the app.

A week where the promise is kept

A week where she confirmed more times than she promised herself. The pendant vibrates, she keeps her promise and does the thing she set out to do, and she confirms it with a squeeze on the pendant, and the application carries the promise while the pendant is off her neck. At the end of the week a reflection shows what she did in her own terms, and completed promises collect in her archive.



Figure 50. A week where her promises are kept: notification screen, weekly reflection, promise archive, and the day's overview.

A week of little promises kept & settings menu

She managed to keep her promise once this week. We are all human, and life gets in the way sometimes, so the week where nothing happens was designed with the same care as the week where everything does. The app meets her with a positive voice, and offers three ways forward (also offered if she did keep her full promise): continue, pause or let the promise go. If she made a mistake, she can edit her days or promise settings at any time.

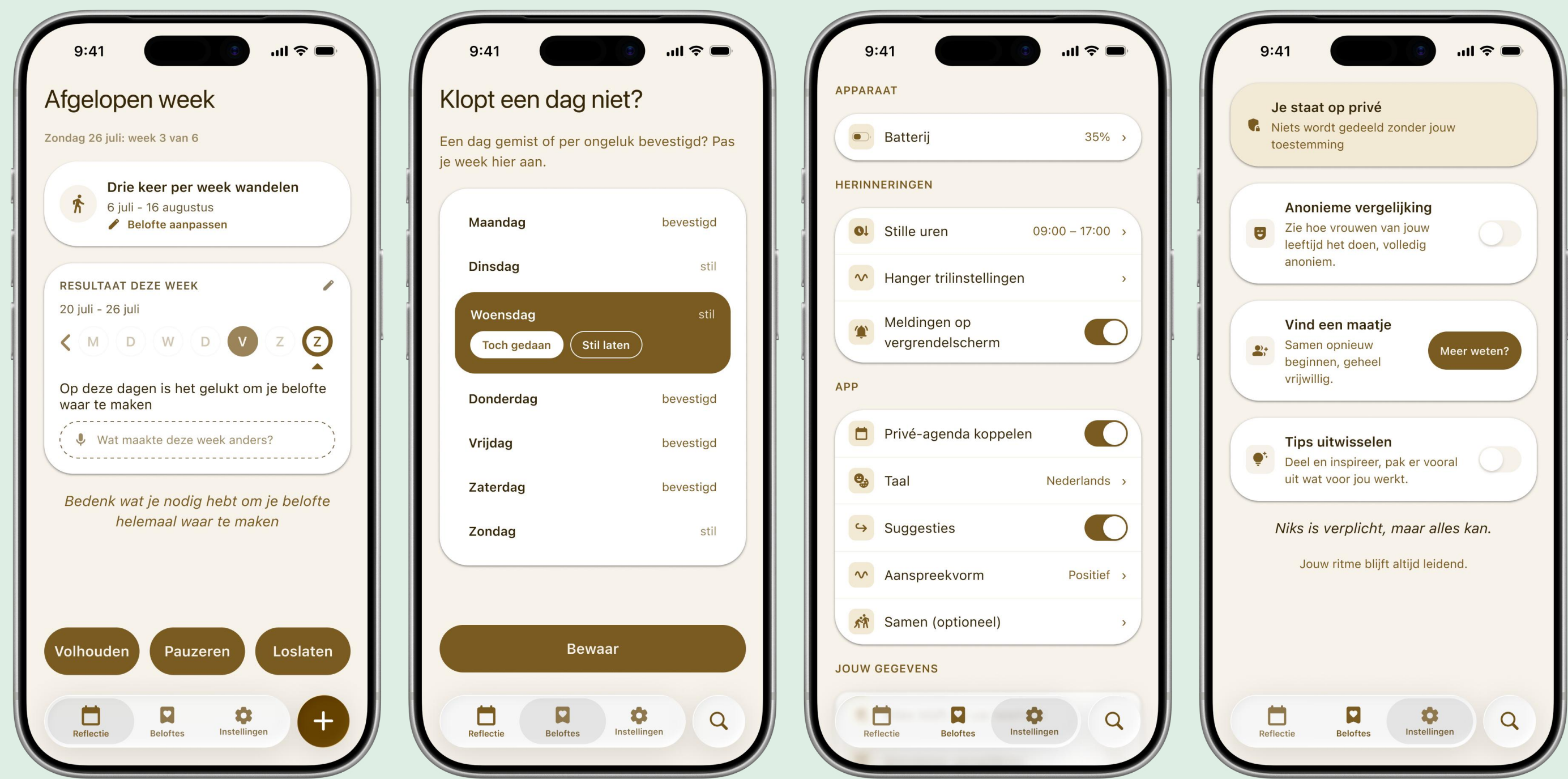


Figure 51. Reflection overview of little promises kept, correction and settings menu's

In the settings menu, she has the autonomy to personalize her experience further: different tones of voice, vibration settings. Some features under “samen” (together) are not completely worked out but participants expressed wanting them: anonymous comparison with other women her age, finding a buddy to keep promises together, and sharing/receiving tips with others.

Pausing or letting go

After a week where she could not keep her promises (see previous page), she has the choice to continue, pause, or let the promise go. If she presses pause, she has the option to choose her own timing, and the app (and pendant if still worn) will remind her again when she has chosen to. When she comes back from a pause, she is offered to cut the promise up in smaller steps so she can ease back into it. If she chooses to let the promise go, the promise is kept under “inspanningen” (efforts), where she can retry the promise whenever she wants to.

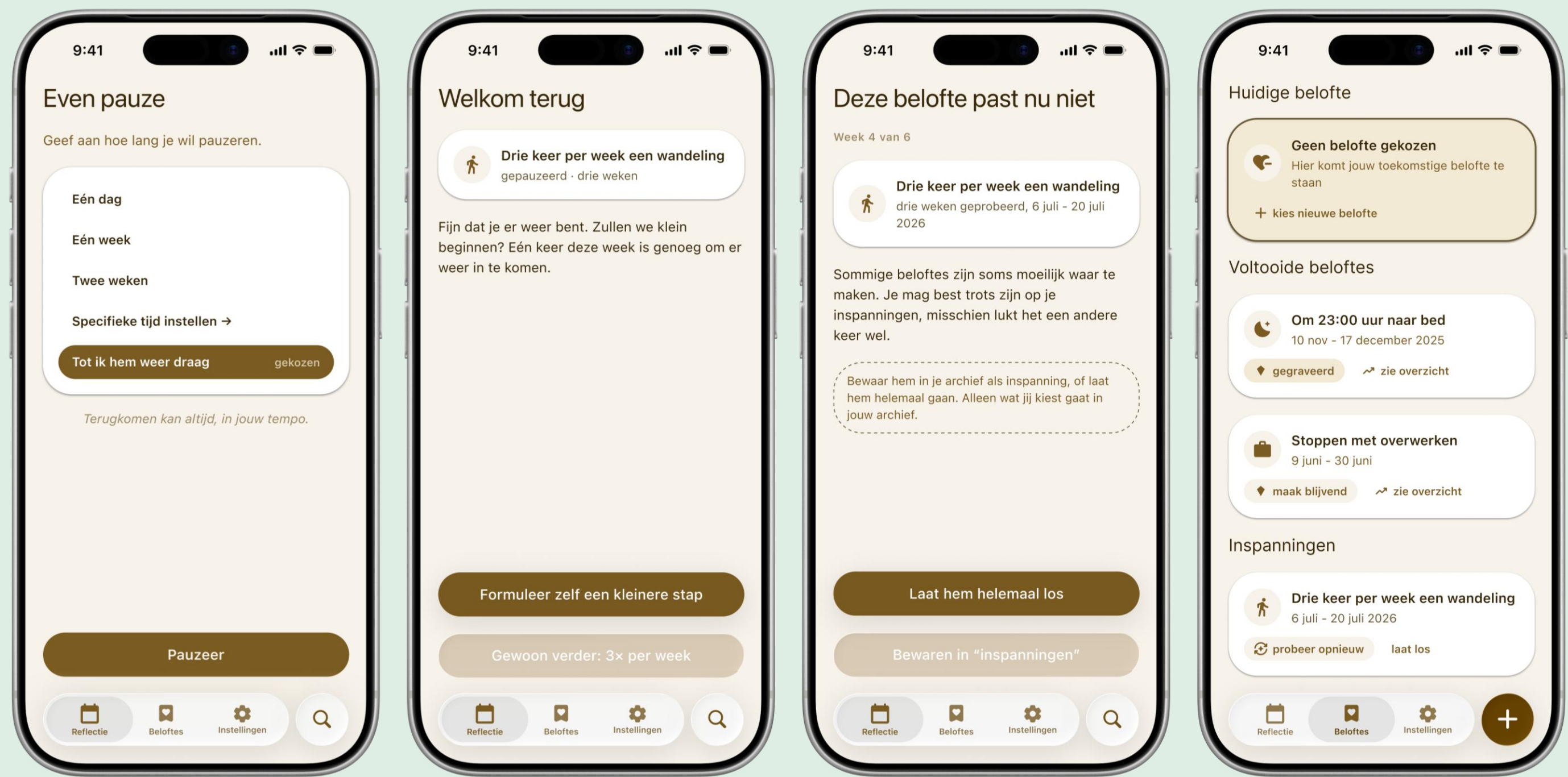


Figure 52. Pause and stopping screens

Making the promise a permanent milestone

When the promise becomes a habit, the promise and its record are kept in the archive. Once the user presses “make permanent”, the app offers the option to have their achievement engraved at a jeweler.

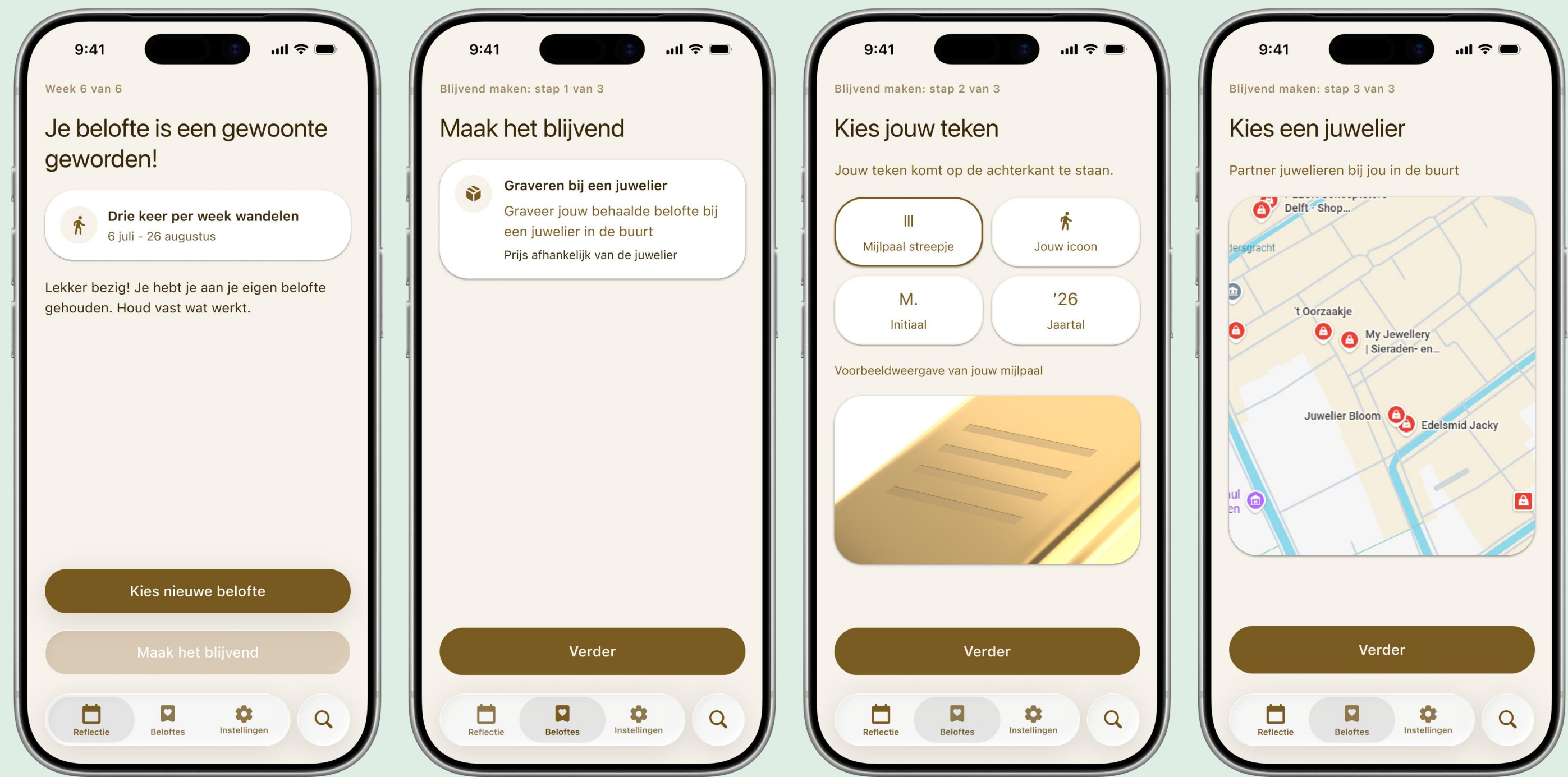


Figure 53. A promise becoming permanent. Overview of setting the engraving and finding a jeweler near her.

On artificial intelligence: this first version of the app uses none. The right moment for a nudge is computed with rules from her own chosen windows, her private calendar's busy blocks, do not disturb, and the weather for outdoor promises, with amount of nudges per occasion set by the user in the app. Future versions could include artificial intelligence to learn on the device from her own confirmations (to drift the nudging moment to where she historically keeps them), and could help with personalization of sentences or provide conversational help on removing user barriers to achieve keeping a promise. No cloud is needed for the core function and no promise text leaves the phone unless she opts in, which also keeps the product in the low risk tier of the European AI Act.

4.10.3. The charging dish



Figure 54. Charging dish rendered in wood material.

A 9 by 9 by 2 cm dish in which the pendant stands upright at the centre, so the user can find the middle of the charging dish at night when it is dark. The chain drapes around it, and there is space for other pieces of jewelry. Charging happens through one bottom pogo pin touching the screw, and multiple pogo pins touching the outer shell. The shell is ground, the contact screw carries the charge voltage. A USB C port sits on one side, and no charger is included, since almost every household already owns one. Placement is left to the wearer, because the sessions showed the object goes where her jewelry already lands, which was the nightstand for some and the desk or kitchen for others. As it would be an added convenience to not have to be home to receive a package, the charger was designed with the height of the letterbox in mind (including packaging).

4.10.4. Service Blueprint

The blueprint maps the system across nine stages (excluding end of life, this is not designed for yet), from the website to a battery service years later. At the daily moment and the weekly reflection, the backstage row is empty. Nothing happens at Silvie while the product does the thing it exists to do, and the support processes at those stages are the phone's own weather, calendar and notification services, each of which improves the experience and none of which is required. The service embodies a "local first" attitude, both in where its data is saved and processed, and how the battery and engraving get serviced. The one step that genuinely needs a jeweller is engraving, since it needs equipment the owner does not have. It has been taken out of the purchase flow for three reasons. The evidence divided rather than pointing anywhere: one participant wanted engraving at purchase and explicitly not for milestones, another wanted it only for what she had achieved and not at the start, two were conditional, and one wanted nothing on it at all. Personalising at the point of sale would also mean that no pendant could ship from the factory finished, so someone in each market would need engraving equipment before the first order could be filled, which is a supply chain built for a feature that needs demand tested on a larger scale first, and is optional in any case. Engraving therefore stays on the table as a later addition, once demand has been tested at a scale this project could not reach, and it is carried into the recommendations rather than into the first version.

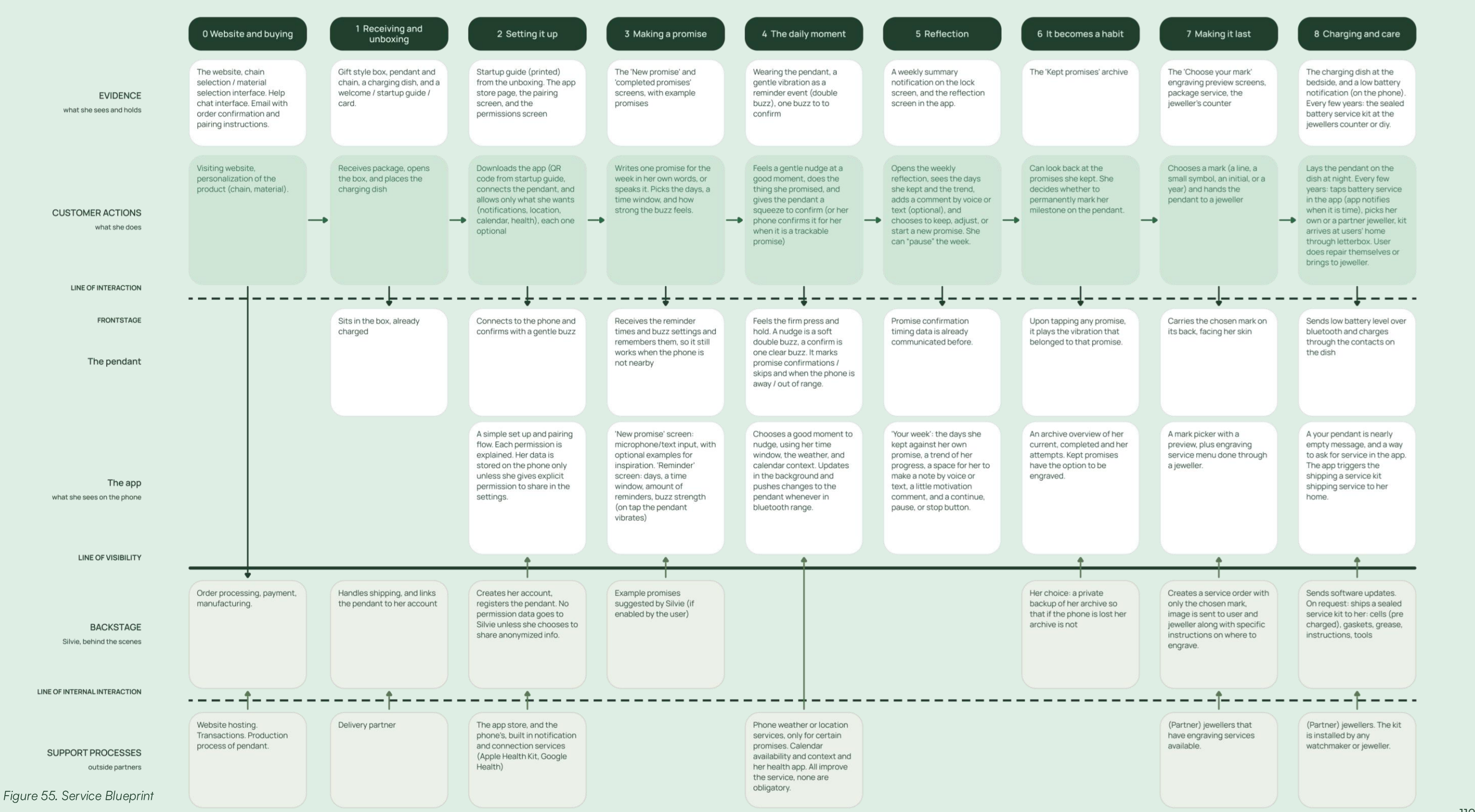


Figure 55. Service Blueprint

4.10.5. The battery service system

The battery is replaced by any jeweller (or DIY), with a kit shipped from Silvie containing the cell, two seals, grease, the tools, and a service sheet. The wearer pays the jeweller their own service fee, so no money flows between Silvie and the shop, and shops appear on an in-app map only after their first service and only if they want to. Engraving runs through the same network with a prepared file pack. The old cell goes into the battery collection the shop already operates for watch batteries.

The procedure was carried out by a jeweller who had never seen the product before, working only from that sheet, and by two participants. It took under 3 minutes on the four-times-scale model, but on a true size model this might require more dexterity as the components are small, which is why some participants mentioned that if they were older, that this might not go as easily anymore.

A jeweller appears in app as a verified option, if the jeweller wants it. The service kit carries a QR code through which any jeweller who has done the procedure once can add themselves to a public list. They are not trained, not certified and not affiliated. The list records only that a shop has said it will do the work, it grows from people who have already done it, it costs Silvie nothing to run, and if nobody ever signs up the service still functions exactly as designed.

SILVIE PILLAR SERVICE SHEET
Battery and seal replacement

#Parts Legend

1Outer shell

2Inner shell

3Battery (Panasonic CG320B)

4Gear clamp plate

5Lid

6Gaskets

7Contact Screw

QR

Scan for the 90 second video and this sheet as PDF

Kit contents

• 1x replacement battery cell (#3)

• 2x replacement gaskets (#6)

• grease dot

• return envelope

• PH0 screwdriver

• Tweezers

• Spudger

Tools

PH0 screwdriver

Tweezers

Spudger

The service, step by step

1. Unscrew the contact screw anticlockwise with a PH0 screwdriver.

2. Lift lid of with tweezers, remove gaskets

3. Twist the gear plate 45 degrees, either way, and lift it out. The springs underneath push it up.

4. Slide the inner assembly out of the shell.

5. Lift the old battery from its two spring clips with the plastic spudger (not with metal). Replace battery.

6. Reassemble in reverse order. Fit both new seals with a thin film of grease first (see next page). Screw to snug.

! Do not touch both poles of the battery ! Use the plastic stick, and keep metal tools off the open boards. The case, lid and gear plate carry no live voltage when the pendant is off its charger.

Never: solder, glue, sharp tools on the seals, or force the screw past snug.

Questions? The QR video shows every step, or mail service@silvie.health

Seals and closing, in detail

The large ring seats on the lid groove. The small ring sits under the screw head. Grease thin, the springs should get no grease on them.

Please dispose of the old battery properly

Bring to your local battery collection point.

Done this service? Get on the map

QR

Scan the QR and register your shop, if you like. Customers nearby will find you for their next battery.

Figure 56. Silvie Pillar Service Sheet. Three pages that travel with the kit written in the format the watch trade is familiar with: which tools are needed & part naming, step by step disassembly and sealing & battery disposal. The QR panels are placeholders for the video and the optional shop registration.

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5.

Validation

This chapter tests the Silvie Pillar against the requirements it was built to meet. Those requirements were written in Chapter 3 for a different problem, so they are restated first as kept, revised, retired or new, and then answered under desirability, feasibility and viability. Desirability rests on 6 sessions with the pendant, 4 of them in person, and on what the client, a working jeweller and the suppliers said. Feasibility mixes a working prototype with a simulated titanium shell. Viability is a cost model built from supplier quotations, so every retail figure in it is modelled rather than quoted. The design held in the sessions. It was not tested over an ordinary week, on a machined part, or in a market.

5.1. How the design was tested

Across the project, 12 women and 6 experts were recruited (as described in chapter 2). A core of five who stayed involved from the first interviews to the final sessions. Some joined mid project through the same channels and met the pendant concept with fresh eyes. Experts were approached directly: a general practitioner, a jeweller, and 13 manufacturers and suppliers. In total six sessions were held with the pendant, four of them in person, and four participants wore the working prototype. Guides are in Appendix I., forms in Appendix H. The sessions changed character over the project, from interviews aimed at understanding to co-design, where participants' corrected the app, chose vibration patterns and opened the pendant themselves. Part of the sessions took place in person and part online. The online sessions used renders and the clickable app and leaned toward language and interface; the in person sessions added size, weight, vibration and the battery service. Every completed session produced before and after forms. The sample is small, and part of it has been involved long enough to be invested in the outcome. The haptic levels were announced by number rather than compared blind.

The six sessions were run by the author. Each opened and closed with the same written sheet in Dutch, filled in by the participant herself, once before she saw the pendant and once after she had held it and worked through the scenarios. Scores were averaged per statement across the participants and reported as the difference between the two means. No significance test was run and none is claimed. The spoken material was not put through the coding procedure used for the interviews in Chapter 2. It was read against the revised requirement list, so each requirement carries what verified it, with each participant's own words standing as the evidence. One session was interrupted before the closing sheet was finished and is excluded from the scales, which is why 5 participants are reported and not 6. All six sessions were recorded and transcribed, with consent. The transcripts are held with the project data and are not published to protect participant privacy (even though they were pseudonymised).

What was not built yet: the fully operational back end / working application, no live cell in the pendant, and no finished material sample (sample arrived only after last sessions were done). Each would have answered a question belonging to a later phase: software behaviour over weeks, battery runtime in daily use, and final finish. Building them now would have cost the time this phase needed for meaning, language and fit, so their absence is a scope and time decision rather than an omission.

5.2. The requirements, revisited

The requirements in chapter 3 were written for a different problem. When the problem changed, the requirements changed with it and are presented in the table below. The table below reports every original requirement as kept, revised or retired, adds the requirements that the pendant added, and states how each was verified and with what result. The first column places every requirement under desirability, feasibility or viability, and the table is grouped that way, because the three sections that follow answer one category each. Row colour shows result evidence. Dark green is where the requirement is met and where there is evidence. The lighter the shade of green, the lighter the evidence. Orange means less evidence, and red means untested. Grey means that the requirement does not apply.

The identifiers changed between Chapter 3 and this table. When the set was revised it was renumbered in the order it now appears, so the numbers do not carry across. Chapter 3's C5 is C1 here; its C1 to C4 are C2 to C5; its W12 is W8; its W10 is W9; and its W11 is W12. Chapter 3's W8 and W9, on professional credibility and on augmenting professional care, are carried here as W10 and W11. The status column refers to the requirement, not to the number.

Table 10. Revised list of requirements, their status, validation type, and result

Category	ID	Requirement, current wording	Source	Status	Verified by	Result
Desirability	D1	The product must help her cross from knowing to doing	Participants, literature	Revised, change of problem statement	Form evaluation and participant feedback	Met, evidenced, yet requires longitudinal behavioural study (not in scope of this thesis)
Desirability	D2	The product must be salutogenic: comprehensible, manageable, meaningful	Literature (Antonovsky)	Kept	Form evaluation and participant feedback	Met on meaning and comprehensibility, manageability
Desirability	D3	The product must feel dignified	Participants, literature	Kept	Form evaluation (semantic scales) and participant feedback	Met, evidenced
Desirability	D4	The user can reach the source and reasoning behind a suggestion	Participants, literature	Not yet implemented	Design decision	Not applicable: The only place where the product has suggestions is in the new promise menu in the app. D4 is a demand, so this is recorded as not yet met rather than as not applicable: where the app suggests a promise or a smaller step, the reasoning behind that suggestion is not reachable by the user. Closing it is carried into the recommendations.
Desirability	D5	The product is honest about certainty, proof and patterns	Participants, literature	Kept	Sessions	Met, evidenced
Desirability	D6	The product must protect her autonomy	Participants, literature	Kept	Sessions	Met, evidenced
Desirability	W1	The product should make her own progress known to her	Participants, literature	Kept	Sessions	Met, evidenced

Desirability	W2	The product attaches to an existing moment or ritual	Participants, literature	Kept	Buzz windows, dish placement	Met in design, sessions
Desirability	W3	Matches the cadence she is able and motivated to keep	Participants, literature	Kept	Weekly rhythm, pause, self set frequency	Met in design, long term open
Desirability	W4	Burdenless enough to keep using over time	Participants	Kept	One squeeze, no daily input required, weekly reflection, charging and servicing ritual	Met in design, long term open
Desirability	W5	The product asks as little digital literacy as possible	Participants	Kept	Sessions with participants	Partly
Desirability	C1	Single handed, low force, readable for women 55 to 70	Demographic, GPSR	Kept	Sessions with the working prototype	Partly, gesture needs teaching once, force required is ok, chain needs easier opening mechanism for those with limited dexterity (existing, easy implementation)
Desirability	W6	The product grows with her over time, allows extension to other health pillars, offers personalization	Client, backcasting	Kept	Promise types open by design, personalisation in app	Met in design
Feasibility	C2	Any intelligence stays in the low risk tier of the AI Act	Regulation	Kept	Version one uses rules, coming versions will run on the device	Met in design
Feasibility	C3	Privacy by design: minimal data, local by default, she controls sharing	Regulation	Kept	Data overview model	Met in design
Feasibility	C5	Safe physical product for older adults	Regulation	Kept	Risk table	Partly, formal assessment open
Feasibility	N2	The product survives water: shower and sea	Participant (P11)	New	Seal design	Designed for, but untested
Viability	W7	The product stays on the wellness side of the medical device regulation	Regulation, client	Kept	No biometric sensing, no diagnosis	Met in design
Viability	W8	The product is feasible to produce and bring to market within about two years	Client	Kept	Bill of materials, supplier correspondence	Met partly
Viability	C4	Only authorised wording for any claim about supplement effects	Regulation	Not relevant	Content rule in app	Not relevant for this design, taking a supplement can be one of the possible promises she makes to herself, but there is no claims in the app
Viability	W9	The product remains suitable for the next, more digital cohort	Future vision	Kept	Design decision	Not tested, out of scope
Viability	W10	The product takes pressure off healthcare	Expert (general practitioner), Future vision	Revised, previously that a general practitioner would find it credible	Expert interview	Met, evidenced for the clock, not tested again for the pendant.
Viability	W11	The product makes it easy for a healthcare professional to review her regimen (when consented to)	Expert	Kept, not yet designed for / implemented	Expert interviews	Not applicable
Viability	W12	The cost to the user is defensible against the benefit she receives	Participants	Kept	Price expectations against the cost model	Partly, real prices open
Viability	N7	The product should be repairable (to extend its lifetime and reduce environmental impact)	Upcoming regulations (future vision), service design, current market failures	New	Two participants and one jeweller performed repair, service blueprint	Met and evidenced on the cell, met in design on the rest

5.3. Desirability

Desirability asks whether the design addresses the values and needs of the user (and stakeholders involved). Twelve requirements carry that question. She has to be able to cross from knowing to doing (D1).

The product has to be salutogenic, which is to say comprehensible, manageable and meaningful (D2). It has to feel dignified (D3), stay honest about certainty, proof and patterns (D5), and protect her autonomy (D6). It has to make her own progress known to her (W1), attach to a moment she already has (W2), match a cadence she is able and motivated to keep (W3), stay burdenless enough to keep using over time (W4), ask as little digital literacy as possible (W5), and grow with her (W6). It has to work in one hand, at low force, and be readable for a woman between 55 and 70 (C1).

For the product service system to be found desirable, the pendant has to be worn willingly as jewelry, the interaction with the device is understood and welcome, and it earns a place over existing wearables, and next to the phone she already owns.

Throughout the project, many sessions were held with stakeholders. For the last round, six sessions were held with the final prototypes and material (as shown in the previous chapter). Four of them were held in person, and four participants wore the working prototype. Sessions used the drawn-out scenario, the functional prototype on a chain, a correctly sized printed model, the app prototype, and the dish in three printed sizes with material renders. Each session opened and closed with a form (see Appendix H.). The written scale came first, then the prototypes. Physical models of the dish and the service kit were only shown where the session was in person, and renders were shown to almost everyone.

5.3.1. It reads as jewelry

In the semantic scaling at the end of the session (see upcoming subchapter), all four who wore the working pendant placed it on the jewelry side of the apparatus to jewellery scale. “... als ik dat nu zou hebben, zou ik dat dragen” (P10). “Dan zou ik hem elke dag dragen. Het is ook een sieraad” (P03). One participant never wears gold, but would wear a silver option instead. One would wear it hidden under her clothing against theft, the other would wear it proudly visible. One critiqued the plastic bottom for cheapening the object and suggested it become a more premium-looking material such as wood or gold, a recommendation for future iterations.

At the close of each session the object was rated on four semantic lines. It reads as for everyone rather than for old people (4.5 of 5), as respectful rather than patronising (4.5), and as jewellery rather than a device (4.8), each on four answers. Almost all the distance from the ceiling comes from one participant, who marked a three and two fours where the others marked fives. These contribute to evidence for D3 (the object must feel dignified).

Figure 58. Render of CAD model

Figure 57. Pendant worn by a participant. Photo by author, gold look added by Gemini (was white plastic), (permission to use Gemini was granted by participant)



5.3.2. It is wanted, and the body beats the phone

The scenario round had already produced unprompted purchase intent from three participants, and the working object did not weaken it. Asked the direct question, P11 answered with a flat yes and positioned the product more sharply than the project had: “Al die berichtjes en al die tingetjes en lichtjes, het is zo obvious de hele tijd. En dit is veel kleiner, veel privéer, veel meer op mij gericht. Hier is het one single ding. Echt alleen maar eentje. Eén ding. Maar wel een heel belangrijk ding.”

Asked whether the same thing could not simply be a notification on the phone, three of five were clear that the body wins. “Wat je op je huid draagt, wat je ook voelt trillen, zou bij mij meer impact hebben dan als het via de telefoon gaat. Want het is een beetje verbonden met je lichaam, met wie je bent” (P04). “Dit is iets wat je niet hoeft te zoeken. Het raakt je ook niet kwijt, want het hangt om je nek” (P11). “Ik denk dat het voor mij zou helpen, omdat het echt op mijn lijf zit” (P08). One was conditional and one was split, judging the phone more practical for a wider audience while preferring the pendant for herself. The value named was never information. It was presence, privacy and meaning. P11 also ranked the two halves of the product honestly: “dat aanslaan heeft voor 80% met het apparaat te maken en maar 20% met hoe het eruit ziet.” The gold buys permission to wear it. The promise is why she wears it. This is also where requirement W2 is answered: the object attaches to the body rather than to a screen, so it is always with her, it adjusts completely to her day and her wishes.

5.3.3. The gesture

The first squeeze failed at first try for all, because the participant consistently squeezed the side the sensing electrodes were not on. After a short demonstration every participant confirmed successfully. This is an onboarding and placement finding rather than a failed mechanism: the prototype electrodes were accidentally stuck to the wrong sides. Intuitively however, participants pressed on the correct sides first. As an assurance the gesture is taught well, a future exploration could be to either teach the gesture once in the app at onboarding or enable sensing on all sides. The C1 requirement is met on force and on reach, but met only partly on immediacy, because the gesture might have to be taught once.

Both the nudge and confirmation vibrations needed adjustment. The two lowest levels (0.15G, 0.25G) were imperceptible to one participant while another felt the lowest clearly, so strength became a per wearer setting and slider in the app at promise setup. When the pendant was off the body, users could still perceive it through the chain. Long patterns won over short ones, “prik prik is te weinig” (P03), so the long pattern became the default and the short one was dropped. Repetition stops after three, “hij moet niet door blijven gaan” (P10). P11 designed the escalation herself: two soft reminders and a third that cannot be missed, the last chance for that day.

5.3.4. The voice of the app

The gentle voice used in the app was endorsed, but the tone needed a range. “Lekker bezig” read as too familiar to one participant, so the inner voice became adjustable across three tones with the neutral one made plainer. A weekly header that asked “hoe trouw was je aan jezelf” was judged too loaded and was rewritten amongst many other tiny adjustments in wording. Both are findings about D3: dignity is decided in the wording.

Three rules came directly from the sessions, and each of them is a finding about D5 (honesty, proof and patterns). Kindness may never rewrite what happened, after the app softened a hard week into “iets rustiger” (aiming at the promises not being kept this week) and was caught: “heel misleidend. Het was helemaal niet rustig” (P01). One term is used everywhere, after the same participant noticed the scenario mixing promise and intention. And interface text teaches behaviour: upon reading the pause option “until you wear it again”, P11 said “als je hem eenmaal af doet, gaat hij in een laadje. Dan komt hij nooit meer terug” (P11), so an option was added to set the pause duration herself.

Autonomy was tested wherever the app asks something of her. If a promise was not kept that week, the flow was co-authored with participants into continue, pause or let go. Dedicated settings were added to support her autonomy. Two participants asked for distance and yearly overviews, which future design explorations could consider as self relative options. That is D6 and W1 held together: her own progress is shown back to her, on her terms, and never as a score against anyone else. Generally, the app was found manageable and presented a clear overview. However, one participant missed the promise input field entirely. W5 is recorded as partly met rather than met: digital literacy is designed for, but not tested at large.

Figure 59. Participant wearing the functional prototype on breastbone to feel the prompt and confirmation vibration variations.





Figure 60. The jewelry charging dish tested for its size in three alternatives

5.3.5. The charging dish

Size was settled with three 3d printed docks. Eight by eight centimetres was too small for most, ten by ten unnecessary (and too big), and nine by nine comfortably held a ring, earrings, a watch and the pendant. Placement could not be settled, and that is the finding: the dish goes where her jewelry already lands, which differs for every participant (contributing to requirement W2). A charging light in the bedroom was rejected outright, “ik heb bloedhekel aan lichtjes” (P11). Participants could find the charging dock and pedant docking point easily (with their eyes closed, to simulate a dark room at night).

Material was not settled, and the disagreement is the finding. On looks the preferences spread. One participant wanted neutral and answered black, with plastic acceptable (P03). One liked the porcelain render as it stood, "dit past wel het beste bij het kettingtje zelf, omdat het strak is" (P01). One wanted something rougher than porcelain and named wood (P10). One went to white marble (P04). Porcelain and marble were rejected on their properties by the same participant who admired them, "nogal fragiel en ook duur" (P04). The one argument made on function came from P11 and was about sound and damage. Wood is "een geruisloos materiaal," so a piece of jewellery dropped in carelessly makes no noise and nothing breaks, where "als het metaal is en ik gooi daar een mooi sieraad in en het komt toevallig verkeerd terecht, dan maak ik iets kapot." Wood is carried as the working choice on the strength of that argument rather than on a majority, and the material is recorded as open and needs further exploration.

5.3.6. What the written scale measured

Table 11. written scales: comparison of participants’ answers before and after seeing the prototypes

Statement	Role	Measurement	1	2	3	4	5	6	7	n	Mean	Change
I know what my body needs.	comprehensibility	before			1		2	2		5	5,0	+0,8
		after					2	2	1	5	5,8	
I regularly doubt whether I am doing the right things for my health. (reverse worded)	control item	before			1	1	2	1		5	4,6	+0,4
		after		1		1		2	1	5	5,0	
I have a grip on my daily health.	manageability	before	1			1	2	1		5	4,2	+1,2
		after			1			4		5	5,4	
What I set out to do for my health, I manage on busy days too.	manageability	before	1	1	1	1	1			5	3,0	+2,4
		after				1	2	1	1	5	5,4	
If it does not work out one day, I pick it up again easily afterwards.	manageability	before			1	1	1	1	1	5	5,0	+1,0
		after				1		2	2	5	6,0	
What I do for my health day to day feels meaningful.	meaningfulness	before					1	2	2	5	6,2	+0,6
		after						1	4	5	6,8	

Each session opened and closed with the same short written scale (see Table 11. written scales: comparison of participants’ answers before and after seeing the prototypes, Appendix H. for form), administered in Dutch. Six statements, scored from one (helemaal oneens) to seven (helemaal eens), covering the three components Antonovsky treats as constitutive of a sense of coherence: comprehensibility, manageability and meaningfulness. Six of the ten are reported here. The remaining four asked specifically about supplementation and no longer applied once the concept changed. Participants completed the first sheet before they saw the pendant and the second after they had held it and worked through the scenarios. This is the evidence behind D2.



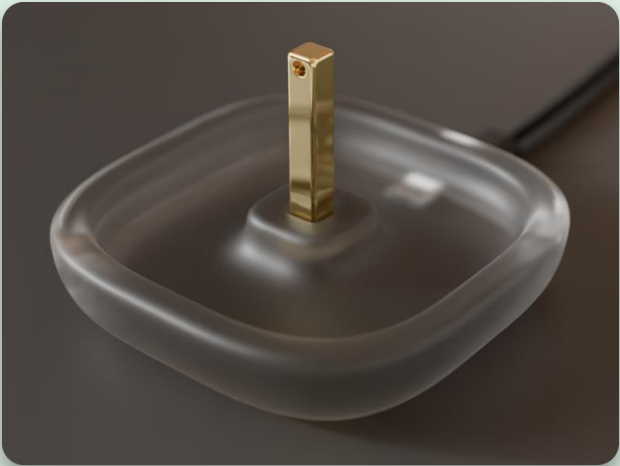
Porcelain



Walnut



White oak



Glass



Pink marble



Marble

Figure 61. Dish material options

Five participants are reported (a sixth session was interrupted and therefore excluded from analysis).

Movement concentrates in manageability. Statement 6, on whether an intention survives a busy day, began at 3.0, the lowest score anywhere in the set, with the five participants spread over the columns. Afterwards none scored below four and the average stood at 5.4. Statement 5, on grip on daily health, moved from 4.2 to 5.4, with four of the five converging on six. Statement 7, on picking things up again after a lapse, moved from 5.0 to 6.0. Comprehensibility moved less: statement 1 rose from 5.0 to 5.8. Meaningfulness was already high and stayed high, from 6.2 to 6.8, which limits statement 8 to showing that the pendant did not disturb something these women already had.

Statement 3 is reverse worded and included as a control question. It asks about doubt, so agreement is the worse outcome and a rise means the opposite of what a rise means everywhere else. It moved least of the six, by 0.4 against shifts of 0.6 to 2.4 on the others. Had participants been agreeing with whatever was placed in front of them at the close of a friendly session, this item would have risen with the rest. It did not, which makes acquiescence a less plausible explanation for the five that did.

Three limits govern how far this reaches. Both measurements come from a single sitting, before and after handling the pendant, so the difference records what the object led five women to expect rather than what wearing it produced. Establishing the latter requires longitudinal measurement, which falls outside the scope of this project. The group is five people, in which one participant carries a fifth of every average, and a shift of one scale point by a single participant moves that average by 0.2. Manageability also carries three of the six statements while comprehensibility rests on one.

5.3.7. Measured at the end of the session

Table 12. After session forms. Responses by the participants.

Response to the pendant (1 = strongly disagree, 7 = strongly agree)										
Statement	1	2	3	4	5	6	7	n	Mean	
A pendant like this would help me trust what I notice myself.						3	2	5	6,4	

Expectation, if the pendant were worn for some months (1 to 7)

A stated expectation about an imagined future, not a measured effect.

Statement	1	2	3	4	5	6	7	n	Mean	
I would know better what my body needs.					1	1	2	4	6,3	
I would have more of a grip on my daily health.				1			3	4	6,3	
I would rely more on what I notice myself.						3	1	4	6,3	
I would allow myself time for myself more often.							4	4	7,0	

How does the pendant feel? (a cross on each line, 1 to 5)

Left anchor	1	2	3	4	5	Right anchor	n	Mean	
for older people			1		3	for everyone	4	4,5	
patronising				2	2	respectful	4	4,5	
a device				1	3	jewellery	4	4,8	

This is where the object stops being a reminder. What the participants described is not a function they wanted added but a meaning they attached themselves: the jewel holds something they decided about their own life, and it gains worth as that thing is kept. W6 is answered here, because what grows with her is not only the object's capability to grow with her promises, but grow in meaning as time passes.

P04 rejected the strongest version of one of the statements: “je legt jezelf een doelstelling waardoor je beter weet wat je lichaam nodig heeft. Dat is heel discutabel. Want wat je lichaam nodig heeft, dat is ook gewoon medisch onderzoek.” That claim has ground, and the claim is narrowed accordingly: the product helps her act on what she already knows, and does not tell her what her body needs. The optional database of promises that the app suggests (fed by Silvie’s expertise on synthesizing research on women’s health over 55) do not go as far as to make her know what her body needs.

Three further blocks were completed at the close of each session, after the pendant had been handled. None of them has a before measurement, so none can show change. Each records a position taken once, with the object in hand. The fourth block, the semantic lines on how the pendant feels, is read above.

Response to the pendant

All five agreed that a pendant like this would help them trust what they notice themselves: three at six, two at seven, a mean of 6.4. Nobody used the neutral point and nobody sat below six. This is the item that speaks most directly to the promise the object is built on, and it is the only one of the blocks answered by everyone.

Expectation

Asked to imagine wearing the pendant for some months, the four who answered projected five to seven across the items, and all four gave seven to allowing themselves time for themselves. This is a stated expectation about an imagined future rather than a measured effect, which makes it the weakest evidence in the set. What it establishes is that nobody recoiled from the prospect, not that the prospect holds. One participant left the block blank as the session was cut short due to an interruption.

5.3.8. What the object came to mean

The idea of carrying something personal and attaching emotional value in the object came from the supervisory team, Stefan Persaud and Gianni Orsini, as a memento, a strand of hair or sand from a place that matters. When ideating with participants about multiple directions and emotional connections (like making the promise to a younger or future version of themselves or to a loved one), participants took the thought further in their own direction. P04 pointed at an existing ritual rather than an invented one, the bead necklace that children in oncology care fill with one bead per treatment: “ik vind het mooi dat mensen de mogelijkheid hebben om trots te zijn op wat ze hebben bereikt, en dat kunnen laten zien.” P11 turned the same idea into reward logic: “die oude belofte zou ik wel willen houden, want daar ben ik dan wel trots op.” Participants specifically wanted the promise to be to themselves, private, not to anyone else. It became engraving, a milestone mark when a promise is completed. Sensitivity to it varies. P08 saw little in it at first, having as a vow at purchase, then reconsidered: once she had accomplished the behaviour, she would seriously consider a mark. Engraving is therefore optional, and its content ranges from a legible word to a private sign.



5.3.9. Desirable for the others involved

Desirability is asked of the stakeholders involved, not of the wearer alone. Four other parties carry this product: the client who would sell it, the jeweller who would service it, the healthcare professional whose time it is meant to protect, and the manufacturers who would build it. Each was put in front of the design, and each answered with a qualification worth keeping. The commercial and technical detail sits in the two sections that follow; what is reported here is only what it says about desirability.

The client

The complete system, the design, the bill of materials, the supplier correspondence and the service model, was presented to the chief executive of Silvie Health. He endorsed the direction and set the build sequence, and he identified where the product closes a loop with the company: when the wearer chooses a new behaviour, the options draw on Silvie's existing literature reviewed evidence base on preventive lifestyle interventions, which is what separates them from generic wellness advice. He also found the one thing the design had not accounted for. Personal engraving had been assumed to happen at the shell manufacturer, and he pointed out what that implies: engraved in Asia, every personalised pendant carries the lead time of an intercontinental shipment. That is a desirability problem before it is a logistics one. He was open to solving this through purchasing laser engraving machines locally, if the demand of engraving at purchase was proven beyond the small sample size of this thesis, and he offered a budget and ways to test this. His approval indicates organisational fit, independent demand at larger scale must be proven outside the scope of this thesis.

The jeweller

A working jeweller (E6) was handed the service model and the service sheet, with no briefing, and performed the entire battery replacement at his own counter, on a model printed at four times true scale. His verdict on the documentation was the one the service was designed to earn: "sommige artikelen is het nog wel eens uitvogelen, maar dit is glashelder." He needs no training and expects that half his staff could do the job. He agreed to be listed as a service point in the application without asking for a contract, and offered, unprompted, to pressure test the sealed pendant on his own equipment, since he will not guarantee a water resistance he cannot measure.

He also corrected the design in six places. The kit has to carry a plastic spatula, because he does not stock one. Spare seals belong in every kit, because seals degrade with moisture and time, which he sees in watches. Fourteen carat matches the Dutch market better than eighteen, so a chain bought separately does not clash. The hole in the pendant has to open from its present 2.75 millimetres to about 3.2 or 3.5, which is what the chain eyes he measured need (to the chain thicknesses the pendant would match with), and it should have a tight tolerance so the pendant does not drop when the chain comes off. Where a wider hole is unwelcome, a bayonet clasp on a multi-strand chain threads without one, and magnetic clasps are not an option because "die komen los". And for hands in their seventies, oversized clasps and eyes should be fitted after the chain threaded through the hole.

What the jeweller refused is the more useful finding. He would not put the pendant in his display case. Asked where it belongs he answered "ik denk inderdaad iets wat in de zorg zit," and reached for his own parents taking medication rather than for jewellery. He then qualified his own answer without being asked: "ik ben geen trendsetter, maar trendvolger. Dus dat is niet de juiste vraag aan mij, denk ik." The service is desirable to the trade and the evidence for that is behavioural, since he performed it. The retail proposition is not desirable to this jeweller, and the channel question is still open, yet most wearables are sold online.

The healthcare professional

A general practitioner assessed the earlier concept (the clock) and set one condition on it: nothing may arrive at her desk. The design holds to that condition. It sends nothing to a practice, produces no measurement a clinician would have to interpret, and generates no record anybody is obliged to read. The condition was tested against the clock and has not been retested against the pendant, which is why WIO is recorded as evidenced for the clock and untested for this object.

Figure 62. Jeweler performing battery repair.

The manufacturers

Eight organisations were approached about the shell and the moulded parts. Two priced the shell, two priced the mouldings, one offered an alternative process with figures attached, one withdrew because its titanium sub supplier was fully booked rather than because of the geometry, and one declined on wall thickness. Supplier B completed an engineering review and concluded that the project is technically feasible, offering a two month development programme; Supplier A offered to invoice and begin samples immediately. Supplier willingness is a weak form of desirability and is treated as such here. It establishes that the object is wanted enough to be quoted, not that it is wanted enough to be bought.

One supplier went further than a quotation and produced samples unprompted, producing them in five finishes: as sintered, polished, brushed, and two golds (see *Figure 63*). As evidence of manufacturability, it shows the geometry produced at this size and at this wall thickness, in metal, before the design was finished.

Other stakeholders

The people around the wearer are given no role in the interaction: the buzz is felt by one person, nothing is displayed, and nobody is notified. “Een lichtje zien anderen ook, en een trillinkje is alweer alleen voor jezelf” (P11). Where most connected products widen the circle around the user, this one closes it. One participant, asked directly, would nonetheless welcome an optional social layer, anonymous comparison with women of her age, a buddy, an exchange of tips, and said yes to all three in succession. Asked whether she would want her partner to wear one as well, the same participant put the decision where it belongs: “moet hij zelf willen.”

5.3.10. Desirability: What is new here, and what is not

Jewelry containing electronics is a populated category, and reminders are the oldest function in consumer technology. What the sessions point at is a change in the object of attention. Trackers and smart jewelry carry data about the body and return it as scores; this jewel carries one promise the wearer wrote herself and returns nothing about her body at all. The value created for her is permission and meaning rather than measurement, and the object gains worth as promises are kept, which is ordinary for jewelry and unknown for electronics.

What the sessions named as value is also what separates the product in the market. The industry answers tracker fatigue by removing screens off the wearable while measuring more (such as Whoop or Google Fitbit Air). Smart jewelry is either a body tracker in pendant form, a connection device between two people, or discontinued, and the notification jewelry of the last decade died of redundancy and battery obsolescence. The intersection this product occupies is empty: real jewelry, one self chosen promise, a well timed haptic moment, no biometrics, serviceable at any jeweler, designed for women over 55. However, an empty intersection is not proven demand, and the category is difficult precisely because serviceability is difficult, which is why the service system is important.

5.3.11. What stays open

None of the four who wore the pendant declined it, and all perceived it as jewelry. However, the sample is small. The forms measured a single session, and expectations, rather than a period of wearing the device. Desirability beyond this group is untested, and nothing here establishes that the shift in manageability survives contact with an ordinary week.

The people closest to her were never studied. Jewelry is bought as a gift at least as often as it is bought for oneself, and one participant placed the product in a shop “waar mensen ook gewoon wel kijken voor cadeautjes voor anderen of voor zichzelf.” A partner, a daughter or a friend could therefore be the buyer, the giver, or an influence on whether a promise is kept, and these roles remain to be tested. That the product is private in use is well evidenced. Whether it is private in purchase, and what a promise would mean when somebody else chose the object it lives in, is outside what this study can answer.



Figure 63. Sample shells made and photographed by a supplier without an order, in five finishes: sintered, polished, brushed, and two golds.



Figure 64. Different chains, matching the pendant finish and size.



5.4. Feasibility: can it be made, and does it work?

Feasibility asks whether the project result can be done. Four of the conditions in the table above carry that question formally. Any intelligence has to stay in the low risk tier of the AI Act (C2). The system has to be private by design, holding minimal data, local by default, under her control (C3). The physical product has to be safe for older adults (C5). And it has to survive water, shower and sea (N2). More questions had to be answered to test feasibility, and they emerged from building it: Can a deliberate squeeze be read through a closed metal wall that nothing may be bonded to? Does the complete system fit inside a bar of this size? Do the parts and the processes exist, at the volumes intended, from suppliers who will price them? This section answers the four stated conditions and those three discovered ones, and it treats the discovered ones as the harder test.

The prototypes existed to answer those questions: the sensing sandwich, the functional pendant on a chain, the production CAD assembly, the service model at enlarged scale, and correspondence with fourteen organisations: thirteen manufacturers and suppliers, and a jeweller.

5.4.1. Does the interaction work

Squeezing the pendant bends its wall inward by a few micrometres. An electrode sits at a fixed distance behind that wall, the air between them is the dielectric, and the gap closing raises the capacitance. The construction and the reasoning behind it are set out in 4.9.1; what matters here is how the findings from prototyping extend to a real production model.

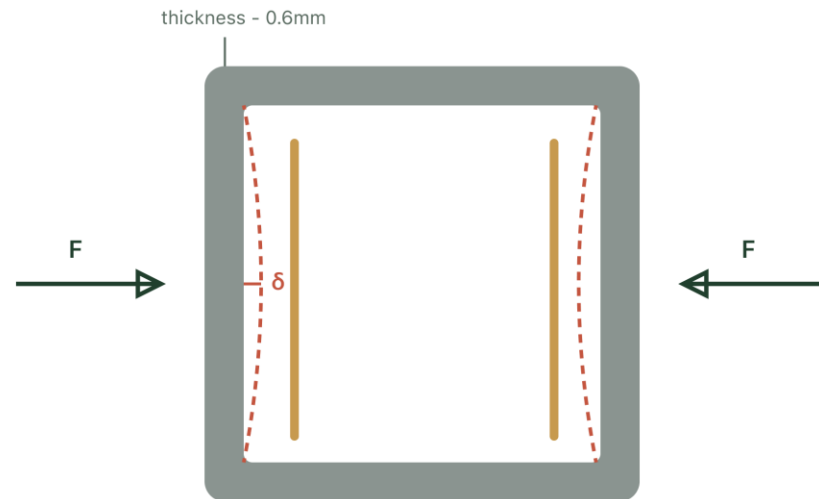
Both prototype builds confirmed the principle, first in isolation with copper plates and foam spacers, then in the wearable version where a running vibration motor shares the same structure. What prototyping could not answer is whether a titanium wall 0.6 millimetres thick, rather than a plastic one with copper tape on it, moves far enough to be read.

It does (see Appendix L. for calculations and *Figure 66* for the model and its limits). The shell was analysed in a SOLIDWORKS simulation as a linear static problem, with a 5N, 10N and 20N spread over the patch a thumb actually covers and applied to two opposing faces, so that the load balances and the section stays free to deform as it would in a hand. Each wall moves 0.45 micrometres at the electrode. Three mesh refinements agree to within 0.35%, and the reaction force, the stress level and the linearity of the response were checked. Closing the 0.125 millimetre gap by that much raises the capacitance from 1.41664 to 1.42179 picofarads, a change of 5.2 femtofarads, against a measurement resolution of 0.5 femtofarads for the sensor (Texas Instruments, 2026). That is ten times over on each of the two electrodes (for 10 N), and a deliberately light five newton press still gives five. The two are read on separate channels rather than combined into one, so that confirming a squeeze requires both walls to have moved, which is how the geometry itself separates a squeeze from the pendant pressing against a chest. Because of this margin, there is room to increase the wall thickness (to 0.8) if production yield is unstable, which is the direction two suppliers pushed.

Figure 65. Participant performing the squeezing gesture on a pendant prototype

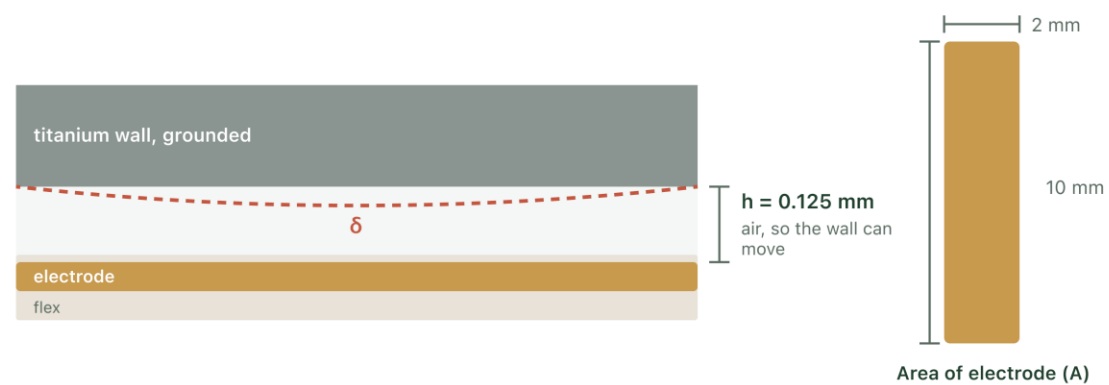
One face of the tube is a plate in bending

Squeezing two opposite faces bends them inward. A Solidworks simulation found how much the walls deflect (δ) at 5N, 10N and 20N (F), light to hard squeeze forces.



The gap

The wall is one plate and it is grounded. The electrode behind it is the other. Nothing is bonded across the gap, which is what keeps the pendant openable.



$$A = 20 \text{ mm}^2, \quad h = 0.125 \text{ mm}, \quad \text{air} \rightarrow \epsilon_r = 1$$

$$\text{Resting capacitance } C_0 = 1.417 \text{ pF}$$

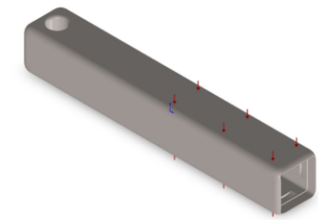
From force to femtofarads

1 How hard she squeezes

$$p = F \div A$$

A squeeze of 10 N spread over the 92.14 mm² patch a thumb actually covers.

$$\rightarrow \text{pressure } (p) = 109 \text{ kPa}$$

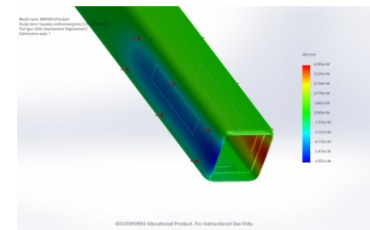


2 How far the wall moves

Finite element analysis of the real shell

Both walls loaded, no fixtures (soft springs enabled), deflection read as the average over the electrode footprint on the inner wall (both sides). Mesh convergence agrees to within 0.35%.

$$\rightarrow \text{deflection } (\delta) = 0.45 \text{ } \mu\text{m at } 10 \text{ N}$$



3 What that does to the capacitance

$$\Delta C = (\epsilon_0 \epsilon_r A \div (h - \delta)) - (\epsilon_0 \epsilon_r A \div h)$$

The gap closes from 0.125 mm to 0.124547 mm behind each squeezed wall (at 10N squeeze). Everything else is unchanged, so that electrode's capacitance rises from 1.41664 pF to 1.42179 pF.

$$\rightarrow \Delta C = 5.15 \text{ fF on each of the two electrodes}$$

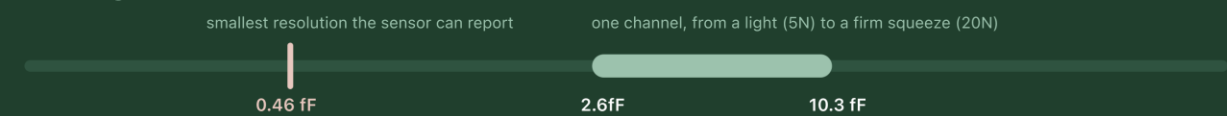
4 Whether the sensor can see it

Measurement resolution = 0.5fF

The FDC1004's measurement resolution is 0.5fF (Texas Instruments, 2026).

$$\rightarrow \text{Sensor picks this up, so capacitive gap sensing would work (theoretically)*}$$

The margin



Each electrode is read on its own channel rather than wired together, so each reports its own change (to avoid accidental triggers). A 10 N squeeze gives eleven times the smallest resolution the sensor can report. Reading the two separately buys the ability to require both walls to have moved before a squeeze is confirmed.

* The deflection is simulated, not measured on a real part. The functional prototype made used a different sensor with plastic as the outer shell material.

Figure 66. The sensing argument on one page. The cross section shows the face that bends and the span that sets how far it moves, the detail shows the gap and the electrode behind it, and the chain on the right runs from squeeze force to a change in femtofarads and compares that change with what the sensor can see.

Sensing through metal is established in industry (Texas Instruments, 2026). Squeeze as a deliberate consumer interaction has shipped at scale in the capacitive force sensor of the AirPods Pro stem (Apple, 2024). The combination is new. Neither ingredient is.

What is still not validated is the deflection of a real machined part. The prototype squeeze was measured through a plastic wall with copper tape, which deflects considerably further than titanium will, and the figure above is simulated rather than measured. The simulation settles the structure, but a model is still not a machined part.

5.4.2. Does it fit

What the CAD model establishes (see 4.9.5) is that this set of catalogue parts fits this form factor. It does not establish that this is the layout that will be built. Inductors and passives are not modelled, a production board would be laid out by a specialist, and at this size the result is likely to differ from the one shown. This demonstrates that the package fits, but it does not demonstrate a finished electrical design.

5.4.3. Does it have the power to do it

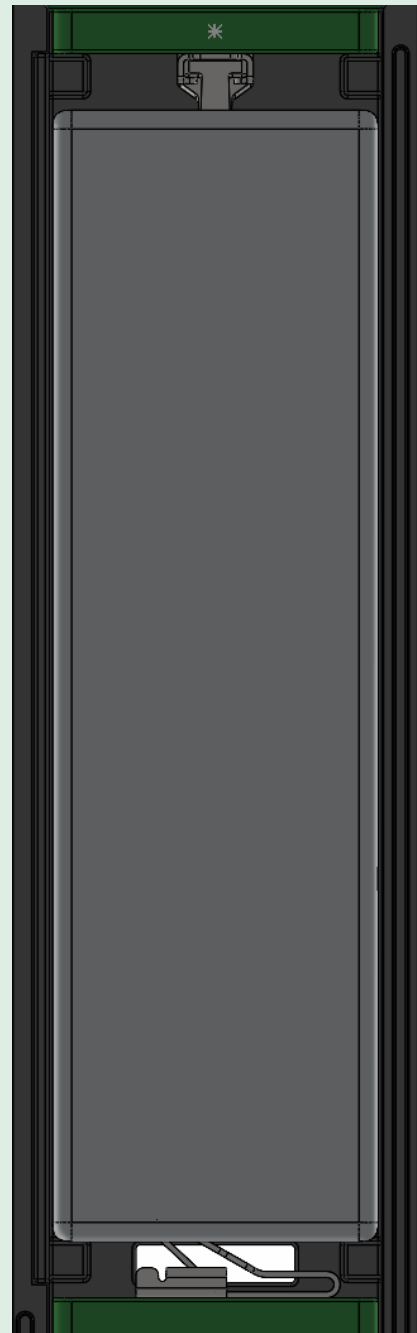


Figure 67. Usable space, as discussed with Supplier C

The estimates given here are built from datasheet figures. Power usage is mostly dependent on the fact that she can squeeze whenever she likes, not only when it has just buzzed, so the sensor listens for the whole time the object is worn. Total use per day comes down to about 3.7 mAh (see Appendix M. for calculations), of which listening is roughly 70% and the haptic prompts, which look like the expensive part of a device whose whole job is to buzz, under one.

Against the cell's 15 mAh, with 80 % taken as usable, that is roughly three days per charge. Runtime is therefore a firmware decision rather than a hardware limit, and the decision is how quickly the object answers a squeeze (battery life could extend to 6 days), or whether the sensor only listens shortly after buzzing (more like ten days). Polling rate is now assumed the fastest reaction time (worst case for energy consumption): 8 times a second (gesture held for a fifth of a second). Assuming the worst case, three days also means the dish is used nightly and a forgotten weekend could cut it close, which strengthens the case for a dish she wants on the nightstand rather than a charger she has to remember.

The remaining opportunity is the cell's shape. A 3.65 mm cylinder stands in an interior 4.4 mm², so the corners are empty along its whole length, and the cell is the longest single component in the object. This square design was explored with battery manufacturer Supplier C, who produces pouch cells, where their maximum feasible cell thickness (excluding swelling space) is 2.2 mm (which led to 2.8 mAh at 12 mm length, and 4.8 mAh at 16 mm), as "thicker cells will cause wrinkling and leakage during forming with high defect rates". Not only is this a capacity problem, but at this size the current could also not be delivered for the motor's pulse. Coin cells would not help, starting around 9 mm in diameter. They suggested metal shell batteries, but these are still under R&D at Supplier C, so for this iteration we end up at the Panasonic pin cell, which is close to alone in its diameter. A hard case prismatic manufacturer, asked for a square section, is the enquiry worth making next.

The CG-320B is rated for 20 mA continuous, while the 304-015 motor draws 25 running and 45 starting (Precision Microdrives, 2021). It resolves because the motor is never run continuously. The CG-320B's datasheet characterises the cell under pulse discharge at 150 mA for 0.5 s, once per hour, against a 0.1 milliampere base current, which is six times the motor's running current and three times its starting current. Three prompts of about a second and a half a day sit far inside that envelope in frequency and well inside it in amplitude. The cell is not being asked to run a motor but to deliver a short pulse, which is the duty it is published as able to do. (Panasonic, 2022)

The characterised pulse is half a second and the prompt is about three times longer, so the published curve does not cover the exact duty, and the pendant's own continuous draw of 0.15 mA sits a little above the 0.1 milliampere base the curve was measured against. The voltage will also sag during the pulse, which is why the regulator sits between the cell and the rest of the circuit, and why the sensing window and the haptic pulse are deliberately not scheduled together. All of it is answerable on a setup and further discourse with Precision Microdrives and Panasonic, but fell out of the scope in this thesis.

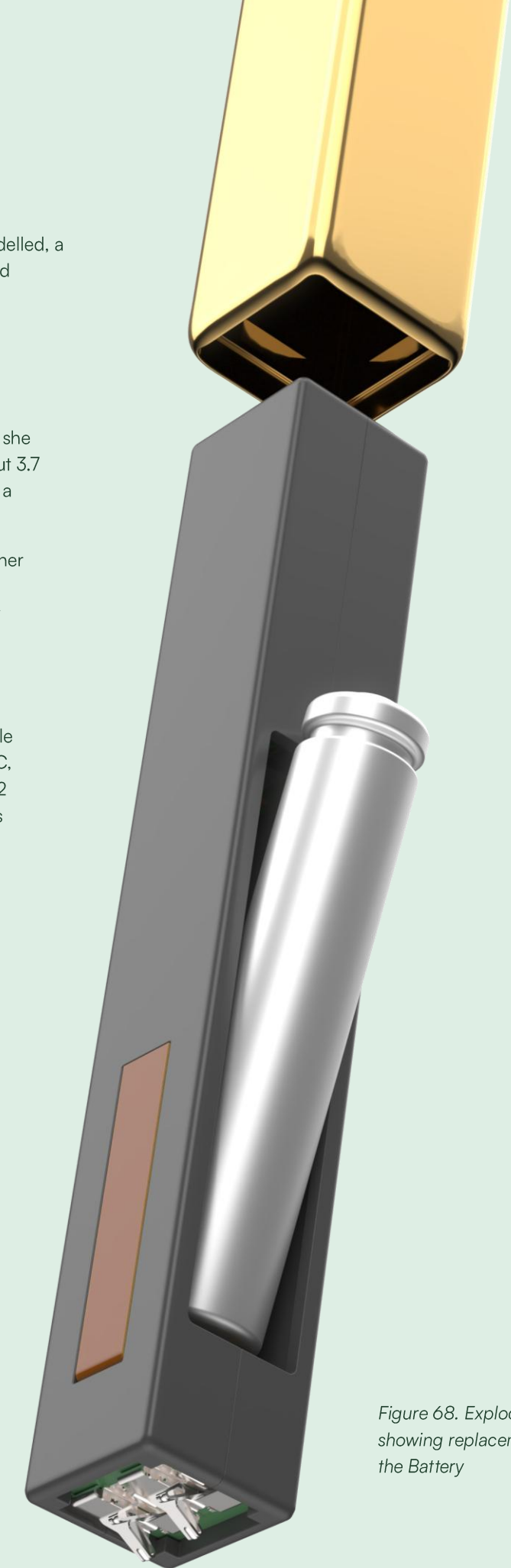


Figure 68. Exploded view showing replacement of the Battery

5.4.4. Manufacturing and cost

There was discourse between thirteen manufacturers and suppliers and a session with a jeweller for the service side. Each was asked to provide manufacturing feasibility feedback and a quote at 10K units and 50K units per year.

A watch case manufacturer named the undercut retaining groove inside the hollow tube as the limiting feature: cutting the groove thins a wall that must still survive machining, polishing and coating. New design propositions (such as (local) thickening of the wall) are on the table and are being reviewed.

The metal injection moulding specialist priced a different strategy altogether, roughly three to six euro per part as sintered against tooling of thirty five to forty thousand, which is the ordinary trade between a cheap part and an expensive start and only pays at the higher volume. And the moulded parts were quoted twice: two moulders agreed on the parts themselves within a few cents and differed by a factor of five on the tooling, one family mould at two thousand six hundred dollars against three separate moulds at thirteen thousand eight hundred. That puts a number on a design decision rather than an opinion, since sharing one mould across three parts saves roughly nine thousand seven hundred euro.

The bill of materials (Appendix J.) carries every part with its price at both volumes and the source behind the figure, colour coded by how well that figure is evidenced. It comes to 38.40 euro per pendant at 50K units / year with every best price obtained, and 70.96 euro at ten thousand with every worst price obtained.

Neither table in the Appendix is what it costs to put the product in a customer's hands. Freight, import duty, the channel decision, the retail price, profit margin etc all come on top. Wearables like this (albeit with a different functionality) are sold at prices such as €529 (Oura, 2026b), and participants price the object between 100 (for the cheaper silver version) to a 1000, while most report their willingness to pay between 150-300 euro.

Three things carry no price here at all. The charging dish was tested with participants as a placement object but was never engineered, never given a material and never shown to a supplier, so its design, its material choice and its manufacture are carried into the recommendations rather than costed. The application is in the table above at a figure estimated rather than quoted. And the pendant is priced in gold coated titanium only, where a silver version would differ in both material and finish and has not been put to a supplier. All prices are subject to change as they need further iterations, these prices are to give a rough approximation.

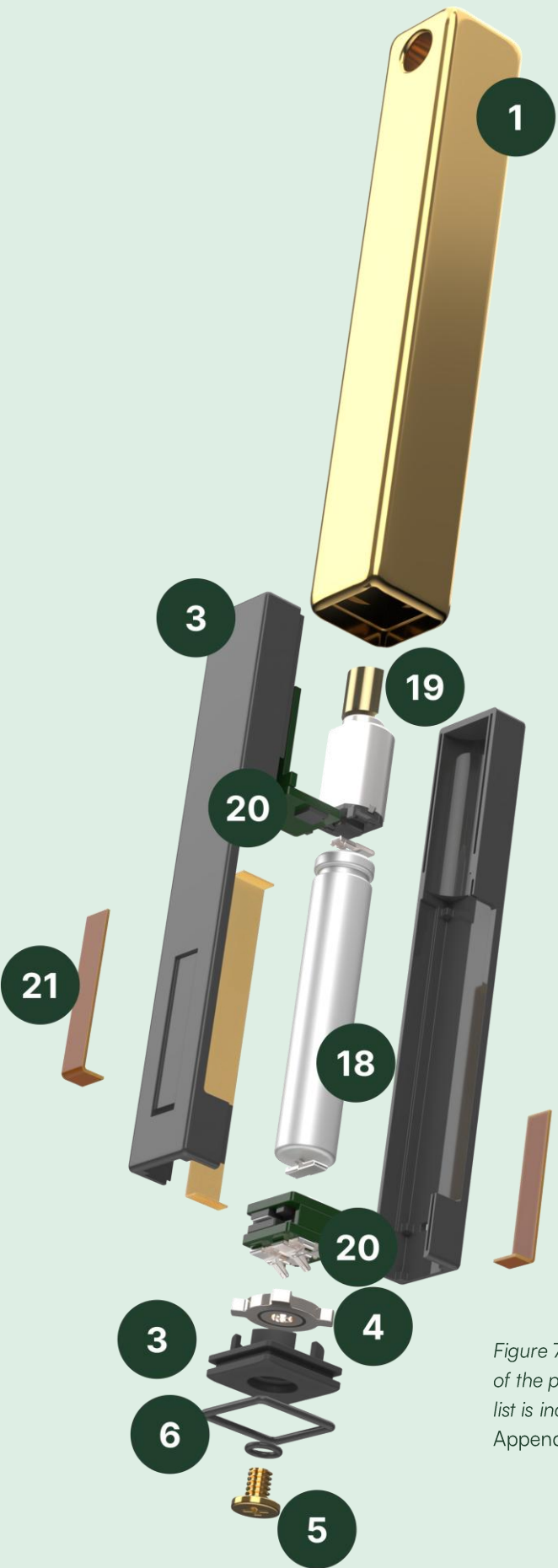


Figure 70. Exploded view of the pendant. A parts list is included in Appendix J.



Figure 69. The retaining groove as the supplier saw it. 倒扣, the Chinese term for an undercut

5.4.5. Is it safe, private and lawful

Requirement C5 asks for a physically safe product for older adults. The product carries a lithium cell, is worn against the skin, is opened by a jeweler and possibly by its owner, and lives in a household that may include children. *Table 13. Safety hazards and designed mitigations* states the hazards that were designed against and is explicit about which mitigations are designed but not yet validated. Before formal risk assessment by GPSR, the product must be worked out further. Thus, C5 is partly met.

Table 13. Safety hazards and designed mitigations

Hazard	Where	Mitigation in the design	Status
Cell punctured or crushed during replacement	Jeweler, home	Cell sits in a carrier rather than loose, kit ships a plastic tool, the sheet warns against metal tools, the cell is keyed so it fits one way	Designed, sequence rehearsed in three sessions on a scaled model with no cell
Short circuit across the cell contacts with a metal tool	Jeweler, home	Plastic tool supplied, warning on the sheet, and the shell and plate carry no live voltage once the pendant is off the dish	Designed, not instrumented
A chain or other jewellery shorting the dish contacts	Daily use	Contacts recessed below the surface, current limited, and the dish stays electrically dead until it recognizes the pendant	Designed, not tested
Skin reaction to the coating	Daily wear	Nickel free coating specified to the manufacturer (Titanium Nitride), with a titanium variant for sensitive skin	Specified, not tested
Small parts swallowed	Household with children	The screw is captive in the lid, but the service kit contains loose small parts and needs a warning and child resistant packaging	Not yet designed
Water ingress damaging the electronics (N2)	Daily wear	Two seals, both renewed at every service, and no water resistance is claimed without a pressure test, which the jeweler offered to perform	Designed, not yet tested
Spent cell disposal	After service	The spent cell enters the battery collection the shop already operates	Designed

N2 asks that the product survives water. Two silicone seals close it, both replaced at every service, which is ordinary watch trade practice and the reason the service kit carries seals and grease. No ingress rating is claimed, because a rating requires a pressure test on real parts. The jeweller consulted in this project offered to perform that test on his own equipment and it has not yet been done, so N2 stands as designed for and untested.

C2 asks that any intelligence stays in the low risk tier of the AI Act. This first version of the application uses none. The moment for a prompt is computed with rules from her own chosen windows, her calendar's busy blocks, do not disturb, and the weather for outdoor promises. Later versions could learn on the device from her own confirmations, which keeps the computation local and the product inside the low risk tier by construction rather than by policy.

Privacy and data

C3 asks for privacy by design. The system was designed to hold as little as possible. It stores her first name, the promise in her own words, the windows in which she wants to be reminded, and the timestamps of prompts and confirmations. Three things are separately optional and separately consented: busy blocks from a private calendar and never event content, coarse weather for outdoor promises, and the phone's do not disturb state. Nothing about her body is measured by the pendant, which carries no sensor for it.

Everything lives on the phone, the pendant holds only the coming schedule and any confirmations not yet synchronised, no account is required for the core function, deleting the application deletes the data, and exports or backups exists only as an act she performs herself. This is what the privacy by design requirement asks for, and it also removes the recurring server cost that a cloud based system would carry.

The map below sets out the same system in full. Movement and sleep can be read from the phone's own health store under a separate permission, so that a kept promise can be recognized without her having to confirm it; that is the one place where something about her body enters the system, and it enters from the phone rather than from the object, but it is never scored. What sits on Silvie's servers is either the account and service record that a warranty and a battery replacement require, or it is optional and separately consented: an encrypted backup of her promises, an anonymous comparison with other women her age, and research donation with identity removed. And the jeweler receives only the engraving text or image, neither of which carries anything about her promises.

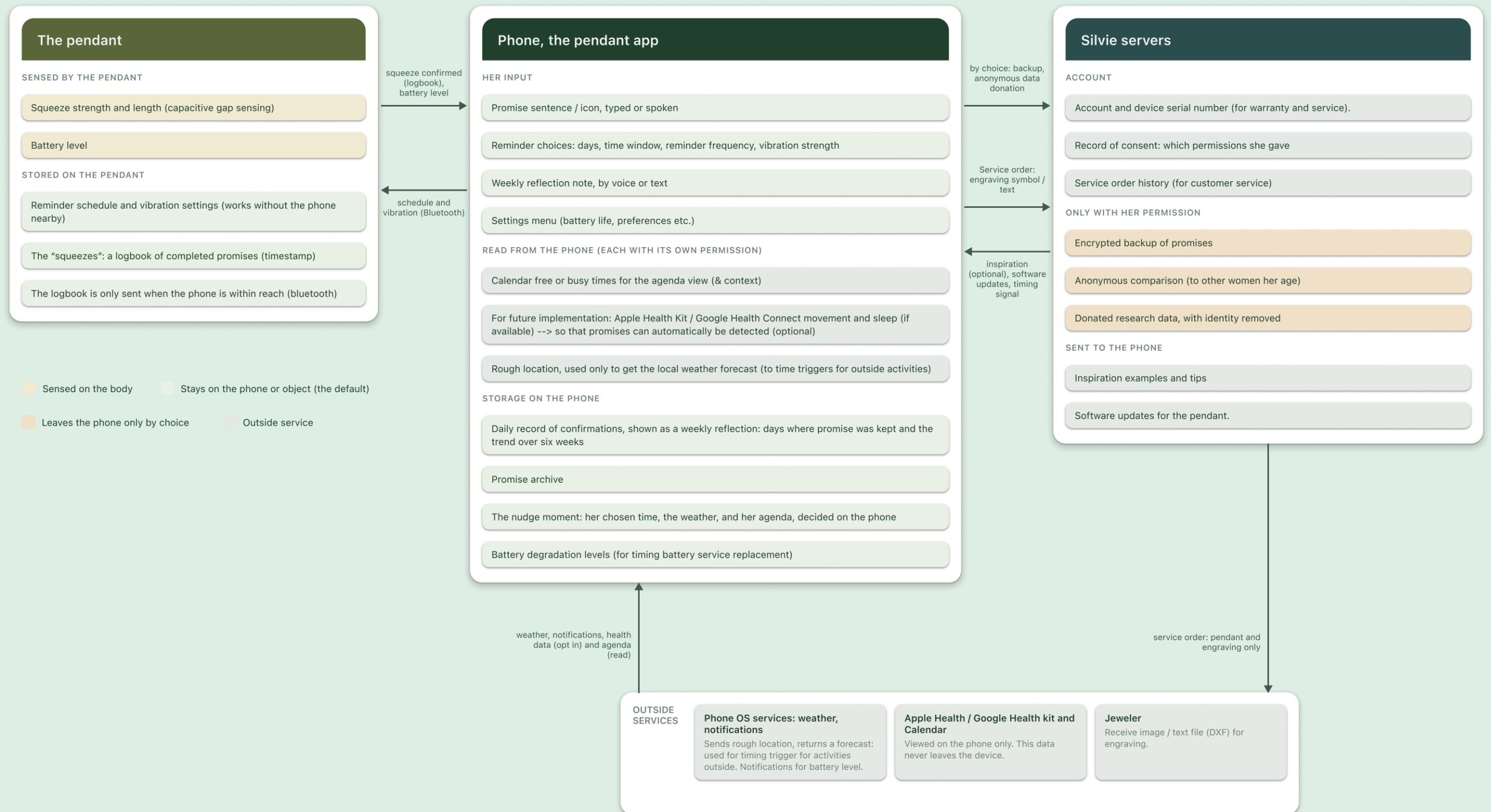


Figure 71. Data overview

5.4.6. Feasibility: what’s new here and what is not

Wearables in this category die when the cell does, and the reason is always the same: water resistance depends on a sealed enclosure. In ear earbuds from the largest manufacturer have scored zero out of ten for repairability in every generation since 2016, and smart rings cannot be opened without destroying them (iFixit, 2024). European law exempts wearables too small to open safely, or relying on a sealed enclosure for water resistance, from the user replaceability requirement (European Commission, 2026d). This pendant qualifies on both grounds and is designed to meet the standard anyway.

It is not the first to take that position. Fairphone's Fairbuds scored ten out of ten using rechargeable lithium coin cells the wearer swaps herself, sold with replacement silicone gaskets, in an IP54 enclosure (iFixit, 2026). What is different here is the cross section and the reasoning behind it: at 6.7 mm the usual methods for sealing are at its strongest, and the way past it was to let the repair requirement choose the sensing principle rather than the other way round. This meant nothing may be bonded to the inside of the wall, which eliminates strain gauges, piezoresistive sensors, load cells and force sensitive resistors, all of which need something glued to the wall or carrying its movement into them (iFixit, 2017b). Capacitive gap sensing is what survives, because it needs no bond at all. A requirement about the end of the product's life chose the technology at the start of it.

The rest is not new. Multifunctional parts are ordinary in miniature products and jewellers have changed watch batteries for years. What is worth recording is that one constraint produced both, since the screw, the shell and the retaining plate each exist because the cell must be reachable at service. Service access and small size usually fight each other. Here service access came first. The water resistance, though, is designed for rather than measured.

5.4.7. What stays open

The revised outer shell with undercut adjustments and inner assembly alignment. Deflection measured on a machined wall rather than simulated, at 0.6 mm and at the thicker wall. The electronics with the production parts tested. The pulse behaviour of the cell under a prompt three times longer than the characterised pulse, and the voltage sag during it. An amplitude test on the specified motor rather than the prototype's. Water resistance. Antenna efficiency measured in a finished, gold plated, body worn housing, which no radio engineer has reviewed. The charging dish material and next iterations. And a formal risk assessment under the General Product Safety Regulation. None of these is a reason the object cannot be made. Each is a reason it is not yet proven.

5.5. Viability

Viability asks whether the project result holds up over a longer term. The product has to stay on the wellness side of the medical device regulation (W7). It has to be producible and bringable to market within about two years (W8). It has to cost the wearer something defensible against what she gets back (W12). The product should be repairable (to extend its lifetime and reduce environmental impact) (N7). It should take pressure off healthcare (W10), make review easy for a healthcare professional (W11), and remain suitable for the next, more digital cohort (W9).

W11 is not applicable, because the product produces nothing a clinician would review. W9 is untested and out of scope, since no younger cohort was recruited. W10 was evidenced against the earlier clock concept with a general practitioner and was never retested against the pendant. The requirements that remain are tested below.

5.5.1. Does its battery survive?

Three things end a wearable in this category: the cell degrades and the product becomes obsolete, the application is switched off, or the company disappears. This design answers each. The cell is replaceable with ordinary tools. The pendant holds its own schedule and works without the phone nearby. And no cloud service is required for the core function, so nothing stops working when a server does. The spent cell goes into the battery collection the jeweller already operates for watch batteries, which he confirmed is routine for lithium cells of any shape, and that is where it ends.

The law requires portable batteries to be removable and replaceable by the end user, with the cell available as a spare for at least five years and any special tool supplied free of charge, but exempts this class of product (European Commission, 2026d). This design goes beyond what the Battery Regulation requires of this exempt class by making the cell replaceable: two participants performed the replacement themselves from the service sheet alone, with no demonstration beforehand, and a working jeweller did the same at his own counter with no briefing at all. All three worked on a model at four times true scale that held no live cell.

One limit applies: the service model is printed at four times true scale, because the real part is too tiny to print with the accuracy necessary. What the sessions establish is that the sequence is legible and the geometry is understood from the sheet alone. They do not establish that the fine motor demands of a 6.7 millimetre part are within reach, and that is the test still to run.

5.5.2. Regulations

It stays under the medical (software) regulation line: it measures no physiological parameter, diagnoses nothing, treats nothing, and the application performs no operation on health data beyond storing and displaying a choice the wearer made herself. This is requirement W7 met. The regulation counts prevention of disease as a medical purpose. Helping someone keep a habit she chose sits outside it; reducing her risk of osteoporosis does not. It is why the application language describes behaviour rather than outcomes.

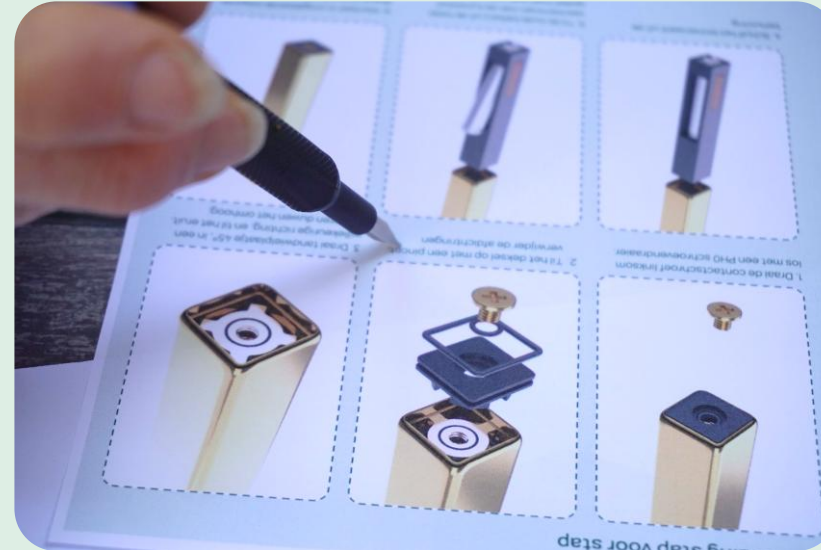
However, the moment the application recommends or links to Silvie's own supplements, that screen becomes commercial communication about a food and the food claims rules apply to it. Therefore, the app is deliberately designed not to, even though it might be commercially attractive.

The larger risk is not regulatory. A reminder the wearer sets for herself carries no authority; a suggestion from a company presenting itself as evidence informed, with a source attached, carries some. That difference matters because a substantial share of this target group takes prescribed medication, ordinary lifestyle suggestions can interact with a condition or a drug, and a database correct in general can be wrong for one person. A participant already drew the boundary the designer had not, that the pendant is not meant for withdrawing from medication or addiction because that belongs with medical supervision.

For future iterations in the app, verbs need to be watched: Helps, supports, makes it easier to, reminds you, you chose: inside the boundary. Prevents, treats, reduces the risk of, improves, monitors, detects: outside it. Citing a study as evidence that a behaviour is generally beneficial is legitimate; citing it as evidence that it is right for this reader is not.



1 P10 screws the lid off. She was the first person ever shown the sheet, and worked without tweezer.



2 Turning the retaining plate often was the most confusing step, and requires instructions with arrows and the tools drawn in future iterations, but upon reading each instruction closer it was managed. “Ik ben heel eigenwijs. Ik ga altijd zelf prutsen.”



3 Turning the retaining plate free (here done with a screwdriver). Future iterations should focus on doing the service with less tools, or a custom tiny all in one tool.



3 Sliding the inner assembly out. Her verdict was “dat zou ik wel zelf aan durven”, with one condition: “niet een keer met haast”.



5 The battery is clamped between to leaf springs, and was able to be removed easily (albeit with this tool), the warning on not using metal parts was read but ignored, which argues for a plastic only tool being delivered with the kit



6 The cell clear of the body, seals were not done as they were not yet made.

What both did

- Completed the full procedure on the enlarged model, working only from the sheet. Neither had tweezers to hand, so both improvised past step two, which the sheet assumes a tweezer for.
- Both raised the scale problem themselves, before being asked. P10: “zo’n klein ding is natuurlijk wel wat betieteriger”, and on the plate rotation at true size, “dat is nog lastiger”.

Recommendations for the next iteration of the service kit

- Supply a custom tool in the set. “Mensen gaan zoeken en dan past die niet... en dan wordt die beschadigd” (P11).
- Add a spare contact screw, because it will be dropped: “die valt op de grond... uiteindelijk hoort iemand die stofzuiger” (P11).

Figure 72: The wearer's own repair. Two participants performed the battery replacement themselves, working from the service sheet. The model is printed at four times true scale (3D printer limitations) and held no live cell.



1 His own tools, his own counter, the service sheet open. “Sommige artikelen is het nog wel eens uitvogelen, maar dit is glashelder.” No training needed: he expects half his staff could do the job.



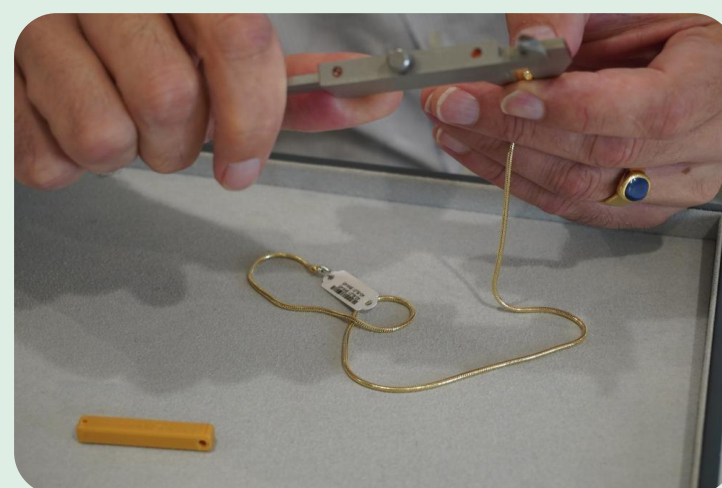
4 Releasing the retaining plate with tweezers. This is the step he misread, and a future iteration of the sheet should show the direction of rotation at steps two and three.

What should change in next iterations

- The kit carries the plastic spatula, because he does not stock one.
- Fourteen carat rather than eighteen. Most Dutch jewellery is 14K, so a chain bought separately will not clash.
- Open the chain hole from 2.75 mm to about 3.2 to 3.5 mm so a chain eye passes through. Keep tolerance low so the pendant does not drop when the chain comes off.
- A bayonet clasp on a multi-strand chain keeps the hole small. Magnetic clasps were rejected: “die komen los”.
- For hands in their seventies, bigger clasps and eyes are necessary, and should be attached after threading rather than enlarging the hole.
- Waterproofing needs testing.



2 The cell in the inner assembly channel. A plastic spatula lifts it out. He does not stock one and was able to get it out with tweezers, so the kit now ships it.



3 He advises a thicker chain and a bayonet opening. The pendant hole is 2.75 and future iterations should increase sizes to 3.2 - 3.5 mm.

Figure 73. Jeweler (E6) performing the repair

5.5.3. Viability through jewellers

armband draad of rijgen	€ 45
collier	€ 55
	€ 75,00
Afbeeldingen laseren	
Instellen voor graveren	
Ring rondom met tekst uitlijnen	€ 42
Per kwart ring	
Tekst op voorwerp	€ 108
Eigen handschrift	vanaf € 42
Vingerafdruk, Logo, Monogram, Familiewapen ect.	€ 48
	vanaf € 96

1 Laser engraving, outsourced by the shop: plain lettering €42, the wearer’s own handwriting €48, a fingerprint, monogram or coat of arms from €96. In house with a diamond stylus it is €15 setup plus €1.50 per character, so three letters is €19.50.

BRILJANT LEVEREN EN ZETTEN			
		G-VVS	G-VS
0,01 crt	1,3mm	€ 76	€ 72
0,02 crt	1,7mm	€ 108	€ 100
0,03 crt	1,9mm	€ 142	€ 128
0,04 crt	2,1mm	€ 174	€ 157
0,05 crt	2,3mm	€ 208	€ 185
0,06 crt	2,5mm	€ 240	€ 214
0,07 crt	2,65mm	€ 274	€ 242
0,08 crt	2,75mm	€ 358	€ 332
0,09 crt	2,8mm	€ 396	€ 370
0,10 crt	2,9mm	€ 436	€ 406
0,11 crt	3,0mm	€ 481	€ 448
0,12 crt	3,1mm	€ 521	€ 484
0,13 crt	3,2mm	€ 559	€ 521
ZIRKONIA LEVEREN EN ZETTEN			
leveren + zetten in bestaande ring			
BRILJANT ZETTING			

2 Stone supply and setting. Zirconia up to 3 mm, supplied and set, €42. A brilliant starts at €72 to €76 at 0.01 ct. Setting work alone runs €42 to €84. These are the prices a milestone stone would carry at the counter.

The jeweller quoted 15 — 20 euro for a repair service, which is where participants had already put it, and he would turn a job round between two hours and the next working day. He would put himself on the map without a contract, training would not be necessary, especially not with the included service kit, and he would dispose of the cells through channels he already uses. No money moves between the brand and the shop in either direction.

Engraving is straightforward, in house with a diamond stylus or outsourced to a laser, with the files going to the subcontractor rather than to the shop. A milestone stone is not. Setting one means milling a hole into the body, and a brilliant cut stone stands seventy five % of its width proud, so a 2 mm stone needs 1.5mm of depth, which the current design does not have. His verdict was "jammer, jammer", and his advice was to deliver the part thicker. Shrinking the stone does not help, because below the smallest visible size it adds nothing. The stone therefore stays a recommendation if demand is high enough.

The battery repair and engraving service are therefore viable. The retail proposition is not viable through him: he would not stock the product as it is not the category he sells. This is one jeweller however, so other jewellers need to be approached to gauge whether retail through this channel is viable.

Why the stone stays a recommendation

- A stone needs a hole milled into the body: “er wordt een gaatje ingefreesd.”
- A brilliant cut stone is 75% of its width in height, so a 2 mm stone is 1.5 mm deep.
- The side wall is 0.6 mm and cannot take it. “Jammer, jammer.” So inclusion of stone setting means increased wall thickness. The top face carries roughly 1 to 1.5 mm, which is marginal.
- Below the smallest visible size a stone adds nothing, so shrinking it is not the answer.

Logistics

- Kits by post to the shop / customers coming with kit: no objection
- Whole pendants shipped and returned: possible, with handling costs added.
- A jeweller shipping out carries theft risk, so he posts under a different name so parcels are not fished out in transit.
- For valuable pieces he uses a tracked micro parcel at about €16 including collection.
- Engraving files go to his laser subcontractor, not to him. He works from a JPEG or PDF; a correctly dimensioned file would remove a step.
- Re-plating a worn PVD layer: he has no address for it, but a pendant wears slowly where a ring wears fast.



3 “Dit is niet gedoubleerd, dit is allemaal PVD.” Gold PVD bracelets on his own shelf at about €129, shown in brushed and in high gloss. The finish of the pendant is already sold at that price.



4 A titanium and gold plated pendant carrying a 0.015 ct diamond, in his case at €129.

Figure 74. What the trade can add and what it charges for it: engraving and stone setting prices, and two shelf products. Juweler (E6)

Table 14. Cost of goods (with charging dish estimate)

	EUR
Pendant, best prices obtained at 50,000 units	38.40
Pendant, worst prices obtained at 10,000 units	70.96
Pendant, midpoint	54.68
Charging dish, estimated	12.00
Cost of goods, midpoint	66.68

Table 15. Retail price at gross margin

	Startup at 10,000 units, 50% gross margin	Wearables benchmark, 60% gross margin
Cost of goods	66.68	66.68
Price excluding tax	133.36	166.70
VAT at 21%	28.01	35.01
Retail price including tax	161.37	201.71

The system is local first, so the recurring expenses are application maintenance and the service kits. A kit is estimated at €12 to €20: the cell, two seals, grease, the tools on a first service, packaging and courier. The wearer pays the jeweller €15 to €25 (E6 quoted these prices for the pendant repair) directly, so a service every 3 to 5 years costs her about what a watch battery with a new gasket costs today. A subscription around €5 a month was put to one participant, who said "om te beginnen wel, kijken hoe ik het ervaar". An option to test, not a plan.

The product reads as jewellery to the women who wore it. The jeweller who serviced it would not stock it and re-routed it toward care. One participant placed it in lifestyle and yoga shops, and named the kind precisely: not an exclusive jeweller, but one "waar mensen ook gewoon wel kijken voor cadeautjes voor anderen of voor zichzelf." A positioning decision for Silvie.

5.5.4. Viability for Silvie Health

The design, supplier correspondence, the service model and the bill of materials were presented to the client. What the session establishes is whether the company that would build this recognises it as buildable and as its own.

No part of the design was rejected. The confirmation mechanism, the registration and the data flow were accepted, as were both volume scenarios, yet he could not say whether 10,000 or 50,000 units a year is realistic, because that depends on demand.

He proposed to test this demand first through making a custom product page showing the object and the interaction, promoted with paid social advertising on a budget of €5,000 to €10,000, with pre-orders as the measure. Tooling follows only if that produces interest. This test is carried into the recommendations.

The application is priced against Bluetooth device apps rather than apps in general. IoT For All puts a high end cross-platform Bluetooth app at \$25,000 to \$130,000 and a simple one at \$20,000 to \$60,000 (Yeti, 2025). This one sits at the bottom of that range: it pairs with a single device, keeps everything on the phone, and does no cloud processing or analytics. Part of the interface is already designed, which the same source puts at 20 to 30% of a build. That gives roughly €35,000 to €55,000 to build, including testing against the physical hardware, and €5,000 to €11,000 a year to maintain it. These are agency estimates, not a quotation.

One part of the system belongs to the client rather than to the product. When the wearer chooses a new behaviour, or asks where a suggestion comes from, the answer draws on Silvie's existing evidence base on preventive lifestyle interventions. Selecting which behaviours to offer, breaking them into steps small enough to keep, and standing behind them with sources is work the company already does, and the pendant gives it somewhere to land. This matters to viability because it is the part a competitor cannot copy by buying the same components.

Engraving had been assumed to happen at the shell manufacturer (if personalisation such as a vow to oneself would have been done at purchase). If the shells are engraved in Asia, every personalised pendant carries the full lead time of an intercontinental shipment before it reaches a customer who has just chosen the words. Separating the steps, engraving later and locally on stock, turns personalisation from a manufacturing step into a service. As participants' were keen on having the milestone engraved, and only a few wanted engraving beforehand, further demand needs to be gauged before committing to personalisation at purchase.

€199 remains a recommendation and needs further testing. Whether the product carries a subscription was not discussed. The boundary between a wellness claim and a health claim was not revisited, although the advertising copy for the proposed test is where it would be crossed first. Only if demand was there, the client would be keen to approach investors.

The pendant costs €38.40 at 50K units a year with every best price obtained, and €70.96 at 10K with every worst price (see Appendix J.). The dish was never quoted and is estimated €12 for the body (material to be determined), a magnet, pogo pins and a small board. The chain is excluded, bought in and replaceable by the wearer with any chain of the same end eye.

Garmin's reported a 60% gross margin for 2025 (Garmin, 2026). Table 14 runs against a more cautious 50%. Gross margin is not profit. Garmin converts about a quarter of revenue into operating profit, so roughly half the gross margin goes to R&D, marketing, support, warranty and overhead. Both also have tooling amortised long ago and no per unit service obligation. Here the quoted tooling adds €2.50 per pendant at 10,000 units, four required one-off costs are still unquoted, and the spare parts commitment is a recurring cost not integrated yet in any of the cost models. The 50% column is the more realistic reading.

€199 including tax returns a 59% gross margin, which is close to Garmin's. The channel decides whether it holds. Sold directly, Silvie receives €164.46 excluding tax against €66.68 of cost. Through a retailer who doubles his buying price (such as E6). the same price returns €82.23 and 19%, which is too little. That route only works at €299, where Silvie receives €123.56 at 46%. This is what stands behind the jeweller's decision not to stock it.

Participants priced the pendant between a minimum of €100 for the silver till €300 for gold plated titanium, "de maximum prijs om het geloofwaardig te houden", with doubt that it could be made for that. The doubt in the second answer supports the price rather than threatening it, since the object reads as expensive to make, while it sits €66 of parts. One said there was almost no limit if it were good for her health, provided it did go over a €1,000. €199 sits a third above the one stated maximum, €100 below the ceiling of credibility. Figures given by the participants are an anchor, not a proof of demand.

The jeweler holds the closest comparators: gold PVD bracelets and a titanium pendant with a 0.015 ct diamond, both at €129. Neither carries electronics, an application or a service, so they do not anchor the price.

In the cost analysis (see Appendix J.), the cell (at €16.08 at both volumes, a broker's published reference rather than a contract price) and the shell carry the most uncertainty and will have to be quoted.

5.5.5. What is new here, and what is not

Repair networks are not new, and neither is paying a jeweller for a battery service. What this project proposes is a set of positions that are stricter than what the law, the category and the business model require.

An environmental position: meet the standard you are exempt from. The European Commission (2026d) gives this exact class of product, small and sealed, permission to be opened only by a professional. The design reaches the stricter version anyways, the end user standard, and two participants demonstrated it (albeit with a scaled model). The proposition is that an exemption granted for safety reasons should be treated as a floor rather than a ceiling, because a reason small sealed wearables become waste is that the alternative is not designed.

A social and economic position: reverse the direction of the money. In most repair programmes the manufacturer pays to keep a service channel alive, which makes repairability a cost centre and explains why it disappears from cheap and small products first. Here no money moves between the brand and the shop at all. The wearer buys the kit, the jeweller charges his own fee, and no network is necessary, but jewelers can easily sign up through the service kit QR code. Repairability becomes something an existing trade already earns from.

An ethical position: refuse to measure. This product sits in a category defined by measurement and self-optimization, and measures nothing about the body. There is no biometric sensor in the object, no score to keep up with. Within this ethical position: minimize data usage and protect user autonomy: there is no cloud analysis of her personal health data. The only exceptions is user choice to opt in to automatically recognize promises from health data that her phone collects (such as going to bed at a certain time), so a kept promise can be recognised without a squeeze. Moreover, records of sale are necessary for warranty. In a market where the wearable is the instrument through which a person is quantified, an object that carries only what she promised to herself is a different proposition about what a body worn device is for.

A position that might cost money (remains to be proven): design toward your own redundancy. As the promises become routines, the products works toward not being needed, and adapts with its user to serve their specific intentions. That is the logical end of a salutogenic position. It is also commercially uncomfortable, because engagement is the metric this industry is built on.

Taken together these make a very small wearable viable across a decade rather than across a battery cycle without a subscription and without measuring anybody. Whether any of it constitutes meaningful long-term behavioural change remains a test for a longitudinal study.

5.5.6. What stays open

Next iterations of production and retail prices, certification costs, the demand proposition by the client, whether the service network grows once it is left to grow by itself, which cannot be known from one jeweler.

5.6. Conclusion on desirability, feasibility and viability

Desirability holds strongest where it was answered with a behaviour rather than an opinion. Four women wore the pendant and none turned it down, a jeweller serviced it at his own counter without a briefing, and two participants replaced the cell working from the sheet alone. The written scales are weaker evidence: 5 women, one sitting, and an expectation about an object they had just handled, which gives a direction and settles nothing about a month.

Feasibility is proven for what was built and calculated for the rest. The sensing principle, the package and the service sequence stand. The titanium wall is simulated, the water resistance is designed for rather than measured, and the electrical design needs further testing. Viability is the least settled of the three, because price, margin and volume are modelled from quotations on a design that will change before it is built.

Nothing in this chapter says the object cannot be made. What is missing is evidence that it will be worn for longer than a session, and bought by anyone outside those who participated in this study.



Discussion

This chapter answers the research question and then states what the answer is worth. The limitations name the sample, the results that are calculated rather than measured, and the costs nobody has priced. The recommendations put the open questions in the order they should be answered, starting with the demand test, because there is no case for spending on tooling until it has run. The chapter closes with a reflection on who designed this and on the methods that both carried the project and cost it weeks, and with the planned timeline set against the one the project followed.

6.1. Conclusion

This project began by asking how a product-service system could help women 55+ adhere to a supplementation routine consistently and correctly. The interviews did not support that question. Routines were largely intact, a missed day carried little consequence, and the dispensers on the market solved a problem participants did not have. The clock built for that question died in one session: 3 of 4 participants moved its function to the phone. What was left was doubt, and under the doubt the distance between knowing and doing. The question became how a product-service system can create the opportunity, at the right moment, for a woman to do the preventive thing she has already chosen, without measuring her body.

The answer is the Silvie Pillar. She writes one promise in her own words in the app. The pendant vibrates on her breastbone at a moment set by her own windows, and one squeeze confirms it. There is no score, no biometric sensor and no cloud. A charging dish, a service blueprint and a battery kit any jeweller can use complete the system.

Four women wore the working prototype and all four placed it on the jewellery side of the scale. Across 5 participants the largest movement was on whether an intention survives a busy day, from 3.0 to 5.4, measured in one sitting, so it records what the object led them to expect rather than what wearing it produced. The squeeze reads at 10 times the sensor's resolution in simulation, not on a machined part. Suppliers priced the pendant between €38.40 and €70.96 across the two volumes, and every retail figure built on that is modelled. Two participants and a jeweller replaced the cell working only from the service sheet, on a model at 4 times true scale.

What the project contributes is a worked counter-example to the current wearable industry: a preventive health wearable can measure nothing, judge nothing, and still hold a place on the body.

6.2. Limitations

The team that made every interpretive decision in this project was four men: the designer, two TU Delft supervisors and one client representative. The user is a woman between 55 and 70. Every persona, every requirement and every reading of an interview passed through that team, which increase risk of egocentric bias (defaulting to what we know best, being ourselves, thereby skewing our perception of how others in a different age and gender will behave). To mitigate this, a total of twelve women were continuously interviewed throughout the project and their input was triangulated against published research.

The direction chosen in Chapter 3 was clarity, and the Silvie Pillar does not deliver it in evidence. It gives the wearer no evidence about whether a health intervention is working for her, because supplying that in an honest way needs a measurement this project could not make. The doubt that Chapter 3 named as the core problem is left standing, and the design addresses the gap between knowing and doing that sits next to it. The personas built in 3.2 were written for the clarity problem and were not carried into the evaluation of the final design.

The evidence behind the problem definition carries its own limits. The literature review was design-oriented rather than systematic: sources were selected by judgement of relevance without a scoring protocol, the search was shaped by the coverage of the tool used, and medication adherence literature stands in for supplementation adherence throughout, which is a transferability assumption which was partly contested by the participants. Most of the included studies address adults over 60 or 65 rather than over 55. Twelve women were interviewed, recruited in Delft and its surroundings, and six of them stuck around till the last session. This sample is not representative of the larger population.

Where themes are counted, the counts indicate breadth rather than significance, and the direction this project committed to rests on one of the lower counts: four of nine women articulated the confusion that became the core problem, against eight for autonomy and seven for invisible support. The case for choosing it anyway is made in the synthesis, but it is an argument rather than a measurement. The framing itself was reformulated repeatedly and was checked repeatedly with participants.

The clock evaluation, which produced the turn the rest of this project depends on, was run with four women and one general practitioner, on a Wizard of Oz prototype, with legibility tested on printed sheets rather than on the device. These sessions give a direction rather than a statistic.

Twelve women and six experts were recruited, and a core of five carried the pendant sessions from the first interviews to the last. This was sufficient for the scope of this project, but the sample size remains small, and as such, wherever results are quantified, one person can shift the average by a large amount. The purpose of these measurements was not to find significance, but to validate requirements and desirability.

The same goes for the purpose of in session measurements such as haptic levels and patterns; they were made to distinguish what these participants felt and whether they had a preference. If all participants point in the same direction, this gives the design a direction, but again, it is not significance. The before and after form values were also made to give an indication of direction and to test requirements. Participants were given the rest and time to fill in the forms, but one (a sixth) session was interrupted and is excluded from the analysis. The before and after measurements come from a single sitting, so they record what the object led five women to expect rather than what wearing it produced. This requires a longitudinal study that is outside the scope of this thesis.

The sessions were run by the designer, who also built the thing being judged. Although this was tried to be avoided, some of the questions asked to participants might have been leading, so these answers are considered reactions, rather than as findings. Part of the sample was recruited from a close circle, which is likely to have made the answers warmer than a stranger would have given, although what they said (and what they co created) was as useful as the rest. The behavioural evidence does not carry this problem. What four women did with the pendant, and what the jeweller did at his own bench, was watched rather than asked.

The prototypes were research instruments, and three gaps follow from that. The service model is printed at four times true scale and held no live cell, so the fine motor demands of a 6.7 mm part remain untested, and two participants raised that limit themselves before being asked. As the prototype carried no live cell, the battery runtime in daily use remains open. As for the charging dish, participants gave insights in interaction, placement and size, yet material preferences varied widely, so that question remains open. As for the pendant model: the finished material sample arrived after the last session, so the material question was answered against renders and prints rather than against the object.

Four results are calculated rather than measured. Although mesh convergence was proven, the wall deflection comes from a finite element model of the outer shell alone, carrying no fixtures and relying on soft springs to remove rigid body motion. The capacitance change follows from that deflection and from a datasheet resolution figure, not from a squeeze on a machined part. The power budget is built entirely from datasheet currents and approximations of use, not real-life data. The cell is specifically designed for wearables, yet its published pulse curve does not cover the duty the pendant asks of it, since the prompt participants preferred is longer than the 0.5 second pulse the datasheet characterises. Water resistance is designed for rather than measured. Each of these is a reason the object is not yet proven rather than a reason it cannot be made.

The cost model is an approximation with named gaps. Four required one-off costs were never priced by anyone, so the tooling bill is higher than the 25,037 euro obtained in writing, by an amount this project has not established. The cell is carried at a broker's published reference rather than a contract price. The cheaper of the two shell quotations carries no tooling figure after two requests, so the two shell scenarios cannot be combined into one. The charging dish remains a complete approximation, as it was never given a material and never shown to a supplier. The application cost is an agency estimate. A silver version was never put to a supplier. Every retail figure is modelled rather than quoted.

The product also has a boundary drawn by a participant rather than by the design: "afkicken van medicatie of verslavende dingen, dat is van een andere zwaarte. Daar is dit apparaat niet voor bedoeld. Daar is medische begeleiding bij nodig" (P01). It supports small self chosen behaviour, not dependency or clinical treatment, and that is a limit of the product's functionality as currently designed.

Some questions sit beyond the length of the project rather than beyond its method. Whether the object still earns its place after a longer period, whether promises keep being made, whether participants experience a shift in the manageability of their health in an ordinary week, and whether the service network grows, cannot be answered here. Neither can demand beyond this group. Participants expressed purchase intent unprompted, but a session led by the person who designed the object invites social desirability bias, so participants were asked beforehand for their most honest opinion, and their behaviour towards the prototypes was weighted above what they said about it. Regardless, willingness as expressed by participants is not proven market demand. The people closest to the wearer, such as a spouse, who shape whether an object like this is worn at all, were never studied.

6.3. Recommendations

Until the demand test has run there is no case for spending on tooling, so this is the most important next step. Everything else is grouped by desirability, feasibility and viability.

Desirability

- Teach the squeeze once at onboarding, or extend sensing to all sides.
- Iterate the service sheet: direction of rotation at steps two and three, arrows, and the tools drawn.
- Ship the tools in the service kit, including tweezers and a spare contact screw.
- Widen the chain hole from 2.75 to between 3.2 and 3.5 mm, and test dexterity across bayonet openings, clasps and eye sizes.
- Retest haptic amplitude with participants once the specified motor is in the object rather than the prototype's motor.
- Continue the app iterations, the connection to the pendant and the back end.
- Add a check up on completed promises, so the object keeps meaning after a goal is reached.
- Engineer the charging dish and add charge confirmation feedback, whether a buzz or something else.
- Explore whether a more premium lid material is worth it, hypoallergenic titanium tier, and other colour and material options for both pendant and dish.
- Design explorations on stone setting, which the 0.6 mm side wall cannot currently support.
- Gauge demand for engraving at purchase, since most participants wanted the milestone engraved rather than the purchase, and the answer decides whether engraving has to move local.

Feasibility

- Iterate the outer shell geometry, slightly increasing wall thickness and locally increasing it at the slots for the retention plate, then requote the shell and obtain the tooling figure the cheaper of the two suppliers has still not given after two requests.
- Measure the deflection on a machined wall, at 0.6 mm and at the thicker alternative, rather than simulating it.
- Squeeze one machined shell with the production sensor behind it, which closes the sensing chain end to end rather than in two halves.
- Measure the cell under a prompt three times longer than its characterised pulse, including the voltage sag during it.
- Run an amplitude test on the specified motor.
- Take the jeweller up on the pressure test he offered, and claim an ingress rating (for waterproofing).
- Have a radio engineer review antenna efficiency in a finished, gold plated, body worn housing.
- Iterate the PCB and the electronics with an electrical engineer.

- 14 carat rather than 18 and obtain a new quote.
- Complete a formal risk assessment under the General Product Safety Regulation, which also settles the small parts warning and the child resistant packaging that the risk table still lists as not yet designed.
- Obtain quotes for CE and Radio Equipment Directive testing, which no test house has yet been approached about.

Viability

- Run the demand test the client proposed: a product page showing the object, the interaction and a price, with paid social advertising behind it.
- Price the four one-off costs nobody quoted, so the tooling bill stops being an unknown amount above 25,037 euro.
- Put the silver version and the retail prices to suppliers.
- Decide the channel, approach other jewellers, and explore sales channels beyond the trade, since one refusal to stock is not a channel finding.
- Explore whether a language model adds value to later app versions, within the regulatory tier, opt in, and only after testing trust with the target group.
- Claim the repairability position publicly and have the product independently assessed, by iFixit or an equivalent. The replaceable cell and the independent service route are ahead of what the law requires of this category, and that lead has a shelf life.
- Design the end-of-life route and source materials sustainably where possible. Consider iterating into a circular business model (was not the scope of this thesis).
- Run the long study this project could not: testing whether the promises are being kept and whether managing her health becomes easier

6.4. Reflection

What I set out to do

At the start of the project I listed what I wanted out of it. This is what became of that list.

Preventive health

I wanted to work on preventive health and behaviour, and at the time supplements were a personal interest. However, self experimentation with supplements is not always healthy: much of the category sells itself by implying a deficit, a shortcut to health for a shortcoming you did not know you had. Salutogenesis asks what generates health instead of what is broken. It argues against designing from the assumption that something is wrong with you and that a product will fix it. I wanted to make something that helps prevent what ageing can bring without telling the wearer she is falling short. The market I am designing against does the opposite. It sells the idea that everything has to be scored, measured and quantified before you count as someone who is doing well, and it keeps raising the bar. I think most people struggle to reach the standard that is being advertised to them, and life simply gets in the way. Therefore, we need to assist there where it is realistic and appropriate to achieve something. That is the argument this design makes.

Physical product design

I wanted to develop my skills in form, interaction and internal mechanisms. The CAD work was not new to me. What I did learn is less technical. A product is largely emotion, what it makes people feel and what meaning they attach to it. I knew that as a principle before. I now understand it as the thing a product succeeds or fails on, it's the thing to get right before any technical detailing should start.

Presentation and aesthetics

I wanted to take a context that is unappealing or looked over, and make it attractive without losing clarity or trust, and I think I did. Most products aimed at this group are protective plastic objects (fall detectors) and they are not designed with dignity. On trust I ran no test. What I do have is the synthesis: what a company must look out for (not only in its marketing), before someone will trust it with something as vulnerable as their health. I will look through this trust lens with every touchpoint I will design from now on.

Technical skills

I wanted to build a working mechanism and get into the electronics, and this is where most of what was new to me sits. I soldered for the first time in my life. I learned capacitive gap sensing, what it takes to drive a motor inside a cell's current limits, what the parts on a PCB actually do, and enough about antennas to understand why a metal shell could be a problem.

Working with a startup

I got what I asked for, including the uncertainty. Thomas had a realistic and grounded view of his business and of the landscape, and I tried to keep the project connected to what Silvie is actually for. What I did not expect was how much of the project would go into finding the problem. We started from a proposition rather than a problem, and an assumption that was wrong. People already had ways of remembering their supplements. Not elegant ways, but working ones, and nothing that justifies buying another object to clean and refill. Had I not questioned that, I would have designed something nobody needed.

Manufacturing

I got further than I expected. I have had long correspondence with manufacturers about whether this can be made, sourced parts across several of them, and started to understand what assembling something like this would take. Managing that contact was new to me. A design project usually stops before a part gets quoted. This is not production, and demand at scale has to be tested before anything is tooled. But I got to a point that manufacturers proudly share a picture of their new injection molding machine, and another made samples in five finishes (which I never asked them to do). This means I got closer to a real product than in any project before.

Where I want to do better next time

In this project I let the reporting take time that belonged elsewhere. I spent it polishing text and going deeper into desk research when I should have been in front of participants. Writing something down is often what makes the reasoning honest, and the desk research was not wasted. But I found out later than I liked that the answers I needed were found more at the participant interviews than they were in desk research.

On who designed this

The team behind this thesis was four men. Me, my two TU Delft supervisors, and the client (Silvie). The user the work is designed for is a postmenopausal Dutch woman aged 55 to 70. The limitations chapter already names this and describes the mitigations.

What mattered most was the co-design sessions towards the end as here participants clearly thought how they wanted the interaction to be. Co-designing surfaces assumptions that cannot be found in literature or thinking your way out. Future iterations should include (and be led by) a woman from the target group in the team rather than only in the sessions.

On planning

The framing of this project (and the problem) moved many times, and each time participants moved it. The shift after the Soma Clock was most costly. The first prototype was finished enough to test and iterate on, and it was killed inside a single session by one question: if this same information lived on the phone, does the clock still add anything. Everything that is now the Silvie Pillar, had relatively little time to come about.

The planning was used for myself as a guideline and to communicate with the client and supervisors, yet the finished timeline looked different from the start. What I think I did right was put a limit on how much time I allowed myself in CAD (as I know myself to lose time on that) and pushed the things with long lead times to the front (manufacturer contact before the design was completely finished, and planning participant and jeweller sessions ahead before I knew what I would ask them).

What I would change is to show lower fidelity prototypes (such as a storyboard, like I did for the pendant) to participants earlier, rather than making a jump to a working prototype.

This shorter timeframe and adjustment in project direction was a deliberate choice aligned with findings from the participant sessions, yet they caused a bigger gap between the final design and the evidence gathered. The journey and evidence shown in this report are still valuable and in line with the final design solution, and the final design solution is still supported by evidence, but it does mean that as the project framing changed, the evidence became less aligned.

On feedback

The design brief I started from was a supplement dispenser. Market research and the first interviews eventually made it clear that this was not something these women wanted, and I kept presenting findings about supplements to the client even where they cut against the original idea. The turn from supplements to promises was accepted by the client partly because it sits closer to Silvie's initial mission, and partly because what the client wanted from the beginning was a project that could become something real rather than a report. Thomas was open, available and gave good advice (like focusing and doing one thing well, rather than everything at once), and the collaboration was easier than I had expected a client relationship to be.

With my supervisors I worked quite autonomously. I updated them with the projects state as we went and asked for feedback when I felt like I needed it. Every session was very useful, and one of them decided the project. Around the clock evaluation they said the concept did not carry enough added value. Here I appreciate their honesty and their care for the bigger picture. Where I could have graduated on a project without added value, they encouraged me to find that value, which led to finding evidence, and to my decision of dropping the concept.

What I underused was their input on the report itself. I brought them design questions, because that is where I wanted the help and where I thought the value was, and I brought them the writing only at a later stage. On the design side the feedback was excellent and I considered all of it, including their push on the emotional layer of the pendant design, which changed the meaning that people attached to the object. On the reporting side I should have opened the door earlier.

From "how to" to "what if"

The TU Delft taught me to work methodically. What my supervisors made me see is that a method can also become a way of recombining only what already exists. "How do I do X" gives you a structured search of the known. "What if X could do Y" gives you permission to think something that is not there yet.

I understood that earlier than I acted on it. My trusted methods gave me structure, direction, which is really a sense of safety: it makes the uncertainty of being judged on your ideas and the chaos of the design process much easier. Simultaneously, they also limited me: I delay design decisions when I am not certain they are right, and I compensate by researching and reasoning until every choice is as watertight as I can make it. That instinct produced a good deal of what is defensible in this report, but it also cost me weeks.

"Soms moet je de bal gewoon vooruit trappen, en de beredenering komt later." In English: sometimes you just have to kick the ball forward, and the reasoning comes later. That is the single most useful sentence the supervisors have told me, as it gave me permission to let go of sticking to the methods, which was a big help in getting to the idea of the pendant.

On validation

Because the framing kept changing, I became hesitant to keep going back to participants with each new version, partly out of respect for their time and partly out of shyness about looking uncertain. Light checks cost them minutes and gave me direction, but I kept worrying that I would lose them as participants. I should have trusted that mechanism more, even though I held a lot of sessions.

What I take with me

Design is a mentally heavy process that does not stop when you put the pen down. What I take with me is an ever so slight increase in tolerance and resilience in showing the risky, unfinished “ugly” things in the moments where my ideas and execution are judged by others.

6.5. Planned versus actual timeline

The two charts below show the planning as it stood at kick-off and the way the project actually ran. The largest divergence follows the clock concept test on 19 June, after which the pendant, its prototypes, the manufacturer correspondence, the evaluation sessions and this report were all completed in the two months that remained. Reasoning is in planning above. Planning was agreed on with client and supervisors.

TASK	PROGRESS	START	END
Initiation			
Meeting with Supervisors	50%	2/2/26	2/2/26
Kick off meeting	0%	2/9/26	2/9/26
Context Mapping/Research			
Desk research (evidence and context)	0%	2/9/26	2/27/26
Stakeholder mapping	0%	2/9/26	2/27/26
Recruitment of study participants/interviewees	0%	2/12/26	3/6/26
Field research (interviews + observation)	0%	2/23/26	3/20/26
Making journeys, service blueprints, list of requirements	0%	3/9/26	3/27/26
BUFFER: Make sure Midterm deliverables are ready	0%	3/23/26	4/1/26
MIDTERM EVALUATION	0%	4/2/26	4/2/26
Prototyping phase			
Ideation + concept directions	0%	4/6/26	4/17/26
Concept selection + system architecture (PSS)	0%	4/13/26	4/24/26
Low-fi prototypes + walkthrough tests	0%	4/20/26	5/1/26
Prototype v1 + feasibility checks	0%	4/27/26	5/15/26
User testing round 1 + iteration	0%	5/4/26	5/15/26
BUFFER: Green Light deliverables	0%	5/18/26	5/29/26
GREEN LIGHT MEETING	0%	6/1/26	6/1/26
Finalisation			
Finalisation: Prototype v2 (hi-fi)	0%	6/1/26	6/12/26
Validation round 2 + final iteration	0%	6/8/26	6/19/26
Report writing + documentation (ongoing)	0%	4/2/26	6/26/26
Final presentation + poster/portfolio assets	0%	6/15/26	6/26/26
BUFFER: Final polish (print, submit, rehearse)	0%	6/22/26	6/26/26
GRADUATION	0%	7/1/26	7/1/26

Figure 76. Planning at the start of the project.

Initiation			
Meeting with Supervisors	100%	02/02	02/02
Kick off meeting	100%	12/02	12/02
Context Mapping/Research (DISCOVER + DEFINE)			
Desk research (evidence, context, micronutrient sensing landscape)	100%	09/02	23/04
Stakeholder mapping	100%	09/02	27/02
Recruitment of study participants/interviewees	100%	12/02	06/03
Field research (interviews + analysis + reporting + illustrations)	100%	23/02	03/04
Making journeys, service blueprints, list of requirements	100%	09/03	01/05
BUFFER: Make sure Midterm deliverables are ready (midterm eval 3 days before)	100%	23/03	01/04
MIDTERM EVALUATION	100%	31/03	02/04
Develop: concepts, pivot, and validation			
Easter weekend public holidays (will be in Austria with family during this time)	100%	03/04	07/04
Ideation + concept directions (How-Tos, SCAMPER, Weighted Objectives) -> Soma Clock selected; clock-face design, Inkplate e-ink firmware, e-paper cost feasibility	100%	07/04	26/06
Clock evaluation: HREC + test protocol prep, 4 participants + GP, synthesis	100%	08/06	01/07
Problem reframe + form exploration, pivot to pendant concept	100%	19/06	06/07
Pendant validation: 4 sessions + findings synthesis	100%	01/07	10/07
Electronics prototype: breadboard + firmware (squeeze/haptic loop) + capacitive sensing	100%	03/07	08/07
Service map A3 (blueprint of pendant + app + Silvie service) + data overview diagram	100%	07/07	20/07
Embodied prototype + interaction validation	100%	03/07	07/07
Report to 80% + GL in MyCase (title, Turnitin, showcase type, HREC docs)	100%	07/07	09/07
GREEN LIGHT MEETING (confirm graduation date, embargo/confidentiality choice)	100%	10/07	10/07
Finalisation (10 Jul - 28 Aug)			
App interaction design in Figma, findings integrated	100%	10/07	20/07
Diploma application, book graduation room + GL feedback processing	100%	10/07	14/07
CAD model (production-like parts) + assembly: pendant + dock + reaching out to manufacturers	100%	13/07	23/07
Report: clock/pendant validation and pivot, validation results + Discussion draft	100%	15/07	23/07
HOLIDAY	100%	25/07	02/08
Final report feasibility + viability (BOM, drawings, energy, requirements), report to 100%, showcase -> UPLOAD 21 Aug	100%	03/08	17/08
BUFFER: FRIDAY 21st is actual report deadline, then build and rehearse presentation	100%	18/08	28/08
GRADUATION CEREMONY	0%	28/08	28/08

Figure 76. Actual execution of the project.

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Appendix A. Interview Poster

The mobile number here was my personal phone number, but I have replaced it here with a fake for illustrative purposes.

DOE MEE AAN EEN INTERVIEW OVER SUPPLEMENTEN (VROUWEN 55-75)

Help mee om een product te ontwerpen dat het nemen van supplementen makkelijker en betrouwbaarder maakt.

Gebruik je (wel eens) supplementen zoals vitamine D, omega-3, magnesium, etc.? Wij onderzoeken hoe we het nemen van supplementen makkelijk, duidelijker en betrouwbaarder kunnen maken.

- ✓ Interview (online of op locatie) 30-45 min
- 📺 Als dank: Silvie cadeaubon t.w.v. €25
- 🔒 Je gegevens worden vertrouwelijk en anoniem verwerkt (TU Delft IDE afstudeeronderzoek)

 **TU Delft**

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Appendix B. Interview Guide

Interview Guide (EN)

Project: A Salutogenic Design Approach to Supplementation and Healthy Ageing (TU Delft IDE)
Method: Interviews (Discover phase)
Target group: Women 55-75, living independently
Duration: 35-50 min
Mode: In person / video call / phone
Materials: Consent form (printed), audio recorder (optional), notetaking sheet, (optional) routine timeline sheet

Research aim

Understand how women 55-75 integrate supplementation into daily life, what helps/hinders consistency/adherence, and what creates trust, clarity, and a "dignified" experience.

1. Introduction and consent (2-3 min)

Script

- Thanks for joining. I'm Dieter, I'm doing my TU Delft graduation project on making supplementation routines easier and more trustworthy for women 55+.
- There are no right or wrong answers, I'm interested in your real experience.
- With your permission, I'd like to audio record so I don't miss details. You can stop at any time, skip any question, or ask me to delete the recording.
- Everything is confidential and will be anonymised in reporting.

Confirm

- Give consent form and make sure the participant has had the chance to ask any questions and has understood.

2. Context (4-6 min)

2.1 Could you tell me a little about yourself and your daily routine?
(Work/retired, living situation, typical day structure)

2.2 What does "healthy ageing" mean to you personally?

2.3 Do you currently take supplements?

- If yes: which kinds broadly? (no need for brand names)
- If no: have you taken them before / do you want to?

3. Current supplementation routine walkthrough (10-12 min)

Core prompt: "Let's walk through a typical day."

3.1 Think about yesterday (or a typical weekday). When did supplements come into your day?

- Morning / midday / evening

- Before/with/after food
- With coffee/tea/water?

3.2 Can you describe the steps?

- Where are they stored?
- How do you decide what to take?
- How do you prepare them?

3.3 How many different supplements do you typically take in a day?
(rough range is fine)

3.4 Do you take them every day or does it vary? What causes that?

Practical environment probes (add if relevant):

3.5 How much space do you want this routine to take up at most?
3.6 Where would you *not* want supplements or a device to be placed?

Optional mini-task (if in-person/video):

3.7 Would you be willing to show me (on camera or describe) where you keep them and how you take them?
(If no, continue, no pressure.)

4. What works well (success patterns) (5-6 min)

4.1 On days it goes well, what makes it easy?

- Triggers/anchors (breakfast, brushing teeth, medication, etc.)
- Prep done in advance?
- Habit strength?

4.2 Have you developed any tricks or systems to stay consistent?
(pillbox, notes, phone alarms, leaving them visible, routine stacking)

5. Frictions, failures, and edge cases (8-10 min)

5.1 What are the most annoying or difficult parts of your supplementation routine?
(choosing, remembering, swallowing, timing, too many bottles, storage, taste, cleanup)

5.2 Tell me about a recent time you forgot or skipped—what happened?

5.3 When does it break down most?

- Travel / weekends / guests / busy mornings
- Illness / stress / schedule changes

Travel probe (make it concrete):

5.4 If you go away for 2-3 days, what do you take with you, and how do you organise that?

5.5 What feels "risky" or uncertain?

- Taking the wrong thing
- Double dosing

- Interactions with medication
- Not knowing if you're doing it right

6. Trust, clarity, decision-making, and information (8-10 min)

6.1 How do you decide which supplements to take and whether you trust them?

- Doctor/dietitian advice
- Brand reputation
- Labels/claims
- Friends/family

Beliefs / mental model:

6.2 What do you believe supplements do for you, and how do you notice that?

Probe: What would make you stop taking a supplement?

Decision authority:

6.3 Who or what influences your decisions the most? (doctor, partner, friends, media, brand, pharmacist)

6.4 How confident do you feel that you're taking them correctly?

- Dosage / timing / with food
- Missed dose: what do you do?

6.5 What information do you wish was clearer or easier?

- What it is, why it matters, how to take it, what to avoid

Shopping/value (light, non-awkward):

6.6 How do you usually buy supplements (separate purchases, subscription, bulk)?

6.7 What matters most to you: convenience, price, quality, or trust? (pick top 2)

7. Attitudes toward “a device/system” (light concept probing) (6-10 min)

(Keep exploratory, don't “sell” anything.)

7.1 If a product/service could make this routine easier, what would it need to do for you?

(e.g., simplify decisions, reduce clutter, reminders, preparation, travel mode)

7.2 How would you feel about a countertop device or “routine station” for supplements?

- What would you like/dislike?
- Where would it live? Would it be “in the way”?

Hygiene / maintenance tolerance:

7.3 How much maintenance or cleaning would be acceptable?

(e.g., daily 30 seconds / weekly 5 minutes / preferably almost never)

7.4 What would make something feel trustworthy rather than gimmicky or medical?

- Appearance, materials, transparency, feedback, calmness, privacy

7.5 Would you want any tracking or feedback (e.g., “you took it”)?

- What feels helpful vs intrusive?

Privacy boundary (make it explicit):

7.6 What information would you want to see, and what would you absolutely not want?

Probe: Would you want it only for yourself, or shared with someone (partner/coach/doctor), or not shared at all?

8. Priorities and wrap-up (3-5 min)

8.1 If you could change one thing about your supplementation routine, what would it be?

8.2 What would success look like for you?

(less thinking, fewer mistakes, more confidence, less clutter, better consistency)

Future state prompt (vision):

8.3 Imagine it feels effortless in 6 months, what does that routine look like day-to-day?

Quick ranking (30 seconds):

8.4 What are your top 2 priorities: convenience, trust, low effort, or overview/clarity?

8.5 Anything I didn't ask that feels important?

Close

- Thanks, explain next steps briefly.
- Ask permission to follow up for a concept test later.
- Confirm compensation (if applicable).

Appendix C. Participant Recruitment Quiz

Interview oproep - supplementen routine (vrouwen 55-75)



Ik ben Dieter van Dortmont (TU Delft Industrieel Ontwerpen) en ik onderzoek hoe we het nemen van supplementen makkelijker en betrouwbaarder kunnen maken in het dagelijks leven. Het interview duurt 30-45 minuten (online of op locatie). Je gegevens worden vertrouwelijk behandeld.

*** Vereist**

1. Volledige naam
2. Hoe kunnen we je het liefst bereiken? *
☐ E-mail
☐ Opbellen
☐ WhatsApp
3. Telefoonnummer

De waarde moet een getal zijn
4. E-mailadres
5. Wanneer ben je het liefst beschikbaar
Meerdere keuzes mogelijk
☐ Ochtend (09:00-12:00)
☐ Middag (12:00-17:00)
☐ Avond (17:00-20:00)

6. Welke dagen passen meestal goed?
Meerdere keuzes mogelijk

☐ Maandag

☐ Dinsdag

☐ Woensdag

☐ Donderdag

☐ Vrijdag

☐ Zaterdag

☐ Zondag

7. Leeftijd

☐ 55-59

☐ 60-64

☐ 65-69

☐ 70-75

☐ Andere

8. Hoe wilt u het interview bijwonen? *

☐ Online deelnemen

☐ Deelname op locatie (in overleg)

9. Woonsituatie *

☐ Zelfstandig (thuis)

☐ Zelfstandig met partner / familie

☐ Hulp aan huis / Zorginstelling

10. Neem je supplementen?

☐ Ja, dagelijks

☐ Ja, 3-6 dagen per week

☐ Soms (minder dan 3 dagen per week)

☐ Nee, maar ik wil wel beginnen

☐ Nee, en ik ben niet van plan te beginnen

☐ Andere

11. Ongeveer hoeveel verschillende supplementen neem je op een 'typische' dag?

☐ 0-2

☐ 3-5

☐ 6-10

☐ 10+

☐ Wisselt sterk

12. Waar loop je het meest tegenaan? (kies max. 2, geen kiezen kan ook)

Selecteer 2 opties.

☐ Ik vergeet het

☐ Te veel potjes / onoverzichtelijk

☐ Timing (met eten / verdeeld over dag)

☐ Ik twijfel of ik het "goed" doe (dosering / combinatie)

☐ Slikken / smaak / maagklachten

☐ Reizen / weekenden / afwijkende routine

☐ Ik vind het gedoe / kost te veel tijd

☐ Ik ervaar geen problemen

☐ Andere

13. Gebruik je al hulpmiddelen?

☐ Pillendoos / organizer

☐ Herinnering op telefoon / app

☐ Schema op papier / notities

☐ Ik doe het op gevoel / uit gewoonte

☐ Geen hulpmiddelen

☐ Andere

14. Hebt u aanvullende vragen voor de organisator?

15. Sta je open voor een vervolgtest van een concept/prototype later in het project?

☐ Ja

☐ Nee

16. Mag ik je na het interview nog 1 korte vraag stellen per mail/WhatsApp/bellen (max 5 min)?

☐ Ja

☐ Nee

17. Ik begrijp dat deelname vrijwillig is en dat mijn gegevens vertrouwelijk worden behandeld. *

☐ Ja, dit begrijp ik



Link to Microsoft Forms: <https://forms.office.com/e/9L40V5b6GB>

Appendix D. Gantt Chart + Milestones

TASK	PROGRESS	START	END
Initiation			
Meeting with Supervisors	50%	2/2/26	2/2/26
Kick off meeting	0%	2/9/26	2/9/26
Context Mapping/Research			
Desk research (evidence and context)	0%	2/9/26	2/27/26
Stakeholder mapping	0%	2/9/26	2/27/26
Recruitment of study participants/interviewees	0%	2/12/26	3/6/26
Field research (interviews + observation)	0%	2/23/26	3/20/26
Making journeys, service blueprints, list of requirements	0%	3/9/26	3/27/26
BUFFER: Make sure Midterm deliverables are ready	0%	3/23/26	4/1/26
MIDTERM EVALUATION	0%	4/2/26	4/2/26
Prototyping phase			
Ideation + concept directions	0%	4/6/26	4/17/26
Concept selection + system architecture (PSS)	0%	4/13/26	4/24/26
Low-fi prototypes + walkthrough tests	0%	4/20/26	5/1/26
Prototype v1 + feasibility checks	0%	4/27/26	5/15/26
User testing round 1 + iteration	0%	5/4/26	5/15/26
BUFFER: Green Light deliverables	0%	5/18/26	5/29/26
GREEN LIGHT MEETING	0%	6/1/26	6/1/26
Finalisation			
Finalisation: Prototype v2 (hi-fi)	0%	6/1/26	6/12/26
Validation round 2 + final iteration	0%	6/8/26	6/19/26
Report writing + documentation (ongoing)	0%	4/2/26	6/26/26
Final presentation + poster/portfolio assets	0%	6/15/26	6/26/26
BUFFER: Final polish (print, submit, rehearse)	0%	6/22/26	6/26/26
GRADUATION	0%	7/1/26	7/1/26

Figure 78. The initial planning (start date), here the planning numbers are American timing from the template that was used

TASK	PROGRESS	START	END
Initiation			
Meeting with Supervisors	100%	02/02	02/02
Kick off meeting	100%	12/02	12/02
Context Mapping/Research (DISCOVER + DEFINE)			
Desk research (evidence, context, micronutrient sensing landscape)	100%	09/02	23/04
Stakeholder mapping	100%	09/02	27/02
Recruitment of study participants/interviewees	100%	12/02	06/03
Field research (interviews + analysis + reporting + illustrations)	100%	23/02	03/04
Making journeys, service blueprints, list of requirements	100%	09/03	01/05
BUFFER: Make sure Midterm deliverables are ready (midterm eval 3 days before)	100%	23/03	01/04
MIDTERM EVALUATION	100%	31/03	02/04
Develop: concepts, pivot, and validation			
Easter weekend public holidays (will be in Austria with family during this time)	100%	03/04	07/04
Ideation + concept directions (How-Tos, SCAMPER, Weighted Objectives) -> Soma Clock selected; clock-face design, Inkplate e-ink firmware, e-paper cost feasibility	100%	06/04	26/06
Clock evaluation: HREC + test protocol prep, 4 participants + GP, synthesis	100%	08/06	01/07
Problem reframe + form exploration, pivot to pendant concept	100%	19/06	06/07
Pendant validation: 4 sessions + findings synthesis	100%	01/07	10/07
Electronics prototype: breadboard + firmware (squeeze/haptic loop) + capacitive sensing	100%	03/07	08/07
App interaction design in Figma, findings integrated	100%	20/04	09/07
Service map A3 (blueprint of pendant + app + Silvie service) + data overview diagram	100%	07/07	09/07
Embodied prototype + interaction validation	100%	07/07	09/07
Report to 80% + GL in MyCase (title, Turnitin, showcase type, HREC docs)	100%	07/07	10/07
GREEN LIGHT MEETING (confirm graduation date, embargo/confidentiality choice)	100%	10/07	
Finalisation (10 Jul - 28 Aug)			14/07
Diploma application, book graduation room + GL feedback processing	0%	10/07	23/07
CAD model (production-like parts) + assembly: pendant + dock + reaching out to manufacturers	10%	13/07	23/07
Report: clock/pendant validation and pivot, validation results + Discussion draft	20%	15/07	02/08
HOLIDAY	0%	25/07	17/08
Final report feasibility + viability (BOM, drawings, energy, requirements), report to 100%, showcase + renders -> UPLOAD Mon 21 Aug	0%	03/08	28/08
BUFFER: FRIDAY 21st is actual report deadline, then build and rehearse presentation	0%	18/08	28/08
GRADUATION CEREMONY	0%	28/08	

Figure 77. Actual execution of the project.

Appendix E. Ethics Documents (Informed Consent)

Informed Consent Semi Structured Interviews

Informatiebrief voor deelnemers

Studie: A Salutogenic Design Approach to Supplementation and Healthy Ageing

Versie 2.0 — 24 februari 2026

U wordt uitgenodigd om deel te nemen aan een afstudeeronderzoek van de TU Delft in samenwerking met Silvie Health. Voordat u beslist, is het belangrijk dat u begrijpt waarom het onderzoek wordt gedaan en wat deelname inhoudt. Lees de informatie hieronder zorgvuldig door en stel gerust vragen.

1) Waar gaat het onderzoek over?

Dit project onderzoekt hoe een product-dienstsysteem vrouwen van 55 jaar en ouder kan helpen om een supplementenroutine consistent en correct vol te houden in het dagelijks leven. Het doel is om echte routines en behoeften te begrijpen en om concepten en prototypes te ontwerpen en te testen. Dit is een ontwerp- en gebruikersonderzoek. Het geeft geen medisch advies en test supplementen niet klinisch.

2) Wie voert het onderzoek uit?

Onderzoeker: Dieter van Dortmont (MSc Integrated Product Design student, Technische Universiteit Delft).

Begeleiders: Stefan Persaud, verantwoordelijke begeleider, TU Delft en Gianni Orsini, begeleider, TU Delft.

Industriepartner/opdrachtgever: Silvie Health (ondersteunt het project). De partner ontvangt uitsluitend geanonimiseerde/geaggregeerde resultaten en ontvangt geen identificeerbare gegevens.

3) Waarom ben ik uitgenodigd?

U bent uitgenodigd omdat u een vrouw bent van 55–75 jaar, zelfstandig woont en ervaring heeft met (of interesse heeft in) het gebruiken van supplementen als onderdeel van dagelijkse zelfzorg.

4) Wat houdt deelname in?

Deelname bestaat uit één semigestructureerd interview (ongeveer 35–50 minuten) over uw dagelijkse routine, ervaringen met supplementen, en wat consistentie helpt of belemmert.

Er worden geen klinische interventies uitgevoerd. U wordt niet gevraagd om supplementen of medicatie te nemen, te starten, te stoppen of te veranderen.

Opname:

Met uw toestemming kan het interview audio-opgenomen worden zodat details niet verloren gaan. Als u geen toestemming geeft voor opname, kan het interview alsnog plaatsvinden met alleen schriftelijke notities.

Audio-opnames worden gemaakt met TU Delft-eigendom apparatuur (een TU Delft-audiorecorder) of via TU Delft-ondersteunde online vergadersoftware (bijv. Teams via een TU Delft-account).

5) Moet ik meedoen?

Nee. Deelname is vrijwillig. U mag vragen overslaan en u mag op elk moment stoppen zonder een reden op te geven. Dit heeft geen negatieve gevolgen.

6) Risico's en ongemakken

Dit is onderzoek met minimale risico's. Sommige vragen kunnen persoonlijk aanvoelen. U mag vragen overslaan, pauzes nemen of stoppen.

Een mogelijk risico is onbedoelde herkenning in rapporten (bijv. door specifieke details in verhalen). Dit risico wordt verminderd door pseudonimisering en door resultaten uitsluitend in geanonimiseerde/geaggregeerde vorm te rapporteren.

7) Welke gegevens worden verzameld?

We kunnen verzamelen:

- Administratieve gegevens (PII): naam en contactgegevens voor planning, en een ondertekend instemmingsformulier.
- Onderzoeksdata (PIRD): interviewnotities en (als u toestemming geeft) audio-opnames en transcripties. Optioneel kunnen foto's worden gemaakt van u en uw supplementenroutines (als u toestemming geeft). Gezichtsbeelden worden niet opgenomen tenzij u daar apart expliciet toestemming voor geeft.

8) Hoe worden mijn gegevens beschermd?

Uw contactgegevens en instemmingsformulier worden apart opgeslagen van de onderzoeksdata. Onderzoeksdata worden gecodeerd met een deelnemerscode (gepseudonimiseerd). Data wordt opgeslagen op TU Delft-beheerde beveiligde opslag (TU Delft OneDrive) en is alleen toegankelijk voor de onderzoeker en TU Delft-begeleiders. Silvie Health ontvangt alleen geanonimiseerde en geaggregeerde bevindingen.

9) Hoe worden de resultaten gebruikt?

Resultaten worden gebruikt voor de MSc-scriptie/het rapport, presentaties en ontwerpdocumentatie (bijv. inzichten, criteria, concepten, prototypes). Anonieme quotes kunnen worden gebruikt om bevindingen te illustreren. Er wordt geen identificeerbare informatie gepubliceerd tenzij u daar apart schriftelijk toestemming voor geeft.

10) Hoe lang worden de gegevens bewaard?

Audio-opnames (indien gemaakt) en gepseudonimiseerde notities worden verwijderd na transcriptie en controle, en in elk geval uiterlijk 3 maanden na afronding van het project (1 juli 2026). Ondertekende instemmingsformulieren kunnen voor dezelfde periode worden bewaard voor audit-/validatiedoeleinden.

11) Terugtrekking en uw rechten

U kunt zich op elk moment terugtrekken. Als u zich terugtrekt voordat de analyse is afgerond, kunt u verzoeken om verwijdering van uw interview-/testsessiegegevens. Nadat data volledig is geanonimiseerd en verwerkt is in geaggregeerde bevindingen, is het mogelijk niet meer haalbaar om uw bijdrage te verwijderen.

12) Contact en klachten

Dieter van Dortmont

E-mail: dietervandortm@tudelft.nl

Telefoon: [REDACTED]

Voor vragen over privacy/gegevensbescherming bij TU Delft kunt u contact opnemen met het TU Delft Privacy Team: privacy-tud@tudelft.nl.

Instemmingsformulier

Studie: A Salutogenic Design Approach to Supplementation and Healthy Ageing

Versie 2.0 — 24 februari 2026

Lees elke verklaring en geef aan of u akkoord gaat.

Verklaring	Yes	No
1. Ik heb de informatie over het onderzoek gedateerd 20 februari 2026 gelezen en begrepen, of deze is aan mij voorgelezen. Ik heb de mogelijkheid gehad om vragen te stellen over het onderzoek en mijn vragen zijn naar tevredenheid beantwoord.	☐	☐
2. Ik doe vrijwillig mee aan dit onderzoek. Ik begrijp dat ik kan weigeren vragen te beantwoorden en mij op elk moment kan terugtrekken zonder een reden op te hoeven geven.	☐	☐
3. Ik begrijp dat deelname aan het onderzoek inhoudt dat ik meedoe aan één semigestructureerd interview (ongeveer 30–60 minuten) over routines, ervaringen, behoeften en barrières rondom supplementen en gezond ouder worden.	☐	☐
4. Ik begrijp dat ik voor deelname aan dit onderzoek een <u>Silvie</u> cadeaubon van 25 euro ontvang.	☐	☐
5. Ik begrijp dat de studie loopt van februari tot en met juni 2026.	☐	☐
6. Ik begrijp dat deelname minimale risico's met zich meebrengt (sommige vragen kunnen persoonlijk aanvoelen). Ik begrijp dat ik vragen mag overslaan, pauzes mag nemen en op elk moment kan stoppen.	☐	☐
7. Ik begrijp dat het onderzoek persoonlijke identificeerbare informatie (PII) verzamelt voor planning en instemming (naam, contactgegevens, ondertekend instemmingsformulier), en mogelijk persoonlijke identificeerbare onderzoeksdata (PIRD) verzamelt zoals notities, transcripties en (als ik toestemming geef) audio-opnames of foto's, met een mogelijk risico op herleidbaarheid. Ik begrijp dat dit risico wordt verminderd door deelnemerscodes te gebruiken, identificeerbare details te verwijderen, veilige opslag en het rapporteren van resultaten uitsluitend in geanonimiseerde/geaggregeerde vorm.	☐	☐
8. Ik begrijp dat sommige informatie kan gaan over gezondheid- en welzijnsroutines, wat onder de Algemene verordening gegevensbescherming	☐	☐

(AVG) als gevoelig kan worden beschouwd. Ik begrijp dat ik dergelijke informatie niet hoeft te delen en vragen mag overslaan.		
9. Ik begrijp dat de volgende stappen worden genomen om het risico op een databreuk te minimaliseren en mijn identiteit te beschermen in het geval van een databreuk: contactgegevens en onderzoeksdata worden apart opgeslagen, <u>pseudonimisering</u> , veilige TU Delft-opslag en toegang beperkt tot alleen de onderzoeker/TU Delft-begeleiders.	☐	☐
10. Ik begrijp dat identificeerbare persoonlijke informatie over mij niet gedeeld wordt buiten het onderzoeksteam.	☐	☐
11. Ik begrijp dat de geanonimiseerde informatie die ik verstrek gebruikt zal worden voor: de MSc-scriptie/het rapport en bijlagen, presentaties en ontwerpdocumentatie, en dat anonieme quotes gebruikt kunnen worden.	☐	☐
12. Ik geef toestemming dat mijn antwoorden anoniem geciteerd mogen worden in onderzoeksoutputs.	☐	☐

Optionele toestemmingen

13. Ik geef toestemming voor audio-opname van het interview (TU Delft-eigendom recorder of TU Delft-ondersteunde software. Als ik geen toestemming geef, maakt de onderzoeker alleen schriftelijke notities. Ik begrijp dat audio-opnames (indien gemaakt) worden verwijderd na transcriptie en uiterlijk 3 maanden na afronding van het project.	☐	☐
14. Ik ga ermee akkoord dat mijn echte naam gebruikt mag worden voor quotes in onderzoeksoutputs.	☐	☐
15. Ik geef toestemming voor het maken van foto's van mijn supplementenroutine of van mijn handen tijdens interactie met supplementen in mijn routine (geen gezicht). Deze beelden mogen in geanonimiseerde vorm gebruikt worden in de scriptie/ontwerpdocumentatie.	☐	☐
15. Ik geef toestemming voor het maken van foto's met mijn gezicht tijdens interactie met supplementen in mijn routine. Deze beelden mogen zonder anonymisering gebruikt worden in de scriptie/ontwerpdocumentatie.	☐	☐
16. Ik begrijp dat de geanonimiseerde informatie die ik verstrek (bijv. interview notities, transcripties en eventuele opnames) niet gearhiveerd zal worden voor toekomstig onderzoek en onderwijs. Ik begrijp dat deze informatie uitsluitend gebruikt wordt voor dit TU Delft-afstudeerproject en in geanonimiseerde vorm	☐	☐

wordt gerapporteerd in de MSc-scriptie/het rapport en gerelateerde presentaties.		
17. Ik ga ermee akkoord dat ik mogelijk opnieuw benaderd kan worden voor een korte follow-up binnen 6 weken na de sessie, voor verduidelijking of conceptfeedback.	☐	☐

Naam deelnemer (in blokketters): _____

Handtekening: _____ Datum: ____/____/____

Ik, als onderzoeker, heb de informatiebrief correct aan de potentiële deelnemer voorgelezen en, naar het beste van mijn vermogen, verzekerd dat de deelnemer begrijpt waar hij/zij vrijwillig mee instemt.

Naam onderzoeker: Dieter van Dortmont

Signature: _____ Date: ____/____/____

Contactgegevens voor verdere informatie: Dieter van Dortmont, [REDACTED]
diervandortm@tudelft.nl

Appendix F. Interview Guides

This is an example of one of the interview guides, experts received questions fitting to their expertise

Interviewgids (NL)

Project: A Salutogenic Design Approach to Supplementation and Healthy Ageing (TU Delft IDE)
Methode: Interviews (Discover fase)
Doelgroep: Vrouwen 55-75, zelfstandig wonend
Duur: 35-50 min
Vorm: Op locatie / videobellen / telefoon
Materialen: Informed consent (geprint), audiorecorder (optioneel), notitieblad, (optioneel) routine-tijdlijn

Doel van het onderzoek
Begrijpen hoe vrouwen 55-75 supplementen in hun dagelijks leven doen, wat consistentie/adherentie helpt of belemmert, en wat vertrouwen, duidelijkheid en een “waardige” ervaring creëert.

1. Introductie en toestemming (2-3 min)

Script

- Bedankt dat je meedoet. Ik ben Dieter en ik doe mijn TU Delft afstudeerproject over hoe we het nemen van supplementen makkelijker en betrouwbaarder kunnen maken voor vrouwen 55+.
- Er zijn geen goede of foute antwoorden, ik ben vooral benieuwd naar jouw echte ervaring.
- Als je het goed vindt, neem ik het gesprek op zodat ik niets mis. Je mag op elk moment stoppen, vragen overslaan of vragen om de opname te verwijderen.
- Alles wordt vertrouwelijk behandeld en in rapportage geanonimiseerd.

Check

- Consentformulier geven en zorgen dat de deelnemer vragen kan stellen en alles begrijpt.

2. Context (4-6 min)

2.1 Kun je iets vertellen over jezelf en je dagelijkse routine?
(Werk/pensioen, woonsituatie, globale dagstructuur)

2.2 Wat betekent “gezond ouder worden” voor jou persoonlijk?

2.3 Gebruik je op dit moment supplementen?

- Zo ja: welke soorten globaal? (merken zijn niet nodig)
- Zo nee: heb je ze eerder gebruikt / wil je ermee beginnen?

3. Huidige routine stap voor stap (10-12 min)

3.1 Denk aan gisteren (of een normale doordeweekse dag). Wanneer komen supplementen in je dag voor?

- Ochtend / middag / avond
- Voor/met/na eten
- Met koffie/thee/water?
- Waarom deze tijd?

3.2 Kun je de stappen beschrijven?

- Waar bewaar je ze?
- Hoe bepaal je wat je neemt?
- Hoe bereid je het voor?

3.3 Hoeveel verschillende supplementen neem je op een typische dag? (een schatting is prima)

3.4 Neem je ze elke dag of wisselt dat? Waardoor komt dat?

3.7 Zou je willen laten zien (op camera) of beschrijven waar je ze bewaart en hoe je ze neemt? (Als dat niet prettig is: geen probleem.)

4. Wat werkt goed (succespatronen) (5-6 min)

4.1 Op dagen dat het goed gaat, wat maakt het dan makkelijk?

- Triggers/ankers (ontbijt, tandenpoetsen, medicatie, etc.)
- Voorbereiding vooraf?
- Gewoonte?

4.2 Heb je trucs of systemen om consistent te blijven?
(pillendoos, notities, telefoon-alarm, zichtbaar neerleggen, routine stapelen)

5. Fricties, fouten en uitzonderingen (8-10 min)

5.1 Wat zijn de meest irritante of lastige onderdelen van je supplement-routine?
(kiezen, onthouden, slikken, timing, te veel potjes, opslag, smaak, opruimen)

5.2 Kun je een recente keer beschrijven dat je het vergat of oversloeg, wat gebeurde er?

5.3 Wanneer gaat het het vaakst mis?

- Reizen / weekend / bezoek / drukke ochtenden
 - Als je 2-3 dagen weggaat: wat neem je mee en hoe organiseer je dat?
- Ziekte / stress / veranderend schema
- Wat voelt “risicovol” of onzeker?
 - Verkeerde nemen
 - Dubbel nemen
 - Interactie met medicatie
 - Niet zeker weten of je het goed doet

6. Vertrouwen, keuzes en informatie (8-10 min)

6.1 Hoe kies je welke supplementen je neemt en of je ze vertrouwt? EN
6.3 Wie of wat heeft het meeste invloed op jouw keuzes? (arts, partner, vrienden, media, merk, apotheek)

- Arts/diëtist
- Merk/reputatie
- Etiket/claims
- Vrienden/familie
- Eigen onderzoek
- Zelf gemaakt

Opvattingen / mental model:
6.2 Wat denk je dat supplementen je opleveren, en waaraan merk je dat?
Doorvraag: Wanneer zou je stoppen met een supplement? Wat moet er gebeuren om te denken: dit werkt niet?

6.4 Hoe zeker voel je je dat je ze correct inneemt?

- Dosering / timing / met eten

6.5 Welke informatie zou je graag duidelijker of makkelijker willen?

- Wat is het, waarom, hoe neem je het, wat moet je vermijden

Koopgedrag/waarde (licht):
6.6 Hoe koop je je supplementen meestal? (los, abonnement, in bulk)

6.7 Wat vind je belangrijker: gemak, prijs, kwaliteit of vertrouwen? (kies top 2)

Hoe ver wil je gaan voor je gezondheid → Wat zou je per dag maximaal willen spenderen aan voedingssupplementen?

Vind je dat voedingssupplementen door de verzekering vergoed zouden moeten worden? Wat/Wanneer/Hoe veel vind je redelijk?

7. Houding t.o.v. een product/systeem (6 - 10 min)

(Exploratief: niet “verkopen”.)
7.1 Als een product/dienst jouw routine makkelijker kan maken, wat zou het dan moeten doen? (beslissingen vereenvoudigen, minder rommel, reminders, voorbereiding, reis-modus)

7.2 Hoe zou je je voelen bij een apparaat of “routine station” op het aanrecht?

- Wat zou je fijn vinden / niet fijn?
- Waar zou het staan? Zou het in de weg staan?

Onderhoud/hygiëne-tolerantie:

7.3 Hoeveel onderhoud of schoonmaken vind je acceptabel? (bijv. dagelijks 30 sec / wekelijks 5 min / liever bijna nooit)

7.4 Wat maakt iets betrouwbaar en niet gimmicky of “medisch”?

- Uiterlijk, materialen, transparantie, feedback, rust, privacy

7.5 Zou je tracking/feedback willen (bijv. “genomen / niet genomen”)?

- Wat voelt helpend vs. opdringerig?

Privacy-grens:
7.6 Welke informatie zou je wél willen zien en wat absoluut niet?
Doorvraag: Alleen voor jezelf, delen met iemand (partner/coach/arts), of liever helemaal niet delen?

Toekomstbeeld:
8.3 Stel: Kan je mij vertellen hou jouw ideal supplementen routine eruit ziet? Wat zou je veranderen/houden. Wat is voor jou toegevoegde waarde?

Snelle ranking (30 sec):
8.4 Wat zijn je top 2 prioriteiten: gemak, vertrouwen, weinig gedoe, of overzicht/duidelijkheid?

8.5 Is er iets belangrijks dat ik niet gevraagd heb?

Afsluiten

- Bedanken, kort uitleggen wat de volgende stappen zijn.
- Toestemming vragen voor een vervolgsessie (concept/prototype test) later.
- Compensatie bevestigen.

Appendix G. Coding workbook

Following is an illustrative example of the coding workbook used for identifying themes and routine moments evidence. Quotes are blurred here to protect the identity of participants.

Participant ID	Quote	Routine moment	Subquestion	Why it matters
P01		n/a	SQ1	
P02		Intake	SQ6	
P03		Recovery-Adjust	SQ5-Trust	
P04		n/a	SQ5-Trust	
P05		n/a	SQ5-Trust	
P06		n/a	SQ7	
P07		Intake	SQ1	
P08		n/a	SQ5-Trust	
P09		Recovery-Adjust	SQ5-Trust	
P01		n/a	SQ6	
P02		Acquire-Replenish	SQ7	
P02		Intake	SQ1	
P03		Intake	SQ1	
P03		Store-Place	SQ7	
P04		Store-Place	SQ1	
P05		Recovery-Adjust	SQ5-Trust	
P06		Acquire-Replenish	SQ7	
P06		Prepare	SQ3	
P07		Intake	SQ1	
P07		Acquire-Replenish	SQ5-Trust	
P08		n/a	SQ5-Trust	
P08		Prepare	SQ7	
P08		Intake	SQ2	
P09		Acquire-Replenish	SQ5-Trust	
P09		Acquire-Replenish	SQ3	
P09		Acquire-Replenish	SQ7	
P02		Exceptions-Disruptions	SQ3	
P03		Recovery-Adjust	SQ3	
P04		Exceptions-Disruptions	SQ3	
P06		Prepare	SQ6	

Appendix H. Validation session forms

The before and after scale, six statements scored one to seven, and the four semantic differential scales. Used in both the concept and the final validation rounds.

Participant sheet 1: VOORAF (v2)

Deelnemerscode: _____ Datum: _____

Omcirkel bij elke stelling het cijfer dat het beste past bij wat u nu vindt. 1 = helemaal oneens, 7 = helemaal eens. Er zijn geen goede of foute antwoorden.

Begrijpen

Stelling	oneens			neutraal			eens
1. Ik weet wat mijn lichaam nodig heeft. *	1	2	3	4	5	6	7
2. Ik kan goed beoordelen of wat ik voor mijn gezondheid doe, ook echt werkt. *	1	2	3	4	5	6	7
3. Ik twijfel regelmatig of ik de goede dingen doe voor mijn gezondheid. *	1	2	3	4	5	6	7
4. Wat er dagelijks met mijn gezondheid gebeurt, is begrijpelijk voor mij. *	1	2	3	4	5	6	7

Kunnen

5. Ik heb grip op mijn dagelijkse gezondheid. *	1	2	3	4	5	6	7
6. Wat ik mij voorneem voor mijn gezondheid, lukt mij ook op drukke dagen.	1	2	3	4	5	6	7
7. Als het een dag niet lukt, pak ik het daarna makkelijk weer op.	1	2	3	4	5	6	7

Zinvol

8. Waar ik dagelijks mee bezig ben voor mijn gezondheid, voelt zinvol. *	1	2	3	4	5	6	7
9. Ik vind dat ik tijd voor mezelf mag nemen.	1	2	3	4	5	6	7
10. Zorgen voor mezelf voelt als iets dat bij mij past.	1	2	3	4	5	6	7

Participant sheet 2: ACHTERAF (v2)

Deelnemerscode: _____ Datum: _____

Dezelfde stellingen als eerder, nu met de hanger in uw achterhoofd. 1 = helemaal oneens, 7 = helemaal eens.

Begrijpen

Stelling	oneens			neutraal			eens
1. Ik weet wat mijn lichaam nodig heeft. *	1	2	3	4	5	6	7
2. Ik kan goed beoordelen of wat ik voor mijn gezondheid doe, ook echt werkt. *	1	2	3	4	5	6	7
3. Ik twijfel regelmatig of ik de goede dingen doe voor mijn gezondheid. *	1	2	3	4	5	6	7
4. Wat er dagelijks met mijn gezondheid gebeurt, is begrijpelijk voor mij. *	1	2	3	4	5	6	7

Kunnen

5. Ik heb grip op mijn dagelijkse gezondheid. *	1	2	3	4	5	6	7
6. Wat ik mij voorneem voor mijn gezondheid, lukt mij ook op drukke dagen.	1	2	3	4	5	6	7
7. Als het een dag niet lukt, pak ik het daarna makkelijk weer op.	1	2	3	4	5	6	7

Zinvol

8. Waar ik dagelijks mee bezig ben voor mijn gezondheid, voelt zinvol. *	1	2	3	4	5	6	7
9. Ik vind dat ik tijd voor mezelf mag nemen.	1	2	3	4	5	6	7
10. Zorgen voor mezelf voelt als iets dat bij mij past.	1	2	3	4	5	6	7
11. Een hanger zoals deze zou mij helpen te vertrouwen op wat ik zelf merk.	1	2	3	4	5	6	7

Als u de hanger een tijd zou dragen (toekomstbeeld)

Stel dat u deze hanger een paar maanden zou dragen. Hoe zou u deze stellingen dan inschatten? 1 = helemaal oneens, 7 = helemaal eens.

Stelling	oneens			neutraal			eens
Ik zou beter weten wat mijn lichaam nodig heeft.	1	2	3	4	5	6	7
Ik zou meer grip hebben op mijn dagelijkse gezondheid.	1	2	3	4	5	6	7
Ik zou meer vertrouwen op wat ik zelf merk.	1	2	3	4	5	6	7
Ik zou mezelf vaker tijd voor mezelf gunnen.	1	2	3	4	5	6	7

Hoe voelt de hanger? Zet op elke lijn een kruisje waar het voor u past.

	1	2	3	4	5	
klinisch						huiselijk
voor ouderen						voor iedereen
betuttelend						respectvol
een apparaat						een sieraad

Appendix I. Validation session guide

This guide is reconstructed from the recordings of the six pendant sessions and the session with the jeweller. It was not written beforehand and it was not followed as a script. The sessions were semi-structured: the sequence below held, but the order within it followed the participant, and not every element was shown in every session. The online sessions used renders and the app scenarios, so the pendant, the vibration, the dish and the service kit could only be shown in person.

How a session ran

1. Written scale, before. Six statements scored 1 to 7, and the semantic differential scales.
2. The concept explained, then an open first reaction.
3. The app, screen by screen: setting a promise, when it may remind you, permissions, the weekly reflection, the four week trend, keep going or pause or let go, and tone of voice.
4. The pendant: size, finish, material, whether it reads as jewellery, and where it would be worn.
5. The vibration: strength ladder and patterns. In person only.
6. The squeeze: whether it is felt, and whether it is understood as a confirmation. In person only.
7. The charging dish: where it would stand, material, colour and size.
8. The battery service: the kit, the service sheet, and the replacement performed by the participant. In person only.
9. Engraving, a milestone marker and a stone.
10. Price and willingness to pay.
11. Written scale, after.
12. Closing: what is missing and what should change.

Prompts as used

First reaction

Wat zie je zoal als je hier naar kijkt? (What do you see when you look at this?)

Wat denk je dat dit is? (What do you think this is?)

The promise

Welke belofte zou je aan jezelf doen, denk je? (Which promise would you make to yourself?)

Zou je liever spreken of intypen? (Would you rather speak it or type it?)

Zou je er meerdere invullen of zou je er maar eentje willen? (Would you enter several or only one?)

Vind je dat die voorbeelden erbij moeten staan of maakt dat het onduidelijker? (Should those examples be there, or does that make it less clear?)

Timing

Wanneer mag je herinnerd worden? Is dit overzicht duidelijk? (When may you be reminded? Is this overview clear?)

Hoe vaak zou je persoonlijk herinnerd willen worden? (How often would you personally want to be reminded?)

Permissions

Waar is dit voor nodig, denk je? (What do you think this is needed for?)

Weekly reflection

Kan je hieruit opmaken hoe vaak je je aan je belofte hebt gehouden? (Can you tell from this how often you kept your promise?)

Wat vind je van de tekst, van wat hij hier zegt? (What do you think of the wording, of what it says here?)

Pause and release

Volhouden, pauzeren en loslaten. Vind je dat duidelijk? (Keep going, pause, let go. Is that clear?)

The object

Wat vind je van de grootte? (What do you think of the size?)

Zou je hem kleiner willen, of zou hij groter mogen? (Would you want it smaller, or could it be bigger?)

Tussen een apparaat en een sieraad, waar zet je hem? (Between a device and a piece of jewellery, where do you place it?)

Wearing it

Hoe hoog zou je hem willen dragen? (How high would you want to wear it?)

Zou je hem laten zien of onder je kleding dragen? (Would you show it or wear it under your clothes?)

The vibration

Voel je hem? (Can you feel it?)

Welke heeft jouw voorkeur? (Which do you prefer?)

Wat vind je van dit patroontje? (What do you think of this pattern?)

The squeeze

Als je hier aan de zijkant drukt, voel je dat dan? (If you press here on the side, do you feel it?)

Wat denk je dat er nu gebeurd is? (What do you think just happened?)

Engraving

Wat zou jij op de achterkant laten graveren? (What would you have engraved on the back?)

The dish

Waar zou je hem opladen? Waar bewaar je je sieraden meestal? (Where would you charge it? Where do you usually keep your jewellery?)

Welk materiaal past bij wat je in huis hebt? (Which material fits what you have at home?)

Zou die kleiner of groter mogen? (Could it be smaller or bigger?)

Battery service

Zou jij hem zo kunnen vervangen als ik dit aan jou geef? (Could you replace it yourself if I gave you this?)

Begrijp je hoe die erin moet? (Do you understand how it goes in?)

Wat verwacht je dat dat zou moeten kosten? (What would you expect that to cost?)

Price

Wat denk je dat het zou mogen kosten? (What do you think it should cost?)

Closing

Heb je nog dingen waarvan je denkt: dit zou je echt moeten veranderen? (Is there anything you think really should change?), Wat heb ik verkeerd geïnterpreteerd? (What have I misread?)

The jeweller session

Zou je hiermee uit de voeten kunnen om het te repareren? (Could you carry out the repair with this?), Is er iets onduidelijk? (Is anything unclear?)

Deze tools hebben jullie in huis? (Do you have these tools in-house?)

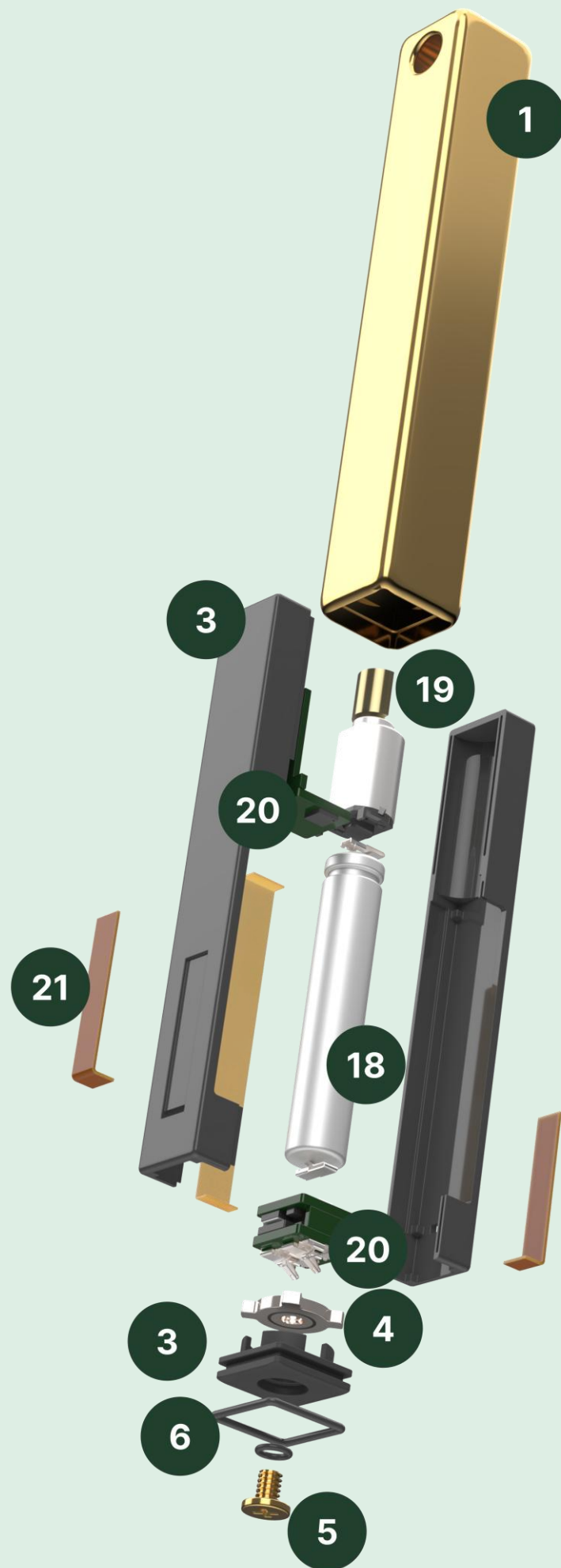
Wat zou je rekenen voor zo'n reparatie? (What would you charge for a repair like this?)

Wat is gebruikelijk bij jullie qua doorlooptijd? (What is your normal turnaround?)

Stel dat het wisselsetje per post komt, is dat ook goed? (If the kit arrived by post, would that work too?)

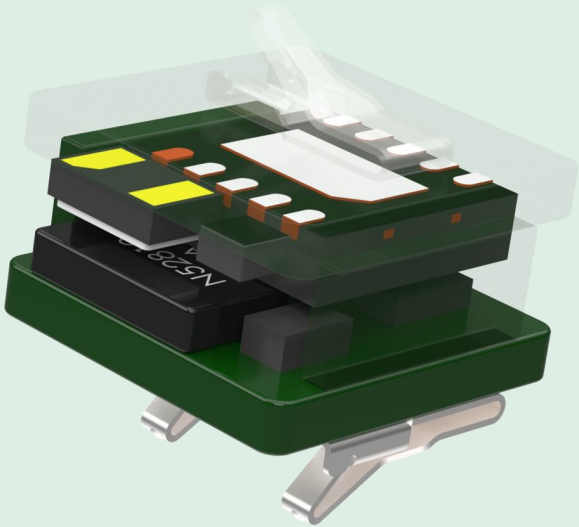
Zou je dit in je vitrine willen hebben staan? (Would you want this in your display case?)

Zou je mij nog iets aanraden voordat ik in productie ga? (Is there anything you would advise before I go into production?)



Appendix J. Bill of materials and cost

#	Part	Qty	EUR at 10,000 high	EUR at 50,000 low	How it is made, or what it does	Source and price basis
Housing and mechanical						
1	Outer shell Grade 5 titanium, polished	1	23.43	8.68	CNC machined from titanium bar, then polished.	Supplier A and Supplier B.
2	PVD gold coating on shell 14K to 18K, titanium nitride interlayer	1	4.34	0.00	PVD deposition onto the finished shell.	Supplier B, plus USD 5.00 per piece. Zero against Supplier A, who include it in the piece price.
3	Inner shell halves and lid Unfilled PBT, black, three parts	3	0.08	0.07	Injection moulded, one family mould for all three parts.	Supplier D, quotation
4	Retaining plate Stainless steel (magnetic), dielectric plastic	1	2.50	0.60	Turned and milled, threaded and stamp pressed together	No shop approached. Estimate.
5	Contact screw Steel, M1.4, gold plated	1	0.80	0.20	Machined, then plated.	MISUMI catalogue screw pricing. Custom form and plating estimated.
6	Seals Silicone O-rings, 4.5 x 0.5 mm and 2.2 x 0.4 mm	2	0.15	0.07	Compression moulded silicone.	Global O-Ring, nearest published catalogue size.
7	Silicone grease One dose per assembly	1	0.05	0.02	Applied to both seals at assembly and again at every service.	No source. Fraction of a gram, estimated.
Electronics						
8	Radio and processor Nordic nRF52810-CAAA-R7	1	1.41	1.41	Bluetooth radio and processor.	Mouser.
9	Capacitive sensor Texas Instruments FDC1004DSCR, WSON-10	1	2.52	2.52	Measures the squeeze.	Texas Instruments.
10	Battery charger Texas Instruments BQ25100H	1	0.65	0.65	Charges the cell at a fixed 4.35 V.	Texas Instruments.
11	Regulator Texas Instruments TPS7A0233PDQNR, X2SON-4	1	0.23	0.23	Drops the cell to 3.3 V, since the cell sits above the radio maximum	Texas Instruments.
12	Haptic driver Texas Instruments DRV2605LYZFR, DSBGA-9	1	0.62	0.62	Drives the motor	Texas Instruments.
13	ESD diode Texas Instruments TPD1E05U06DPYR	1	0.03	0.03	Protects the exposed screw contact against static when it is touched.	Texas Instruments.
14	32 MHz crystal Abracon ABM11W	1	0.32	0.32	Radio clock.	Mouser.
15	32.768 kHz crystal Abracon ABS05, 1610 package	1	0.47	0.47	Sleep clock. Saves energy.	Mouser.
16	Spring finger contacts TE Connectivity 2329497-2	6	0.08	0.07	4 carry charge and ground between the boards and the plate, 2 clamp and centre the cell.	Mouser.
17	Passive components	~25	0.02	0.01	Manage and shape electricity in the circuit.	Estimate, no source.
Battery						
18	Cell Panasonic CG-320B, pin type lithium ion, 3.65 x 20 mm, 15 mAh	1	16.08	16.08	Powers the pendant. Certified catalogue cell.	Cytech
Actuator						



19	Vibration motor Precision Microdrives 304-015, 4 mm	1	2.09	1.35	Produces the buzz.	Supplier G, quotation
Boards and assembly						
20	Rigid boards Three FR-4 boards, 4.5 x 4.5 x 0.6mm four layer, castellated rails	1	1.20	0.30	Standard multilayer PCB	No quotation.
21	Flex cables Two electrode flexes and one flex, single sided polyimide	1	2.20	0.60	Etched polyimide flex. The electrode flexes are the sensing plates.	No quotation.
22	Board assembly and test SMT both sides, estimated ~200 solder joints	1	2.50	0.80	Stencil print, pick and place, reflow, optical inspection, electrical test.	JLCPCB published rate card.
23	Final assembly, sealing and test Manual, under magnification	1	8.00	2.50	Hand assembled, seals greased, screw torqued, then charge and function test.	Estimate
Not costed						
	Charging dish and accessories Dish body, dish electronics, magnet, spring contacts, USB cable		not costed	not costed	Tested with participants as a placement object, but never engineered and never shown to a supplier.	Carried into the recommendations rather than given a number.
TOTALS						
Bill of materials per pendant			70.96	38.40		
Sold with the pendant, yet to be priced as prototype fidelity increases						
	Engraving at factory Personal text on the back face, different on every piece, not in final design (quoted for reference here)	1	4.34	0.00	Individual laser engraving, run in line.	Supplier B, plus USD 5.00 per piece.
	Packaging Box, insert, welcome card, service sheet	1	-	-	Jewellery grade box with printed inserts.	No quote.
	Chain Gold coloured, 14K or plated, 42 to 45 cm, end eye 3.2 to 3.5 mm	1	-	-	Bought in. Replaceable by the wearer with any chain of the same end eye.	No wholesale price obtained.
	Charger Jewelry dish	1	-	-	Charging device, added in box	Prototype needs higher fidelity before price estimates
Source colour QUOTED PUBLISHED NEAR EQUIVALENT OR RATE CARD ESTIMATE NOT PRICED						

TOOLING AND ONE-OFF COSTS

Obtained in writing from a named source

Family mould, inner shell halves and lid One mould producing left half, right half and lid together	2,256	2,256	Two plate tool, two sliders, P20 or S50C base, rated 100,000 shots.	Supplier D, quotation. USD 2,600.
Shell development and tooling DFM, drawings, cutting tools, machining trials, 3 to 5 samples	12,367	12,367	A two month development programme before production can start.	Supplier B. USD 14,250.
Bluetooth product qualification Adopter full qualification fee, one product	10,414	10,414	Paid once per qualified design, not per unit.	Bluetooth SIG fee, USD 12,000.
Total obtained	25,037	25,037	The same at both volumes, because a tool is paid for once. Every figure traceable to a dated document.	

Required, but never quoted

Seal tool Custom silicone seals	not quoted	not quoted		No supplier or test house approached.
Contact screw first article Custom M1.4 screw, plated	not quoted	not quoted		No supplier or test house approached.

	CE and RED radio testing Regulatory testing before the product may be sold in the EU		not quoted	not quoted		No supplier or test house approached.
	IP rating Waterproofing		not quoted	not quoted		No supplier or test house approached.
	Board and flex non recurring engineering		not quoted	not quoted		No supplier or test house approached.
None of these four was priced by anyone. The one off bill is therefore higher than 25,037 euro, by an amount this project has not established.						
Quoted, but not part of the current design						
	Three separate moulds instead of one family mould		11,976			Supplier E, USD 13,800.
	Metal injection moulding route for the shell		35,000 to 40,000			Supplier F, Part EUR 3 to 6 as sintered.
	Custom pouch cell mould		8,678			Supplier C, USD 10,000. Rejected.
	Technician replaceable cell sleeve		34,713			Supplier C, About USD 40,000. Rejected.
Supplier A gave a unit price of about USD 10 but no tooling or NRE figure, after two requests. The cheaper of the two shell prices therefore carries no tooling number at all, while the dearer one does. The two cannot be combined into one scenario.						
Estimated, not quoted						
	Application development Back end, security and privacy work, app store release		35,000	55,000	Professional time rather than tooling, estimate.	(Yeti, 2025)

Neither table is what it costs to put the product in a customer's hands. Freight, import duty, the channel decision, the retail price, profit margin etc all come on top. Wearables like this are sold at prices such as €529 (Oura, 2026b), and participants price the object between 100 (for the cheaper silver version) to a 1000 (as a maximum limit), while most report to expect between 150-300 euro.

Three things carry no price here at all. The charging dish was tested with participants as a placement object but was never engineered, never given a material and never shown to a supplier, so its design, its material choice and its manufacture are carried into the recommendations rather than costed. The application is in the table above at a figure estimated rather than quoted. And the pendant is priced in gold coated titanium only, where a silver version would differ in both material and finish and has not been put to a supplier. All prices are subject to change as they need further iterations, these prices are to give a rough approximation.

Appendix K. Arduino code (capacitive gap sensing)

```
1  /* =====
2  SILVIE PILLAR
3  Capacitive squeeze sensing with haptic feedback - test firmware
4  =====
5  Target board : Seeed Studio XIAO ESP32-S3
6  Toolchain   : Arduino IDE, board package "esp32" by Espressif
7  Libraries   : Adafruit_DRV2605, Adafruit_MPR121 (both via Library Manager)
8  Serial      : 115200 baud
9
10 PURPOSE
11 -----
12 This firmware exists to answer two design questions experimentally, before
13 either is committed to a production build.
14
15 Question 1 - CAN A SQUEEZE BE SENSED WITHOUT A MECHANICAL SWITCH?
16 Two conductive plates separated by a compressible gap form a capacitor.
17 Squeezing the grip closes the gap, which RAISES the capacitance. An
18 MPR121 capacitive touch controller measures that capacitance
19 continuously, and this firmware converts the resulting number into a
20 press/release event with a defined threshold and dwell time.
21
22 Question 2 - HOW WEAK A VIBRATION MOTOR IS STILL PERCEPTIBLE?
23 The prototype is fitted with a strong motor (HYY 4Z08). The G simulator
24 drives that motor at reduced power so that the sensation of a weaker,
25 cheaper motor can be judged directly, without first ordering samples.
26 This informs the PMD 304-015 versus 304-103 selection.
27
28 HOW THE TWO HALVES FIT TOGETHER
29 -----
30 [conductive plates] --> MPR121 --> I2C --> ESP32-S3 --> I2C --> DRV2605L
31                                     |
32                                     v
33                                     USB serial log      vibration
34                                     (data capture)      motor
35
36 THEORY OF OPERATION IN ONE PARAGRAPH
37 -----
38 The MPR121 measures capacitance by pushing a known packet of electric charge
39 into the electrode and reading back the voltage that results. It reports
40 that voltage as a 0..1023 number ("counts"). Because  $Q = C \times V$ , and Q is
41 fixed, MORE capacitance produces LESS voltage, that is, FEWER counts. A
42 squeeze therefore makes the number go DOWN. The firmware maintains a
43 slowly-moving average of the resting value ("baseline"), and declares a
44 press when the live value drops more than CAP_THRESHOLD counts below that
45 baseline.
46
47 SUGGESTED READING ORDER FOR THIS FILE
48 -----
49 1. setup() - what happens at boot, in order
50 2. loop() - the 10 ms main cycle; the press detector is at the
51    bottom of it
52 3. tuneAFE() - the automatic calibration that makes the sensor
53    work at all; the single most important function
54    in this file
55 4. gBurst()/playPat() - the haptic output side
56 Everything else is support for those four.
57
58 SERIAL COMMAND REFERENCE (single keypresses, no Enter required)
59 -----
60 DIAGNOSTICS v DRV2605 self-test i scan the I2C bus
61 r one-shot sensor reading ? print help + current settings
62 SENSOR s toggle text streaming o toggle Serial Plotter mode
63 w toggle CSV logging b force a re-tune now
64 f threshold -5 g threshold +5
65 d dwell -50 ms D dwell +50 ms
66 e move sensing to the next electrode (ELE0..ELE11)
67 HAPTICS p prompt buzz c confirm buzz
68 a toggle the auto-prompt +/- auto-prompt interval +/-15 s
69 G SIMULATOR 1..7 select a strength AND play it
70 x replay current strength t/T burst shorter/longer
71 PATTERNS h heartbeat j breath k calm pulse l soft hum
72 m cycle pattern intensity: full -> gentle -> faint
73
74 KNOWN LIMITATIONS
75 -----
76 a) The G simulator scales AMPLITUDE, not FREQUENCY. A real 304-015 at its
77 own rated voltage spins at its full rated speed of roughly 11k rpm,
78 whereas this prototype's motor at a reduced voltage spins slower. Weak
79 levels therefore feel duller here than the real part would. This
80 firmware is a valid instrument for judging STRENGTH. CHARACTER must be
81 judged on physical PMD samples.
82 b) tuneAFE() accepts any result in the range 217..807 counts, but the
83 drift monitor treats only 250..790 as healthy. A tune that lands in the
84 217..249 or 791..807 gap will trigger a "baseline drifted" re-tune
85 roughly 3 s later. In practice the tuner almost always lands near 700,
86 so this is rare. Narrowing the accept window carries the opposite risk:
87 a working tune could be misreported as an electrode fault.
88 c) Timer comparisons written as "now >= nextTuneAt" are not safe across
89 the millis() counter rollover at about 49.7 days. This is irrelevant
90 for a bench session lasting minutes. The comparisons written as
91 "now - lastX > INTERVAL" elsewhere in this file ARE rollover-safe,
92 which is why the two forms look different.
93 d) Execution is entirely blocking, delay() is used freely, and a haptic
94 burst suspends sensing for its duration. This is acceptable for an
95 experimental instrument but would not be acceptable in a product.
96
97 WIRING
98 -----
99 DRV2605L : VIN -> 3V3 GND -> GND SDA -> D4 SCL -> D5 (addr 0x5A)
100 motor across OUT+ / OUT-
```

```
101 MPR121 : 3.3V -> 3V3 GND -> GND SDA -> D4 SCL -> D5 (addr 0x5B)
102 ADD -> 3V3 <-- this is what makes it 0x5B instead of 0x5A
103 sense electrode -> ELE0
104 Both controllers share one I2C bus and must therefore have different
105 addresses, which is the purpose of the ADD pin. With ADD left on GND the
106 MPR121 would also be 0x5A and would collide with the DRV2605L.
107
108 TROUBLESHOOTING
109 -----
110 "ELE0 SHORTED" Power off and check continuity between ELE0 and GND. The
111 usual causes are the electrode touching the grounded
112 shell, the two plates touching because the insulating film
113 is missing, or a solder bridge.
114 "ELE0 OPEN" The wire is not actually connected. Copper tape ADHESIVE
115 IS NOT CONDUCTIVE - the joint must be soldered to the
116 copper face rather than relying on the sticky side.
117 Sanity check Disconnect the electrode entirely. A healthy MPR121 then
118 reports OPEN. If a bare pin still reports SHORT, the
119 controller itself is dead (ESD) or not properly powered.
120 "MPR121 MISSING" Press 'i' to scan the bus. The DRV2605 answering at 0x5A
121 already proves that SDA, SCL and the pull-ups are sound,
122 so if nothing new appears the fault lies in the MPR121's
123 own VDD/SDA/SCL joints. If a device appears at an
124 unexpected address, the ADD pin is wired to the wrong net.
125 ===== */
126
127 #include <Wire.h> // I2C master (both controllers share this bus)
128 #include "Adafruit_DRV2605.h" // haptic driver: ROM effect library + RTP
129 #include "Adafruit_MPR121.h" // capacitive sensor: used only for begin()
130
131 // Forward declarations. Both functions are CALLED before they are DEFINED
132 // further down the file. The Arduino build system normally inserts these
133 // prototypes automatically and invisibly; writing them out makes the
134 // dependency explicit and keeps the file portable to a plain C++ compiler.
135 void rtpSetup();
136 void afterBuzz();
137
138 /* =====
139 SECTION 1 - HARDWARE CONSTANTS
140 ===== */
141
142 // The XIAO ESP32-S3 silkscreen labels the pins D0..D10, but the ESP32 API
143 // expects the underlying GPIO numbers. D4 is GPIO5 and D5 is GPIO6. Swapping
144 // these two is the single most common reason this sketch reports both
145 // controllers MISSING.
146 const int PIN_SDA = 5; // silkscreen D4
147 const int PIN_SCL = 6; // silkscreen D5
148
149 const uint8_t MPR121_ADDR = 0x5B; // because ADD is tied to 3V3
150 const uint8_t DRV_ADDR = 0x5A; // DRV2605L is fixed at 0x5A
151
152 // Which of the MPR121's 12 electrode inputs is actually being sensed.
153 // NOT const: the 'e' key cycles this 0->1->...->11 at runtime. That exists so
154 // that a suspected damaged pad or pin can be ruled out by moving the wire to a
155 // neighbouring input and confirming that the controller is still healthy.
156 uint8_t SENSE_ELE = 0;
157
158 // The count value that tuneAFE() aims for when calibrating. 700 out of 1023
159 // sits comfortably high, which leaves plenty of headroom BELOW it - and down
160 // is the direction a squeeze moves the reading.
161 const int TARGET_FILT = 700;
162
163 // Lookup table for the MPR121's CDT (charge/discharge time) field. The
164 // controller stores CDT as a 3-bit code 0..7; this converts a code into the
165 // microseconds it actually represents. Code 0 means "disabled", hence the
166 // leading zero.
167 // code : 0=off 1=0.5us 2=1us 3=2us 4=4us 5=8us 6=16us 7=32us
168 const float TUS[8] = {0, 0.5f, 1, 2, 4, 8, 16, 32};
169
170 /* -----
171 Converting raw counts into picofarads
172 -----
173 The controller pushes a known packet of charge into the electrode and
174 reports the resulting voltage as 0..1023 measured against 3.3 V.
175
176 charge Q = CDC[uA] x CDT[us] (microamps x
177 and C = Q / V microseconds = pC)
178
179 Substituting and rearranging:
180
181 C[pF] = (CDC x CDT x 1024) / (3.3 x counts)
182
183 The units resolve to picofarads directly, because picocoulombs per volt IS
184 picofarads. Note the inversion sitting in that denominator: MORE capacitance
185 means FEWER counts. Squeezing the grip therefore makes counts fall while pF
186 rises. This is why the plotter trace and the raw "filt" number move in
187 opposite directions, which is confusing on first encounter.
188
189 Reporting in pF rather than counts matters for documentation and analysis:
190 counts are meaningless outside this particular front-end setting, whereas
191 picofarads are a physical quantity that can be compared against a different
192 build, or against a hand calculation of a parallel-plate capacitor.
193 ===== */
194
195 uint8_t tunedCDC = 16; // uA, whatever tuneAFE() last settled on
196 float tunedCDT = 1.0f; // us, likewise - the pair defines the current scale
197 float countsToPF(int counts) {
198 if (counts < 1) return 0.0f; // guard: no /0
199 return (tunedCDC * tunedCDT * 1024.0f) / (3.3f * counts);
200 }
```

```
201 }
202
203 /* =====
204 SECTION 2 - PRESS DETECTOR TUNING
205 ===== */
206
207 // Baseline tracking rate for the exponential moving average. On each 10 ms
208 // cycle the baseline moves 0.2% of the way toward the current reading, so it
209 // takes roughly 5 s to absorb a step change. This is deliberately sluggish: it
210 // must follow slow thermal and humidity drift WITHOUT following an actual
211 // squeeze. Raising it stops slow squeezes registering; lowering it lets the
212 // resting point drift away uncorrected.
213 const float BASE_ALPHA = 0.002f;
214
215 // After any motor activity, ignore the sensor for this long. The motor's
216 // vibration physically moves the plates and its current draw disturbs the
217 // supply, so readings taken during a buzz are unusable. Without this mute the
218 // confirm buzz would immediately re-trigger the press detector.
219 const uint32_t MOTOR_SETTLE_MS = 350;
220
221 // A press held longer than this is assumed to be stuck - a plate has deformed
222 // and stayed closed, or the baseline is wrong. The handler force-reseeds the
223 // baseline so the detector recovers instead of latching indefinitely.
224 const uint32_t MAX_PRESS_MS = 3000;
225
226 // If the reading sits in the ambiguous zone (above the dead band but below the
227 // press threshold) for this long, it is treated as a new resting state and the
228 // baseline is hard-reseeded. This is what recovers from a hand resting on the
229 // grip, or from the electrode being physically bent.
230 const uint32_t OFFSET_CLEAR_MS = 1500;
231
232 // SANE * answers "is this reading physically possible?" - values pinned at 0
233 // or at 1023 indicate a shorted or open electrode, not a very hard squeeze.
234 const int SANE_MIN = 20, SANE_MAX = 1010;
235
236 // REST_* is the narrower question "is the BASELINE still in a good place?" If
237 // the resting value has wandered outside this window, the front-end gain is no
238 // longer appropriate and the sensor needs re-tuning, not merely re-baselining.
239 const int REST_MIN = 250, REST_MAX = 790;
240
241 const uint32_t INSANE_MS = 1500; // out of range this long -> re-tune
242 const uint32_t DRIFT_MS = 3000; // baseline out of REST_* this long -> re-tune
243
244 const uint32_t FAULT_RETRY_MS = 10000; // with a broken electrode, retry only every
245 // 10 s
246 const uint32_t FAULT_NAG_MS = 5000; // ..and log a complaint only every 5 s
247
248 // The two parameters intended to be adjusted during testing. NOT const - f/g
249 // and d/D change them at runtime, so good values can be found by feel and the
250 // winners hard-coded later.
251 const int CAP_THRESHOLD = 50; // counts below baseline that constitute a press
252 const uint32_t HOLD_MS = 150; // how long a press must be held before the
253 // confirm buzz fires (debounce + intent filter)
254
255 /* =====
256 SECTION 3 - G SIMULATOR (motor selection aid)
257 =====
258 The physics being exploited: for an ERM (eccentric rotating mass) motor, the
259 perceived vibration acceleration is roughly proportional to the SQUARE of
260 the drive voltage. So to make the fitted strong motor produce the
261 acceleration that a weaker motor would produce, drive it at
262
263 V = V_rated x sqrt( G_target / G_rated )
264
265 Concretely, the 4Z08 delivers 0.70 G at 3.0 V on a 100 g test load. To
266 present 0.35 G, drive it at 3.0 x sqrt(0.35/0.70) = 2.12 V.
267
268 The DRV2605's real-time playback (RTP) mode is what permits an arbitrary
269 drive level rather than a selection from the ROM effect library.
270 ===== */
271
272 const float REF_G = 0.70f; // 4Z08 rated acceleration on a 100 g load
273 const float REF_V = 3.0f; // ..at this rated voltage
274 const float ODCLAMP_V = 3.0f; // DRV open-loop full-scale output voltage
275
276 // The seven strengths under evaluation, in G.
277 const float G_LEVELS[7] = {0.15f, 0.25f, 0.35f, 0.40f, 0.50f, 0.60f, 0.70f};
278
279 // What each strength corresponds to in the real world. These names describe
280 // the PART BEING SIMULATED, not what the fitted motor is doing: at level 4 the
281 // 4Z08 runs at about 2.27 V, not 3.2 V. 3.2 V is what a 304-015 would require
282 // in order to reach that same 0.40 G.
283 const char* G_NAMES[7] = {"304-015 min", "304-015 typ", "304-103 min",
284 "304-015 @3.2V", "304-103 typ", "in-between",
285 "current 4Z08 (ref)"};
286
287 // A brief full-power kick ahead of weak levels. An ERM has a "start voltage"
288 // below which it will not begin turning from rest - for the 4Z08 that is up to
289 // 2.4 V, which is ABOVE several of the simulated levels. A real 304-015 starts
290 // reliably at its own rated voltage, so without this kick the simulation would
291 // show a stall that the real part would not exhibit. The kick sets the mass
292 // moving; once turning, the motor continues at the lower level.
293 const uint32_t KICK_MS = 60;
294
295 uint8_t glevel = 1; // index into G_LEVELS; default = 0.25 G
296 uint32_t gBurstMs = 250; // burst length; t/T adjust it, 100..1000
297
298 /* =====
299 SECTION 4 - CALM HAPTIC PATTERNS
300 ===== */
```



```

299 The DRV2605 holds 123 pre-designed vibration effects in ROM. A sequence is
300 played by loading up to 8 "waveform slots" with effect IDs and pulsing the
301 GO bit. A slot value with bit 7 set (0x80 | n) is not an effect at all - it
302 is a WAIT of n x 10 ms, which is how rhythm is produced. A slot value of 0
303 terminates the sequence.
304
305 Four patterns, three intensity variants each ('m' cycles the variant). All
306 effect IDs below were checked against the manufacturer's waveform library
307 table.
308
309 [0] heartbeat : bump, pause, softer bump
310               7/8/9 = Soft Bump at 100% / 60% / 30%
311               0x88 = wait 8 x 10 ms = 80 ms
312 [1] breath   : a smooth swell up, then down
313               82 = Ramp Up Long Smooth 1, 0 to 100%
314               70 = Ramp Down Long Smooth 1, 100 to 0%
315               106 = Ramp Up Long Smooth 1, 0 to 50% (half depth)
316               94 = Ramp Down Long Smooth 1, 50 to 0%
317               110 = Ramp Up Short Smooth 1, 0 to 50% (half, quick)
318               98 = Ramp Down Short Smooth 1, 50 to 0%
319 [2] calm pulse : 54 = Pulsing Medium 1 100%, 55 = Pulsing Medium 2 60%,
320               67 = Transition Hum 4 40%
321 [3] soft hum   : Smooth Hum, chosen because these variants have NO kick or
322               brake pulse - they fade in and out instead of snapping,
323               which is what makes them read as calm rather than urgent.
324               119 = 50%, 121 = 30%, 123 = 10%
325
326 Array layout is [pattern][intensity][slot].
327 ===== */
328 const uint8_t PATTERNS[4][3][4] = {
329   {{7, 0x88, 0, 0}, {8, 0x88, 9, 0}, {9, 0x88, 9, 0}}, // heartbeat
330   {{82, 70, 0, 0}, {106, 94, 0, 0}, {110, 98, 0, 0}}, // breath
331   {{54, 0, 0, 0}, {55, 0, 0, 0}, {67, 0, 0, 0}}, // calm pulse
332   {{119, 119, 0, 0}, {121, 121, 0, 0}, {123, 123, 0, 0}} // soft hum
333 };
334 const char* PAT_NAMES[4] = {"heartbeat", "breath", "calm pulse", "soft hum"};
335 const char* VAR_NAMES[3] = {"full", "gentle", "faint"};
336 uint8_t patVar = 0; // 'm' cycles full -> gentle -> faint
337
338 /* =====
339 SECTION 5 - RUNTIME STATE
340 ===== */
341
342 // --- auto-prompt: fires a buzz on a timer, to test whether an unprompted
343 // --- reminder is noticed or ignored during a long session
344 bool autoPrompt = true;
345 uint32_t promptInterval = 60000UL; // 60 s; +/- adjust in 15 s steps
346 uint32_t lastPrompt = 0;
347
348 // --- output modes. Only one of these three formats is emitted at a time; the
349 // --- precedence is csv > plotter > human-readable text.
350 bool streamCap = false; // master switch: emit anything at all?
351 bool csvMode = false; // machine-readable rows for a spreadsheet
352 bool plotterMode = false; // the "label:value," format the IDE plotter wants
353 uint32_t lastStream = 0; // rate-limits streaming to 10 Hz
354
355 // --- timers, each holding a millis() timestamp
356 uint32_t muteUntil = 0; // ignore the sensor until this time (motor running)
357 uint32_t quietSince = 0; // when the signal last looked settled
358 uint32_t insaneSince = 0; // when readings first went out of SANE * range
359 uint32_t driftSince = 0; // when the baseline first left REST * range
360 uint32_t lastMprTry = 0; // last attempt to re-init a missing MPR121
361 uint32_t nextTuneAt = 0; // earliest permitted re-tune; 0 = allowed now
362 uint32_t lastNag = 0; // last time a fault was reported to the log
363
364 int faultCode = 0; // 0 = healthy, 1 = shorted, 2 = open, 3 = unknown
365
366 Adafruit_DRV2605 drv;
367 Adafruit_MPR121 cap;
368 bool mprOK = false, drvOK = false; // did begin() succeed?
369
370 // --- press detector state
371 float sbase = 700; // the tracked baseline (float so the
372 // 0.2% EMA steps do not round to 0)
373 int h0 = 700, h1 = 700, h2 = 700; // last three raw readings, for the
374 // 3-sample median despike filter
375 bool pressing = false; // currently in a press?
376 bool fired = false; // has this press already buzzed?
377 uint32_t pressT0 = 0; // when the current press started
378 int peak = 0; // deepest delta seen this press
379
380 /* =====
381 SECTION 6 - RAW I2C HELPERS
382 =====
383 The Adafruit libraries are used for begin() and for the DRV's high-level
384 effect calls, but most of the MPR121 work here pokes registers directly. The
385 library does not expose the analog front end configuration, and that is
386 precisely what tuneAFE() has to control.
387 ===== */
388
389 // Write one byte to one register. No error reporting - a failure surfaces
390 // downstream as an implausible reading.
391 void wr8(uint8_t addr, uint8_t reg, uint8_t val) {
392   Wire.beginTransmission(addr); Wire.write(reg); Wire.write(val); Wire.endTransmissi
393   on();
394 }
395
396 // Read one byte from one register. Returns -1 on any bus error, which is why
397 // the return type is int and not uint8_t.
398 int rd8(uint8_t addr, uint8_t reg) {

```

```

398   Wire.beginTransmission(addr); Wire.write(reg);
399   // endTransmission(false) sends a REPEATED START instead of a STOP: it retains
400   // ownership of the bus between "here is the register requested" and "now
401   // return its contents", so no other transaction can interleave.
402   if (Wire.endTransmission(false) != 0) return -1;
403   Wire.requestFrom(addr, (uint8_t)1);
404   return Wire.available() ? Wire.read() : -1;
405 }
406
407 // Read one of the MPR121's 10-bit filtered-data registers.
408 // The MPR121 sends the LOW byte first, then the high byte, and only the bottom
409 // 2 bits of the high byte are meaningful - hence the 0x03FF mask.
410 int rd10(uint8_t reg) {
411   Wire.beginTransmission(MPR121_ADDR); Wire.write(reg);
412   if (Wire.endTransmission(false) != 0) return -1;
413   Wire.requestFrom(MPR121_ADDR, (uint8_t)2);
414   if (Wire.available() < 2) return -1;
415   uint16_t lo = Wire.read(), hi = Wire.read();
416   return ((hi << 8) | lo) & 0x03FF;
417 }
418
419 // Address-only transaction: does anything ACK at the DRV's address?
420 bool drvPing() { Wire.beginTransmission(DRV_ADDR); return Wire.endTransmission() ==
421   0; }
422
423 // The filtered-data registers form a contiguous block of 16-bit pairs starting
424 // at 0x04, so electrode N lives at 0x04 + 2N. ELE0 = 0x04, ELE11 = 0x1A.
425 int filtNow() { return rd10(0x04 + 2 * SENSE_ELE); }
426
427 // Median of three, by three compare-and-swaps. This is the despike filter: a
428 // single wild sample (an I2C glitch, an ESD event, mains pickup) is discarded
429 // entirely, whereas an average would admit it at one third strength. Unlike an
430 // average it also adds no lag to a genuine step change.
431 int median3(int a, int b, int c) {
432   if (a > b) { int t = a; a = b; b = t; }
433   if (b > c) { int t = b; b = c; c = t; }
434   if (a > b) { int t = a; a = b; b = t; }
435   return b;
436 }
437
438 int iabs(int v) { return v < 0 ? -v : v; }
439
440 /* -----
441 I2C bus scanner - key 'i'
442 -----
443 This is useful precisely because the bus is already PROVEN GOOD whenever the
444 DRV answers at 0x5A. So when the MPR121 is missing, the scan distinguishes
445 two cases:
446 - nothing new in the list -> a bad VDD / SDA / SCL joint on the MPR121
447 - an unexpected address -> its ADD pin is on the wrong net
448 The ADD pin selects the MPR121's address:
449 ADD -> GND = 0x5A (clashes with the DRV!) ADD -> 3V3 = 0x5B (this build)
450 ADD -> SDA = 0x5C ADD -> SCL = 0x5D
451 ----- */
452 void i2cScan() {
453   Serial.println(F("I2C scan 0x08-0x77:"));
454   int n = 0;
455   // Addresses 0x00-0x07 and 0x78-0x7F are reserved by the I2C specification,
456   // so a standard scan covers 0x08..0x77 only.
457   for (uint8_t a = 0x08; a <= 0x77; a++) {
458     Wire.beginTransmission(a);
459     if (Wire.endTransmission() == 0) { // 0 means the device ACKed
460       const char *tag =
461         a == DRV_ADDR ? " DRV2605" :
462         a == MPR121_ADDR ? " MPR121 (expected here)" :
463         a == 0x5A ? " <- MPR121 ADD on GND? (clashes with DRV)" :
464         a == 0x5C ? " <- MPR121 ADD on SDA?" :
465         a == 0x5D ? " <- MPR121 ADD on SCL?" : "";
466       Serial.printf(" 0x%02X%s\n", a, tag);
467       n++;
468     }
469   }
470   if (n == 0) Serial.println(F(" nothing ACKed - check SDA=D4, SCL=D5, 3V3, GND, pu
471   ll-ups"));
472   else Serial.printf(" %d device(s). Want 0x%02X (DRV) and 0x%02X (MPR121).\n",
473     n, DRV_ADDR, MPR121_ADDR);
474 }
475
476 /* =====
477 SECTION 7 - DRV2605 HAPTIC DRIVER
478 ===== */
479
480 // Decode the DRV2605 status register (0x00).
481 bits 7:5 DEVICE ID - 7 = DRV2605L, which is the part on this board
482 bit 3 DIAG RESULT - result of the last self-test (see drvDiag)
483 bit 1 OVER TEMP - thermal shutdown
484 bit 0 OC DETECT - overcurrent, that is, the outputs are shorted
485 Overcurrent almost always means OUT+ and OUT- are touching, or the motor
486 leads are pinched. */
487 void drvStatus(const char *tag) {
488   int st = rd8(DRV_ADDR, 0x00);
489   if (st < 0) Serial.printf("%s DRV not answering on I2C\n", tag); return; }
490   Serial.printf("%s DRV status=0x%02X id=%d overtemp=%s OVERCURRENT=%s\n",
491     tag, st, (st >> 5) & 0x07,
492     (st & 0x02) ? "YES" : "no",
493     (st & 0x01) ? "YES <- OUT+/OUT- shorted?" : "no");
494 }
495
496 /* Run the DRV2605's built-in actuator self-test.

```

```

495
496 Mode 0x06 is diagnostics. The controller pulses the motor and measures the
497 back-EMF to determine whether an actuator is actually attached and intact.
498 It is the fastest way to distinguish "the firmware is not commanding a buzz"
499 from "the motor is disconnected". */
500 void drvDiag() {
501   Serial.println(F("running DRV diagnostic..."));
502   drv.setMode(0x06); drv.go();
503   uint32_t t0 = millis();
504   // Register 0x0C is the GO register; bit 0 stays set while a sequence or a
505   // diagnostic is still running. Poll until it clears, with a 1.5 s escape
506   // hatch. Note that a failed rd8 returns -1, and -1 & 0x01 == 1, so a dead
507   // bus exits via the timeout rather than hanging.
508   while ((rd8(DRV_ADDR, 0x0C) & 0x01) && millis() - t0 < 1500) delay(10);
509   int st = rd8(DRV_ADDR, 0x00);
510   if (st < 0) Serial.println(F("DRV not answering"));
511   else Serial.printf("diag=%s overtemp=%s overcurrent=%s (0x%02X)\n",
512     (st & 0x08) ? "FAIL - actuator missing or shorted" : "pass - mo
513     tor OK",
514     (st & 0x02) ? "YES" : "no", (st & 0x01) ? "YES" : "no", st);
515   // Return the controller to the state the rest of the firmware expects:
516   // internal trigger mode (play on GO) with ROM library 1 selected.
517   drv.setMode(DRV2605_MODE_INTTRIG); drv.selectLibrary(1);
518 }
519
520 /* An inexpensive watchdog, called before every haptic output.
521
522 The DRV2605 can brown out and reset if the motor's inrush current dips the
523 3V3 rail. When that happens it returns with default registers and silently
524 stops buzzing. Rather than diagnose that in the field, the controller is
525 pinged before every use and fully re-initialised if it has gone away. */
526 void ensureDrv() {
527   if (drvPing()) return;
528   Serial.println(F("!! DRV stopped answering - re-init"));
529   drvOK = drv.begin();
530   if (drvOK) { drv.selectLibrary(1); drv.setMode(DRV2605_MODE_INTTRIG); rtpSetup();
531   }
532 }
533
534 /* =====
535 SECTION 8 - G SIMULATOR IMPLEMENTATION
536 ===== */
537
538 /* Prepare the DRV2605 for real-time playback at a known voltage scale.
539
540 Two settings matter:
541
542 1. ERM_OPEN_LOOP (register 0x1D, bit 5). By default the DRV runs CLOSED
543 loop: it measures back-EMF and servos the motor to a target speed, which
544 means the written value is not a voltage. Open loop makes the output a
545 straight proportional drive, which is what a defined voltage-to-G mapping
546 requires.
547
548 2. OD_CLAMP (register 0x17) sets the full-scale output voltage. The scale is
549 21.96 mV per LSB, so 3.0 V is 3.0 / 0.02196 = 137. The +0.5 performs
550 rounding ahead of the truncating cast.
551
552 A note on the RTP value range: RTP values here stay within 0..127 on
553 purpose. The controller's default data format is SIGNED, where 0..127 means
554 forward and 128..255 means reverse (255 is -1, that is, almost nothing).
555 By never exceeding 127 the value reads identically whether the controller is
556 in signed or unsigned mode, so the scale cannot silently invert. */
557 void rtpSetup() {
558   int c3 = rd8(DRV_ADDR, 0x1D);
559   if (c3 >= 0) wr8(DRV_ADDR, 0x1D, (uint8_t)c3 | 0x20); // bit 5 = ERM_OPEN_LOOP
560   wr8(DRV_ADDR, 0x17, (uint8_t)(ODCLAMP_V / 0.02196f + 0.5f)); // OD_CLAMP ~3.0 V
561 }
562
563 /* Convert a target acceleration in G into an RTP drive value.
564 step 1: G -> volts, via the square-law relationship V = Vref x sqrt(G/Gref)
565 step 2: clamp, since the open-loop full scale cannot be exceeded
566 step 3: volts -> 0..127 RTP counts
567 ===== */
568 uint8_t rtpForG(float g) {
569   float v = REF_V * sqrtf(g / REF_G);
570   if (v > ODCLAMP_V) v = ODCLAMP_V;
571   float r = 127.0f * v / ODCLAMP_V; // 0..127 only - see rtpSetup()
572   return (uint8_t)(r + 0.5f);
573 }
574
575 /* Play one burst at the currently selected G level.
576 Blocking by design: the device is meant to be held while this runs. */
577 void gBurst() {
578   ensureDrv();
579   uint8_t rtp = rtpForG(G_LEVELS[gLevel]);
580   if (!plotterMode) // stay silent in plotter mode;
581     Serial.printf(">> G-SIM %2fG (%s) V=%2f rtp=%u %lums\n", // text would
582       G_LEVELS[gLevel], G_NAMES[gLevel], // corrupt the
583       REF_V * sqrtf(G_LEVELS[gLevel] / REF_G), rtp, // graph
584       (unsigned long)gBurstMs);
585 }
586
587 drv.setMode(DRV2605_MODE_REALTIME); // RTP: the output follows the
588 // written value until 0 is written
589
590 // The kick is only applied at levels weak enough to risk a stall, so the
591 // kick duration is only deducted from the remaining burst time when a kick
592 // actually occurred. Every level therefore vibrates for exactly gBurstMs.
593 // Equal durations across levels matter here: the entire purpose of this
594 // function is comparing strengths against each other, and unequal on-times
595 // would confound that comparison.
596 bool kicked = (rtp < 100); // weak enough to risk stalling?

```



```

593 if (kicked) {
594     drv.setRealtimeValue(127); // full power...
595     delay(KICK_MS); // ...just long enough to spin up
596 }
597 drv.setRealtimeValue(rtp); // then drop to the real level
598 uint32_t left = kicked ? (gBurstMs > KICK_MS ? gBurstMs - KICK_MS : 0)
599                 : gBurstMs;
600 delay(left);
601 drv.setRealtimeValue(0); // stop
602 drv.setMode(DRV2605_MODE_INTTRIG); // back to ROM-effect mode
603 afterBuzz(); // and mute the sensor briefly
604 }
605
606 /* Play one of the calm ROM patterns.
607 Loads the effect IDs into the DRV's waveform slots, pulses G0, then waits
608 for the sequence to finish. */
609 void playPat(uint8_t p) {
610     ensureDrv();
611     if (!plotterMode)
612         // The & 0x7F on slot 1 strips the "this is a wait, not an effect" flag so
613         // the printed number is the wait length rather than 0x88 = 136.
614         Serial.printf(">> PATTERN %s (%s): %d %d %d\n", PAT_NAMES[p], VAR_NAMES[patVar],
615                     PATTERNS[p][patVar][0], PATTERNS[p][patVar][1] & 0x7F,
616                     PATTERNS[p][patVar][2]);
617     drv.setMode(DRV2605_MODE_INTTRIG);
618     for (uint8_t s = 0; s < 4; s++) drv.setWaveform(s, PATTERNS[p][patVar][s]);
619     drv.setWaveform(4, 0); // belt-and-braces terminator,
620                             // in case slot 3 was non-zero
621     drv.go();
622     // The long smooth ramps run for roughly a second, so unlike a click the G0
623     // bit must be polled until it clears before muting and returning. The 2.5 s
624     // limit is an escape hatch.
625     uint32_t t0 = millis();
626     while ((rd8(DRV_ADDR, 0x0C) & 0x01) && millis() - t0 < 2500) delay(10);
627     afterBuzz();
628 }
629
630 /* =====
631 SECTION 9 - MPR121 ANALOG FRONT END
632 ===== */
633
634 /* Reconfigure the MPR121's charge current and charge time.
635
636 The MPR121 will not accept configuration changes while it is actively
637 scanning, so the sequence is always: stop, configure, restart.
638
639 0x5E Electrode Configuration Register (ECR). Writing 0 stops scanning.
640 0x7B Auto-Config Control 0. Zeroed to disable the controller's OWN
641 automatic gain calibration, since tuneAFE() performs that role here
642 and the two competing produce drifting nonsense.
643 0x5F+n Per-electrode charge current override. Writing 0 selects "use the
644 global setting", which is the intent here.
645 0x6C+n/2 Per-electrode charge time override. Two electrodes packed per
646 register. Writing 0 selects "use the global setting". Note that this
647 clears BOTH electrodes in the pair, which is harmless because no
648 per-electrode value is ever set in the first place.
649 0x5C Global charge current CDC in bits 5:0 (1 uA per step, so 0..63 uA).
650 Masking with 0x3F also leaves bits 7:6 (FFI, first-filter
651 iterations) at 0 = 6 samples.
652 0x5D Global charge time CDT in bits 7:5, second-filter iterations in bits
653 4:3, electrode sample interval in bits 2:0. The | 0x04 sets the
654 sample interval field to 100b = 16 ms and leaves SFI at 00 =
655 4 samples. 16 ms is the controller's default and gives a comfortable
656 margin over the 10 ms polling loop.
657 0x5E = 0x8F Restart scanning:
658     bits 7:6 = 10b baseline tracking on, and seed the baseline from
659     the first reading rather than from 0. Without
660     this the internal baseline starts wrong and takes
661     seconds to catch up.
662     bits 5:4 = 00b proximity mode off
663     bits 3:0 = 1111b all 12 electrodes enabled
664
665 The 120 ms settle afterwards lets the internal filter chain refill; readings
666 taken sooner are still averaging in pre-change data. */
667 void applyAFE(uint8_t cdc, uint8_t cdtCode) {
668     wr8(MPR121_ADDR, 0x5E, 0x00); wr8(MPR121_ADDR, 0x7B, 0x00);
669     wr8(MPR121_ADDR, 0x5F + SENSE_ELE, 0x00);
670     wr8(MPR121_ADDR, 0x6C + (SENSE_ELE >> 1), 0x00);
671     wr8(MPR121_ADDR, 0x5C, cdc & 0x3F);
672     wr8(MPR121_ADDR, 0x5D, (cdtCode << 5) | 0x04);
673     wr8(MPR121_ADDR, 0x5E, 0x8F);
674     delay(120);
675 }
676
677 // Snap the baseline and the whole median history to the current reading. Used
678 // after any change that invalidates the previous numbers.
679 void reseed() { int f = filtNow(); if (f > 0) { sbase = h0 = h1 = h2 = f; } }
680
681 /* Explain a diagnosed electrode fault in plain language, once, rather than
682 flooding the log. Called only when the fault CHANGES. */
683 void reportFault() {
684     if (faultCode == 1)
685         Serial.printf("!! ELE%d reads as SHORT (filt=0 at max charge, 2016 pC).\n"
686                     "    Either a real path to GND, or the chip's analog front end is d
687                     ead:\n"
688                     "    if this persists with NOTHING connected to the pin, the MPR121
689                     is\n"
690                     "    broken (ESD) or phantom-powered - check 3V3 at its pins.\n", S
691                     ENSE_ELE);
692     else if (faultCode == 2)

```

```

690     Serial.printf("!! ELE%d OPEN. Reads full scale - almost no capacitance.\n"
691                 "    Wire not connected (copper tape glue is not conductive -\n"
692                 "    solder to the copper face). Bare pin reading OPEN = chip healt
693                 hy.\n", SENSE_ELE);
694     else
695         Serial.println(F("!! electrode capacitance outside anything the chip can measure
696         ."));
697 }
698
699 /* -----
700 tuneAFE() - automatic calibration. The most important function in the file.
701 -----
702 THE PROBLEM. The MPR121's sensitivity depends on how much charge it pushes
703 per measurement, set by charge current (CDC, 1..63 uA) and charge time (CDT,
704 0.5..32 us). Push too little charge into a large capacitance and the reading
705 pins at 0; push too much into a small one and it pins at 1023. Either way
706 all resolution is lost. The correct setting depends on electrode geometry,
707 cable, gap material and assembly - all of which change with every rebuild of
708 the hardware. It therefore has to be measured, not assumed.
709
710 THE METHOD. Two passes:
711
712 PASS 1 - MEASURE. Set the charge current to maximum (63 uA) and sweep the
713 charge time from shortest to longest. Take the first setting that
714 produces a usable reading, and compute the electrode's actual
715 capacitance C from it. C is a property of the hardware, so once known it
716 holds regardless of the front-end setting chosen afterwards.
717
718 PASS 2 - AIM. Knowing C, compute the charge Qt needed to land exactly on
719 TARGET FILT counts: Qt = C x V target = C x 3.3 x 700 / 1024.
720 Then for each available charge time, work out the current that would
721 deliver that charge (cdc = Qt / CDT), reject anything outside the
722 controller's 1..63 uA range, apply it, and verify by reading back.
723 Accept the first setting that lands in a sensible window.
724
725 IF BOTH PASSES FAIL, the electrode is not merely mis-tuned, it is broken.
726 Diagnosis applies the maximum possible charge (63 uA x 32 us = 2016 pC) and
727 examines what comes back:
728     -0 counts -> capacitance is effectively infinite -> SHORTED TO GND
729     -1023 counts -> capacitance is effectively zero -> OPEN CIRCUIT
730     anything else -> genuinely out of measurable range, cause unclear
731 Diagnosing rather than retrying matters, because no charge setting can
732 compensate for a piece of wire; endless retries would only fill the log.
733
734 Returns true if a working setting was found.
735 ----- */
736 bool tuneAFE() {
737     if (!mprOK) return false;
738
739     // ---- PASS 1: find any charge time that gives a usable reading at max current
740     for (uint8_t probe = 1; probe <= 7; probe++) {
741         applyAFE(63, probe);
742         int f = filtNow();
743         if (f < 40) continue; // pinned low: too little voltage left to
744                             // compute C accurately, try more charge
745
746         // C in pF, from Q = C V rearranged (see countsToPF for the derivation)
747         float C = (63 * TUS[probe] * 1024.0f) / (3.3f * f);
748         // Charge required to land on TARGET FILT counts with this capacitance
749         float Qt = TARGET_FILT * 3.3f * C / 1024.0f;
750
751         // ---- PASS 2: find a (current, time) pair that delivers Qt
752         for (uint8_t c = 1; c <= 7; c++) {
753             int cdc = (int)(Qt / TUS[c] + 0.5f); // pC / us = uA
754             if (cdc < 1 || cdc > 63) continue; // outside the chip's range
755             applyAFE((uint8_t)cdc, c);
756             int f2 = filtNow();
757             // Accept anything reasonably near the 700 target. The window is wide
758             // because rounding cdc to a whole microamp becomes coarse at long charge
759             // times - see KNOWN LIMITATIONS (b) in the header.
760             if (f2 >= 217 && f2 <= 807) {
761                 // Retain the settings so countsToPF() can report real picofarads
762                 tunedCDC = (uint8_t)cdc; tunedCDT = TUS[c];
763                 Serial.printf("AFE tuned: CDC=%d uA CDT=%f us -> filt=%d (C=%f pF)\n",
764                             cdc, TUS[c], f2, C);
765                 delay(60); reseed();
766                 insaneSince = driftSince = 0; nextTuneAt = 0; // clear all fault timers
767                 if (faultCode) { Serial.println(F(">> electrode recovered")); faultCode = 0;
768                 }
769                 return true;
770             }
771         }
772     }
773
774     // ---- DIAGNOSIS: nothing worked, so classify the failure
775     applyAFE(63, 7); delay(60); // maximum possible charge
776     int fmax = filtNow();
777     int newFault = (fmax <= 5) ? 1 : (fmax >= 1000 ? 2 : 3);
778
779     // Park at a harmless middle setting so the firmware keeps producing readings
780     // that can be observed while the wiring is repaired, instead of sitting at
781     // maximum charge.
782     applyAFE(16, 2); tunedCDC = 16; tunedCDT = TUS[2]; delay(60); reseed();
783
784     if (newFault != faultCode) { faultCode = newFault; reportFault(); } // report onc
785     e
786     nextTuneAt = millis() + FAULT_RETRY_MS; // back off; do not spin
787     insaneSince = driftSince = 0;
788     return false;
789 }

```

```

786
787 /* Initialise (or re-initialise) the MPR121.
788 setThresholds(255, 255) disables the controller's own touch detection by
789 setting it to a value that can never be reached. The binary touched /
790 not-touched output is not wanted here; the raw filtered number is, because a
791 squeeze is an ANALOG quantity and the purpose of this instrument is
792 measuring how hard, not merely whether. */
793 void mprInit() {
794     mprOK = cap.begin(MPR121_ADDR);
795     if (mprOK) cap.setThresholds(255, 255);
796 }
797
798 // Blank the sensor for MOTOR_SETTLE_MS. Called after every haptic output.
799 void afterBuzz() { muteUntil = millis() + MOTOR_SETTLE_MS; }
800
801 /* Two named haptic outputs used by the interaction model.
802 PROMPT - "attention is requested": effect 7 (Soft Bump 100%) played twice
803         220 ms apart, that is, a double tap. Two events read as
804         intentional; a single event reads as an accident.
805 CONFIRM - "the squeeze was registered": effect 1 (Strong Click 100%), a
806         single sharp click. Short and crisp so that it feels causally
807         linked to the squeeze rather than like a separate message.
808         Setting slot 1 to 0 terminates the sequence after slot 0. */
809 void promptBuzz() {
810     if (!plotterMode) Serial.println(F(">> PROMPT"));
811     ensureDrv();
812     drv.setWaveform(0, 7); drv.setWaveform(1, 0);
813     drv.go(); delay(220); drv.go(); // fire, wait, fire again
814     afterBuzz();
815 }
816 void confirmBuzz() {
817     if (!plotterMode) Serial.println(F(">> CONFIRM"));
818     ensureDrv();
819     drv.setWaveform(0, 1); drv.setWaveform(1, 0);
820     drv.go();
821     afterBuzz();
822 }
823
824 // Print the command reference plus every live setting. Called on '?' and after
825 // any key that changes a value, so the log always records the state under
826 // which a measurement was taken.
827 void help() {
828     Serial.println(F("p prompt | c confirm | v DRV diag | i I2C scan | r cap | s strea
829     m | o plotter | w csv log | f/g thr | d/D dwell | b re-tune | +/- interval | a
830     uto | ?"));
831     Serial.println(F("G-SIM: 1..7 = level+burst | x replay | t/T burst len"));
832     Serial.println(F("PATTERNS: h heartbeat | j breath | k calm pulse | l soft hum | m
833     intensity"));
834     Serial.printf("SENSE: e swap electrode (now ELE%d)\n", SENSE_ELE);
835     Serial.println(F(" 1=.15G 015min 2=.25G 015typ 3=.35G 103min 4=.40G 015@3.2V")
836 );
837     Serial.println(F(" 5=.50G 103typ 6=.60G 7=.70G current motor"));
838     Serial.printf("thr=%d dwell=%lum auto=%d every %lus stream=%d plotter=%d fault=%d
839     | G=%f burst=%lum\n",
840 CAP_THRESHOLD, (unsigned long)HOLD_MS, autoPrompt,
841 promptInterval / 1000, streamCap, plotterMode, faultCode,
842 G_LEVELS[gLevel], (unsigned long)gBurstMs);
843 }
844
845 /* =====
846 SECTION 10 - SETUP
847 =====
848 Boot order matters here. Wire.begin() must come first, because the Adafruit
849 libraries call Wire.begin() with no arguments inside their own begin(), and
850 on ESP32 that would fall back to the DEFAULT pins had the custom pins not
851 already been registered.
852 ===== */
853 void setup() {
854     Serial.begin(115200);
855     Wire.begin(PIN_SDA, PIN_SCL);
856     delay(400); // let USB CDC enumerate, otherwise the boot
857               // banner is lost and the board appears dead
858     Serial.println(F("\nSilvie Pillar - boot"));
859
860     drvOK = drv.begin();
861     Serial.printf("DRV2605 %s\n", drvOK ? "OK" : "MISSING");
862     if (drvOK) { drv.selectLibrary(1); drv.setMode(DRV2605_MODE_INTTRIG); rtpSetup();
863     }
864     drvStatus("boot:");
865
866     mprInit();
867     Serial.printf("MPR121 %s\n", mprOK ? "OK" : "MISSING");
868     if (!mprOK) i2cScan(); // only scan when there is a problem to solve
869
870     tuneAFE(); // calibrate the sensor to this build
871     quietSince = millis();
872     help(); // record the starting configuration
873     drvDiag(); // confirm the motor is attached
874     confirmBuzz(); // audible and tactile "the board is alive"
875     lastPrompt = millis();
876 }
877
878 /* =====
879 SECTION 11 - MAIN LOOP
880 =====
881 Runs roughly every 10 ms. The order of the stages is deliberate and is the
882 main thing to understand about this file:
883
884 1. serial commands - always, so the firmware never becomes
885                    unresponsive
886
887
888
889

```



```

964 Serial.printf(">> sensing on ELE%d now (e cycles 0-11) - m
          ove the wire, then 'b' to re-tune\n", SENSE_ELE);
965 tuneAFE(); quietSince = millis(); }
966

```

```

1061         Serial.println( "electrode fault (filt=%d) - fix the wiring, retrying...\n", filt);
1062     }
1063     if (now >= nextTuneAt) tuneAFE();
1064     delay(10); return;

```


Appendix L. Squeeze sensing: the calculation in full

What must be established is a single number: how much the capacitance changes when she squeezes, and whether that change is larger than the smallest change the sensor can report. Everything below serves those two quantities.

1. The change in capacitance

The outer titanium wall is grounded and forms one plate. An electrode 0.125 mm behind it forms the other. The gap is air. A squeeze closes the gap by δ . So the capacitance is calculated twice, once with the gap at rest and once with the gap closed, and the difference between them is what the sensor sees.

Equation 1. Difference in capacitance

$$\Delta C = \frac{\epsilon_0 \epsilon_r A}{h - \delta} - \frac{\epsilon_0 \epsilon_r A}{h}$$

Table 16. Variables used in Equation 1

ΔC	The change in capacitance a squeeze produces. This is what has to be detected.	the result, below
ϵ_0	Permittivity of free space	8.854×10^{-12} F/m (a constant)
ϵ_r	Relative permittivity of whatever fills the gap	1, because the gap is air
A	Overlapping area of the two plates	20 mm ² , the 2 by 10 mm electrode
h	Gap between wall and electrode at rest	0.125 mm
δ	How far the wall moves inward under the squeeze	0.4529 μ m, from section 2

Filling those in, at a 10 N squeeze:

Table 17. Calculations of Capacitive Difference in pendant design

Capacitance at rest	$(8.854 \times 10^{-12} \times 1 \times 20 \times 10^{-6}) \div (125 \times 10^{-6})$	1.416640 pF
Gap while squeezed	$125 \times 10^{-6} - 0.4529 \times 10^{-6}$	124.5471×10^{-6} m
Capacitance while squeezed	$(8.854 \times 10^{-12} \times 1 \times 20 \times 10^{-6}) \div (124.5471 \times 10^{-6})$	1.421791 pF
Difference	1.421791 pF – 1.416640 pF	5.15 fF

That is the change on one electrode. There are two, one behind each of the squeezed walls, and each is read on its own channel rather than wired together, so each reports its own 5.2 fF (as then there is less chance of an accidental trigger).

2. Finding deflection through Solidworks analysis

The shell was analysed in SOLIDWORKS as a linear static problem. Only the outer titanium shell was modelled, since nothing is bonded across the sensing gap and the wall moves less than half a micrometre against a 125 micrometre clearance. Material was Ti-6Al-4V ELI at E = 114 GPa and ν = 0.34; Grade 5 and Grade 23 are identical elastically.

A pressure of 0.10853 N/mm² was applied over a 92.14 mm² split face on each of two opposing walls, which is 10 N per face. Loading both matters, because a squeeze is self-equilibrating and fixing one wall to push the other would stop the section deforming into an oval, which is the behaviour in question. The model therefore carries no fixtures and relies on soft springs to remove rigid body motion. Since the part is then free to float, the deflection was read as half the difference between the average displacements of the two inner faces, over split faces matching the electrode footprint.

On mesh convergence: It was solved three times, at maximum element sizes of 0.30, 0.20 and 0.15 mm. The deflection moved 0.23% on the first refinement and 0.12% on the second, a spread of 0.35% % across all three, so the result is mesh independent.

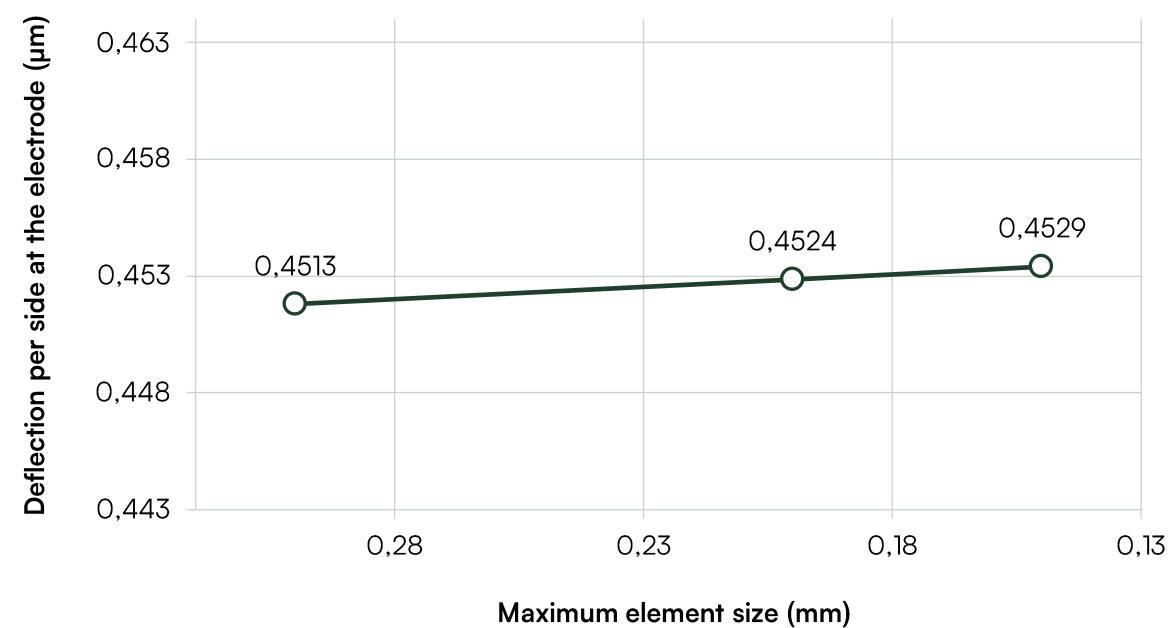


Figure 79. Graph on Mesh Convergence

The following was checked to make sure it was a sound analysis: the resultant reaction force came out at 1×10^{-33} N, so the two pressures balance exactly and the soft springs carry nothing. Peak von Mises stress (at 20N) was 15.66 MPa, 2% of yield. Doubling the load doubled the displacement. And the finest mesh carried 1,544,501 elements,

The deflection per side at the electrode is 0.453 micrometres at a 10 N squeeze. The largest displacement in the model is not at the electrode but near the open end of the tube, where there is no closed ring to resist ovalising. The electrode sees about two thirds of the model peak, which is why the average over its footprint is the figure used rather than the maximum.

Table 18. Measured values from SolidWorks at specified nodes (titanium inner wall area above the sensing electrode) and calculated outcomes

Squeeze force	δ	ΔC
5 N, light	0.23 μm	2.6 fF
10 N	0.45 μm	5.2 fF
20 N, firm	0.91 μm	10.3 fF

The two electrodes sit behind opposite walls and both move under the same squeeze. They are read on separate channels rather than summed into one, and the reason is geometric rather than electrical. A squeeze deflects both walls, while the pendant resting against a chest or pressed by a sleeve deflects one. Requiring both channels to rise together therefore rejects a class of false trigger that the shape of the object itself produces, at the cost of a smaller reading on each channel than a single combined measurement would give.

3. What the sensor can see

The FDC1004 senses at a resolution of 0.5 fF (Texas Instruments, 2026)

4. What this establishes, and what it does not

It establishes that the wall moves 0.45 micrometres per side at an ordinary squeeze, from a converged mesh model that passes its own balance, stress and linearity checks, and that this produces a capacitance change of 5.2 femtofarads on each of the two electrodes. That is ten times the smallest change the sensor can report (0.5 fF), and even a deliberately light five newton press produces five times it. This means that if the design requires thicker walls, there is room for it to grow.

It does not establish that the interaction works on a real part. The deflection is simulated rather than measured, and the prototype that produced the picofarad readings used a different sensor through a plastic wall. Squeezing one machined shell with the production sensor behind it is the test that closes this.

Appendix M. Power budget for the pendant

This appendix supports the runtime figure in the feasibility chapter. It is a rough calculation from published datasheet currents, not a measurement. Four things draw power worth counting. Everything else is small enough to carry as one line.

Where the current goes

Table 19. Energy consumption calculations.

What draws it	What it is doing	Current, from the datasheet	How long, per day	Per day
Listening for a squeeze	The capacitance sensor takes a measurement eight times a second and sits idle in between	750 µA measuring 29 µA idle (Texas Instruments, SNOSC5C)	8 checks a second x 15 ms = 0.12 s of every second. 24 h x 0.12 = 2.9 h measuring, 21.1 h idle	2.77 mAh
Processor	Wakes to read each measurement, sleeps in between	2.2 mA awake 1.1 µA asleep (Nordic nRF52810-CAAA-R)	8 wakes a second x 1 ms = 0.008 s of every second. 24 h x 0.008 = 0.2 h awake, 23.8 h asleep	0.45 mAh
Radio	Keeps the link to the phone alive and sends the day's confirmations	6.1 mA receiving (Nordic, v1.4)	Connected 20 h, one check-in a second: 72,000 x 1.5 ms = 108 s. Searching 4 h: 14,400 x 3 ms = 43 s. Four exchanges of 2 s = 8 s. 159 s of radio, plus 86 s of processor time	0.32 mAh
Buzzing	Three prompts a day, about 1.5 seconds each	45 mA starting 25 mA running (Precision Microdrives 304-015)	3 prompts x 1.5 s = 4.5 s, of which 0.3 s starting and 4.2 s running	0.03 mAh
Everything else, always on	Regulator, charger and haptic driver sitting idle	4.2 µA in total	24 h	0.10 mAh
Total				3.68 mAh

The cell holds 15 mAh (Panasonic, 2022). Taking 80 % of that as usable gives 12 mAh, so about three days per charge. The buzzing, which is the only part the wearer notices, is under one % of the total.

Every current in the table is a published datasheet figure and is cited beside it. Four things are not measured and are estimated: how long one measurement takes (taken as 15 ms), how long the processor is awake for each one (1 ms), how much of the day the radio spends connected rather than idle, and how much of the cell is usable (taken as 80%).

They can be wrong by a lot without changing the conclusion. If all four are out by a factor of two in the worst direction, the pendant draws 6.5 mAh a day and lasts 1.8 days instead of three. It loses a day; it does not stop working. What actually sets the runtime is how often the sensor checks for a squeeze, and that is a design choice rather than a limit.

What runtime costs

Table 20. Comparison of how different polling rates affect battery capacity

How often it checks for a squeeze	Current, continuous	Days per charge	What it costs her
Twice a second	74 µA	6.7	The squeeze has to be held about half a second
Four times a second	100 µA	4.9	About a quarter of a second
Eight times a second	152 µA	3.3	About a fifth of a second. The figure used in this report
Sixteen times a second	256 µA	1.9	Effectively immediate

Listening all day is the expensive choice. If the sensor only listened for ten minutes after each prompt it would last about ten days on the same cell, and likely more with the help of an electrical engineer.

Two things this does not settle

The cell is rated for 20 mA continuous and the motor draws 25 mA running and 45 mA starting. It works because the motor never runs continuously, but the published pulse curve covers half a second and the prompt participants preferred is about three times longer. That needs measuring on a real cell.

And one finding is worth carrying forward. The custom cell enquiry through Supplier C was run against a stated requirement of 25 µA average, six times below what this budget arrives at, so that route was ruled out on generous assumptions rather than harsh ones. It would close again on the corrected figures.

Appendix N. Soma Clock Evaluation testing materials

The Soma Clock concept was validated against requirements set in Chapter 3, through two routes. The full analysis (including manufacturing, regulation, and cost) was started but never finished as the concept was abandoned after participant insights, but the evaluation approach remains.

Four women aged 55 to 75 each spend about seventy minutes with the functional prototype. The session tests the concept requirement by requirement: structured observation against criteria fixed before the first session, identical before-and-after self-ratings read only as direction (up, down, or unchanged, never “significantly”), and the participant’s own words as primary evidence. With four participants there is no statistical claim; and no claim that these reactions generalise. A round this size can show whether a concept is understood and whether the people in the room want it, which is what this round was for. Each requirement resolves in the matrix as Met, Partial, or Not yet, with its evidence named.

The data is of two kinds. Paper carries the numbers: two short sheets the participant fills in herself, one before she sees the clock and one near the end, repeating identical statements so each can be compared one to one. Voice carries the meaning: everything else is asked aloud and recorded, and for half the requirements the participant’s spontaneous wording is the measurement. Alongside what is observed in the room, a short projection block asks her to imagine living with the clock for some weeks; those answers are recorded as anticipated rather than observed.

The map below states, for every requirement, what is measured, how it is captured, how it becomes a finding, and how strong the resulting evidence can be. Row colour marks evidence value: the deeper the green, the more directly this round observes the behaviour the requirement names. The requirement numbers in this table refer to the list as it stood at the time of the clock evaluation. The list was revised after the pivot and renumbered in, so these identifiers do not map one to one onto the table there.

Evaluating Desirability

Table 21. Desirability requirement evaluation plan for the clock.

Req	Requirement (in plain words)	What is measured	How it is measured	Evidence value
D1	Using it should quiet her doubt about knowing what her body needs.	Whether her doubt moves, and which part of it moves. We want to learn (1) the direction of change from before to after she sees the clock, and (2) which facet it touches: knowing what her body needs, judging whether what she does works, or how often she doubts.a	HOW: 1 to 7 Likert Scale before and after prototype demonstration 'Ik weet wat mijn lichaam nodig heeft', 'Ik kan goed beoordelen of wat ik doe werkt', 'Ik twijfel regelmatig'. After the session also: 'Een klok zoals deze zou mij helpen te vertrouwen op wat ik zelf merk'. Plus an anticipated rating after the session (the “toekomstbeeld” lines), recorded separately from the before/after.	MODERATE. One session shows an indication, not a longitudinal study.
D2	Stopping a supplement or health intervention must be as legitimate an outcome as adding one.	Whether “permission to stop” is a real issue for these women. We want to learn whether, faced with a supplement that seems to change nothing, she can reason her way to stopping, and what she says she would need to dare to.	Upon showing Clock Face D (Daylight time): if she draws her own vitamin D conclusion from that real face, that is the observed, strong part. Generalized to other supplements (as far as other supplements are possible). “Wat zou u doen? Zou u durven stoppen? Wat zou u daarvoor nodig hebben?” Classify reasoning: from her own observation, from the clock as authority, or mixed. Record whether she formulated a stop herself (yes/no) and what she named as needed.	STRONG. The stop reasoning can be fully tested, but it is not based on her data
D3	Does it increase her sense of coherence: comprehensible, manageable, meaningful?	Whether the display spontaneously reads as affirming rather than corrective, and whether her felt grip on her health moves. We want to learn (1) the balance of “what goes well” versus “what is wrong” on her view of the clock (without explanation from the researcher) and (2) the direction of the three coherence statements.	While she reads her day with no explanation, count sentences about what goes well versus what is wrong. PRE/POST 1 to 7 statements: “begrijpelijk”, “grip”, “zinvol”.	STRONG. Her spontaneous framing is directly observable.
D4	It must feel dignified: not clinical, medical, or paternalising.	Whether the object passes socially in a real living room, where dignity is actually decided. We want to learn where it sits on four dignity dimensions, where she places it in her home, and what a visitor would read it as.	POST: 1 to 5 scale: klinisch - huiselijk, voor ouderen - voor iedereen, betuttelend - respectvol, een apparaat - een meubelstuk In the home: the spot she walks to (photographed, if consent) and “als er visite komt, wat denken ze dat het is?”	STRONG. Tested in her real home, with her real social frame.

Req	Requirement (in plain words)	What is measured	How it is measured	Evidence value
D5	She must be able to find out where information comes from.	Whether a three-line plain explanation makes the source feel reachable, and what mental models or fears exist before it. We want to learn the gap between her guess and her understanding after reading the source view.	First her guess: “Waar denkt u dat de klok dit vandaan haalt?” Then she reads Clock Face E and is asked “Is dit te volgen? Zou u meer willen zien?” Mark: guess close or far off; after reading, understands or does not.	MODERATE. Tests whether the explanation lands, not the full inspection trail of a real product.
	It must be honest when it is not certain.	Whether admitted uncertainty builds or breaks trust for this group. We want to learn the direction (does admitting uncertainty raise or lower trust) and her reason.	In the source view (Clock Face E) the clock states in plain words that some things are an estimate, not a certainty: “De klok geeft hier aan dat sommige dingen een schatting zijn. Wat vindt u ervan dat hij dat zo eerlijk aangeeft?” Mark per participant: raises trust, lowers trust, or neutral, with the deciding quote.	STRONG. The reaction to admitted uncertainty is directly observable.
D7	She reaches her own conclusions; the clock never decides for her.	Whether she confirms her own observation, corrects the clock, treats the clock as authority.	Count those three sentences across the session. The planted error in Face B: “Wat is hier anders? Klopt deze?” Her reasoning source in the scenario. Record the best correction verbatim.	STRONG. The best-covered requirement in the session.
W6	Readable without any explanation or digital skill.	Whether the visual language works at all, with zero explanation: whether she reads sleep, sitting, exercise and outside correctly, unaided. If this fails, the face design must change before anything else.	She receives the clock with no explanation and tells her day. Checklist: sleep, sitting, outside read without help. Pass = at least 2 of 3 unprompted. Record her first words verbatim and exactly what, if anything, had to be explained.	STRONG. Comprehension happens or it does not, in front of you.
W1	She should be able to see her own progress.	Whether progress, when displayed, is readable as progress by her. We want to learn whether she can narrate the week’s change unaided.	Week view (Clock Face C) contains one visible change across seven days: “Wat is er in deze week veranderd, als u zo kijkt?” Mark: narrates the change yes / partly / no, with quote. (a shared example week, framed as “stel dat dit uw week was”)	MODERATE. Real progress takes weeks; this tests whether displayed progress is readable.
W2	It should fit a moment that already exists in her life.	Whether the clock attaches to a concrete existing moment in her day.	“Op welk moment van de dag zou u erop kijken, denkt u?” Record the named moment per participant.	MODERATE. Intention, not observed behaviour.
W3	She stays in control of her own choices.	Whether ignoring the system is guilt-free, which is what control means in practice. We want to learn how it feels to do nothing with what the clock shows.	“Stel dat de klok u iets laat zien, zoals u vandaag heeft gezien, en u besluit er niets mee te doen. Hoe voelt dat?” Listen for “ik beslis” versus obligation.	MODERATE. Perception of control at concept stage.
	It should never become a chore.	What she expects the burden of the device to be: what she thinks it would ask of her (now and after some time).	“Wat zou deze klok van u vragen? Wat moet u er zelf voor doen?” Projection block: whether anything would get old or become a chore over weeks. One line per participant.	WEAK. Real burden only shows over time; the projection answer is stated expectation.
W4	It should match the rhythm at which she wants to interact.	Not this round. Could be measured later by logging glance moments in a multi-week in-home deployment and comparing them with her stated rhythm.	Not measured this round.	Not this round.
C5	Operable with one hand, readable type, low force, for 55 to 75 hands and eyes.	An indication only, observed in passing while she handles the object.	Noted.	WEAK. It remains a Wizard of Oz prototype, touch / UI interactions cannot be validated

Appendix O. Clock evaluation interview guide

Soma Clock researcher protocol

Participant code	Date	Location	Start time

Phone intake (10 min, a few days before the session)

Purpose: to acquire data to make her two personalised day faces (Clock Face A and B) and confirm logistics. Nothing is measured; clock faces are built from what she says. Week faces remain shared examples.

“Hoe ziet een gewone dag er voor u uit? Neem me eens mee, van het opstaan tot het naar bed gaan.”

“Hoe laat gaat u meestal naar bed, en hoe laat staat u op?”

“Wanneer zit u op een dag langere tijd stil? (televisie, lezen, computer)”

“En wanneer beweegt u juist? (wandelen, fietsen, sporten, huishouden)”

“Gaaf u op een gewone dag naar buiten? Wanneer, en hoe lang ongeveer?”

“Zijn er vaste momenten in uw dag? (bijvoorbeeld koffie om tien uur, een wandeling na het eten)”

From this, build Clock Face A (her typical day) and Clock Face B (the same day with one deliberate, findable error). Also confirm (again): date, time, address; that it takes about 60 minutes; and that it is audio-recorded (consent is repeated in person).

Before she arrives (in person)

Clock on, showing Clock Face O (neutral). Recorder charged and tested. Papers ready: consent x2, PRE, POST. No cards, no print.

Step 1. Welcome and consent

→ Sign both copies, confirm audio consent, START RECORDER (say participant code).

Step 2. PRE sheet

“Zes korte stellingen die gelden voor nu.”

→ Hand over the sheet, do not do anything else.

Step 3. Silent prototype demonstration (measures W6), Clock Face A

→ WIZARD OF OZ: Clock Face A. Say nothing about what it shows.

“Dit is hem. Voordat ik er iets over zeg, wat ziet u? Neem rustig de tijd.”

“Vertel mij eens uw dag, zoals de klok hem laat zien.”

Read without help?		Notes
Sleep	yes / no	
Sitting / rest	yes / no	
Outside / active	yes / no	

First words (verbatim)	
What I had to explain (if any)	
Result	PASSED / NOT PASSED (pass = at least 2 of 3 unprompted)

Step 4. Recognition, Clock Faces A and B, measures D3, D7

“Klopt dit met hoe uw dag normaal voelt? Wat klopt wel, wat niet?”

“Wat zegt deze klok over hoe het met u gaat?”

→ Count: sentences about what goes well versus what is wrong.

→ WIZARD: Clock Face B.

“De klok laat nu een andere dag zien. Wat is hier anders? Klopt deze?”

Why: planted error makes D7 observable: correcting the device means trusting her own knowledge over the machine.

Sentence type	Count	Best quote
Confirms own observation		
Corrects the clock		
Clock as authority		
About what goes well		
About what is wrong		

Found & corrected the error?	yes / no
Best correction quote (verbatim) (D7)	

Step 5. Week view, Clock Faces C and E, measures W1, D5, D6

→ WIZARD: Clock Face C.

“Dit is een voorbeeld van een week. Stel dat dit uw week zou zijn: wat is er in deze week veranderd, als u zo kijkt?”

Why: W1: can she tell the week’s story unaided?

“Waar denkt u dat de klok dit allemaal vandaan haalt?”

Why: her guess reveals her mental model before any explanation (cameras? microphones? = trust risk).

→ Let her speculate first. Then WIZARD: Clock Face E, let her read it.

“Is dit te volgen? Zou u meer willen kunnen zien over het waarom?”

Why: D5: can she retell where the information comes from?

“De klok geeft hier aan dat sommige dingen een schatting zijn, geen zekerheid. Wat vindt u ervan dat hij dat zo eerlijk aangeeft? Geeft dat u juist vertrouwen of niet?”

Why: D6: does admitting uncertainty in plain words (in the source view) build trust or break it?

Tells the week’s change? (W1)	yes / partly / no	quote:
Guess where data comes from (D5)	close / far off	note:
After source view, Clock Face E (D5)	understands / does not	note:
Honesty about estimates (D6)	ok / lowers trust / raises trust	note:

Step 6. Sun to supplement connection, Clock Face D, measures D7, D2

→ WIZARD: Clock Face D.

“Deze stand laat zien hoeveel u vandaag buiten bent geweest, en wat de zonkracht vandaag was. Wat leest u hier?”

Why: this face holds the thesis boundary: show, never advise. Does it invite her OWN supplement conclusion? (Keep the face descriptive: no IU number, no daily-need figure.)

→ SAY NOTHING about supplements. If she draws a vitamin D conclusion herself, write it down immediately.

“Wat zou u met deze informatie doen?”

Why: informed (she decides) versus steered (the clock decided)?

→ Doorvragen: “Voelt dit als informatie of als advies?”

“Zoals u net zag, laat de klok zien hoe uw dagen eruitzien. Stel: u twijfelt al langer over een supplement dat u slikt, en u ziet een maand lang dat uw dagen er hetzelfde uitzien, met of zonder dat supplement. Wat zou u doen? Zou u durven stoppen? Wat zou u daarvoor nodig hebben?”

Why: D2 (stopping must be a legitimate outcome). “Wat zou u nodig hebben” surfaces what permission-to-stop is made of. Anchored to the sun gauge she just read, so it is not a cold hypothetical.

Drew a supplement conclusion herself? (verbatim)	yes / no
Felt like information or advice?	info / advice / unclear
Reasons from (D2)	own / clock / mixed
Stop formulated herself? (D2)	yes / no
Quote	

Step 7. POST sheet

“Nog een keer dezelfde stellingen, nu met de klok in uw achterhoofd. En vier lijntjes over hoe de klok voelt.”
Why: closes the before/after pair while it is fresh, and captures the dignity scores privately. (The longer-term view is asked in Step 11, kept separate so the before/after stays clean.)

Step 8. Place, life, burden, GP, measures D4, W2, W5, W9, camera

“Stel dat u hem mocht houden: waar zou hij staan of hangen? (Als we bij u thuis zijn:) Wilt u het laten zien?”
Why: D4 lives in her real home. Walking to the spot turns an opinion into a decision; take a photo if consent was given.
“Als er visite komt en die ziet hem, wat denken ze dat het is? Hoe zou u zich daarbij voelen?”
Why: the social mirror; if visitors read it as a care device, D4 fails where it matters most.
“Op welk moment van de dag zou u erop kijken, denkt u?”
Why: W2: a concrete existing moment (bij de koffie) means it has a place in her life.
“Wat zou deze klok van u vragen? Wat denkt u er zelf voor te moeten doen?”
Why: W5: expected effort.
(Optional, drop first if short on time) “Stel dat u dit zou laten zien aan uw huisarts. Hoe zou dat gesprek gaan?”
Why: W9 by proxy, the weakest row: a guess of someone else’s reaction. First to drop if time is short; the real GP test is future work.

Chosen spot (D4) • photo? yes / no	where:
What visitors would think it is (quote)	
Moment she would look (W2)	
What it would ask of her, now (W5)	
GP prediction (W9, optional)	positive / dismissive / mixed quote:

Step 9. Value and control, measures W12, W3

“Als dit echt te koop zou zijn: wat zou het mogen kosten, denkt u?”
Why: open first, so her own reference frame appears before any number anchors it.
“En als het 150 euro eenmalig zou kosten? Waar zou u het verwachten te kopen?”
Why: W12: reaction to a concrete number, plus the channel for Silvie’s distribution thinking.
“Stel dat de klok u iets laat zien, zoals u vandaag heeft gezien, en u besluit er niets mee te doen. Hoe voelt dat?”
Why: W3: control is only real if doing nothing is guilt-free. Listen for “ik beslis” versus obligation.

Price (W12)	spontaneous: € _____ anchor €150: accepts / hesitates / rejects channel: _____
Doing nothing with what the clock shows (W3)	

Step 10. Attention, calm, and what she would want to see, explores D4, W5, W7

Probe for need and the limit, not the feature: a wish for notifications is easy to voice; the question is what form stays calm and where it tips into being watched.
“U heeft nu een tijd naar deze klok gekeken. Zou u willen dat hij u laat weten wanneer er iets is dat aandacht vraagt? Of juist niet?”
“Als hij dat zou doen, hoe zou u dat het liefst zien? Een rustige verandering op de klok zelf, een melding op uw telefoon, of iets anders?”
“Wanneer zou zo’n klok die om aandacht vraagt, gaan voelen alsof hij u in de gaten houdt?”

Then, what she would want to see (future / personalisation):
“Als deze klok iets over uw dag of gezondheid zou laten zien dat u belangrijk vindt, wat zou dat dan zijn?”
“En zou u willen kunnen kiezen wat hij laat zien, of houdt u het liever simpel?”
“Over welke periode zou u dit het liefst zien: een dag, een week, een maand, of een jaar?”
Why: light user preference for W7 (extends to other pillars) and personalisation. Generative input for Recommendations, not a validated demand.

Wants an attention cue?	yes / no / depends
Preferred form	clock itself / phone / other:
Where it tips into “watching me”	
What she would want it to show (W7)	
Choose what it shows, or keep it simple?	choose / simple / depends
Preferred horizon	day / week / month / year

Step 11. Living with it: projection, ANTICIPATED, not observed, D1, D3, W1, W2, W5

“Stel dat deze klok een paar weken bij u thuis zou staan. Wat denkt u dat er zou veranderen, als er iets verandert?”
“Denkt u dat u na een tijdje anders naar uw dag zou kijken? Hoe?”
→ WIZARD: **Clock Face F** (week, weinig buiten).
“Stel dat de klok u na een week dit laat zien: u bent veel minder buiten geweest dan u zelf dacht. Wat zou u dan doen?”
“Is er iets waarvan u denkt: daar zou ik na een maand op uitgekeken zijn, of dat zou gaan vervelen, of iets dat u als een belemmerende taak zou zien?”

What would change over weeks	
Look differently at her day?	
Clock Face F: what she would do	
Anything that would get old / a chore	

Step 12. Close (2 min) • STOP RECORDING

“Bedankt. Heeft u nog vragen? Wilt u nog iets delen? En mag ik u eventueel nog kort bellen voor een verduidelijking?”

Session length	----- min
Unexpected observations	

Participant sheet 1 : VOORAF

Deelnemerscode: _____ Datum: _____

Omcirkel bij elke stelling het cijfer dat het beste past bij wat u nu vindt. 1 = helemaal oneens, 7 = helemaal eens. Er zijn geen goede of foute antwoorden.

Stelling	oneens			neutraal			eens
1. Ik weet wat mijn lichaam nodig heeft.	1	2	3	4	5	6	7
2. Ik kan goed beoordelen of wat ik voor mijn gezondheid doe, ook echt werkt.	1	2	3	4	5	6	7
3. Ik twijfel regelmatig of ik de goede dingen doe voor mijn gezondheid.	1	2	3	4	5	6	7
4. Wat er dagelijks met mijn gezondheid gebeurt, is begrijpelijk voor mij.	1	2	3	4	5	6	7
5. Ik heb grip op mijn dagelijkse gezondheid.	1	2	3	4	5	6	7
6. Waar ik dagelijks mee bezig ben voor mijn gezondheid, voelt zinvol.	1	2	3	4	5	6	7

Participant sheet 2: ACHTERAF

Deelnemerscode: _____ Datum: _____

Dezelfde stellingen als eerder, nu met de klok in uw achterhoofd. 1 = helemaal oneens, 7 = helemaal eens.

Stelling	oneens			neutraal			eens
1. Ik weet wat mijn lichaam nodig heeft.	1	2	3	4	5	6	7
2. Ik kan goed beoordelen of wat ik voor mijn gezondheid doe, ook echt werkt.	1	2	3	4	5	6	7
3. Ik twijfel regelmatig of ik de goede dingen doe voor mijn gezondheid.	1	2	3	4	5	6	7
4. Wat er dagelijks met mijn gezondheid gebeurt, is begrijpelijk voor mij.	1	2	3	4	5	6	7
5. Ik heb grip op mijn dagelijkse gezondheid.	1	2	3	4	5	6	7
6. Waar ik dagelijks mee bezig ben voor mijn gezondheid, voelt zinvol.	1	2	3	4	5	6	7
7. Een klok zoals deze zou mij helpen te vertrouwen op wat ik zelf merk.	1	2	3	4	5	6	7

Als de klok een tijd bij u thuis zou staan (toekomstbeeld)

Stel dat deze klok een paar maanden bij u thuis zou staan. Hoe zou u deze stellingen dan inschatten? 1 = helemaal oneens, 7 = helemaal eens.

Stelling	oneens			neutraal			eens
Ik zou beter weten wat mijn lichaam nodig heeft.	1	2	3	4	5	6	7
Ik zou meer grip hebben op mijn dagelijkse gezondheid.	1	2	3	4	5	6	7
Ik zou meer vertrouwen op wat ik zelf merk.	1	2	3	4	5	6	7

Hoe voelt de klok? Zet op elke lijn een kruisje waar het voor u past.

	1	2	3	4	5	
klinisch						huiselijk
voor ouderen						voor iedereen
betuttelend						respectvol
een apparaat						een meubelstuk