Adoption factors of frugal health innovations

A closer look into enablers and barriers of frugal health innovation adoption

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By

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Preface

Having studied bioengineering (MSc Life Science and Technology, Faculty of Applied Sciences, Delft University of Technology, and minor MSc Chemistry, Faculty of Engineering, London Imperial College), there has always been a personal interest in technical solutions to enhance the accessibility to medicine/diagnostics. Having worked on a frugal health innovation, a point-of-care vitamin biosensor to enhance data availability on hidden hunger targeted to low- and middle-income countries, together with fellow students, there was a realization that many frugal health innovations are not adopted, even though they have the technical potential to tackle urgent societal solutions. Apparently, there are more factors than merely technical factors that enable, or act as a barrier to, the adoption of frugal health innovations. As part of this MSc Management of Technology Thesis (Faculty of Technology, Policy, and Management, Delft University of Technology), I wish to gain a better understanding of the enabling factors and barriers of frugal health innovation adoption. By doing so, and sharing my knowledge to the public, I hope to contribute to the enhancement of the adoption of frugal health innovations, thereby contributing to the potential of frugal health innovations to transcend society by eliminating persistent problems, and further guide future research on frugal health innovations by theory.

Mathijs Jacobus Verhoev, Rotterdam, 20-08-2024

Executive summary

The healthcare sector is facing serious challenges. On the one hand, the population is ageing, resulting in a higher pressure on healthcare resources. On the other hand, less than half of the world's global population is covered by essential healthcare services due to limiting resources. Frugal health innovations are developed to be affordable, accessible, and make effective use of limited resources. As such, frugal health innovations can help to decrease the resource-dependency in the healthcare sector, contributing to healthcare access to all. Yet, the adoption of frugal health innovations remains limited. Adding to this issue, the adoption is not studied from a theoretical perspective and empirical evidence on the reasons for (non-)adoption remains scarce. Understanding what affects the adoption from a theoretical perspective helps to identify underlying principles at hand, allowing to build a conceptual framework. Such a conceptual framework can guide frugal health innovation development for increased adoption probability and promote future theoretical studies on frugal health innovations. This research aims to understand what factors affect the adoption of frugal health innovations from a theoretical perspective, by asking the research question "What factors affect the adoption of frugal health innovations?".

To guide the research, the first sub-research question "What theoretical framework is most appropriate to describe adoption of frugal health innovations?" was asked. Answering this question ensured a departing point for the theoretical understanding of frugal health innovation adoption. Secondary data from the literature was retrieved through a literature review, from which it followed that nine theoretical perspectives have been used to study the adoption of non-health-related frugal innovations. By comparing the theoretical perspectives against the context of frugal health innovations, it followed that the Unified Theory of Acceptance and Use of Technology 2 is the most appropriate theoretical perspective to study the adoption of frugal health innovations.

To further guide the research, the second sub-research question "What empirical evidence exists, that can give information on factors affecting the adoption of frugal health innovations?" was asked. Answering this sub-research question allowed to synthesize empirical evidence in the Unified Theory of Acceptance and Use of Technology 2 framework to arrive at a conceptual framework for the adoption of frugal health innovations. Secondary data from the literature was retrieved through a literature study, and the empirical evidence was put in the context of frugal health innovations. From this, it followed that the possibility to experiment with the innovation (Trialability), the innovation-fit with the customers' lifestyle (Lifestyle Compatibility), the availability of required knowledge to use the innovation (Consumer Literacy), the trust toward the provider of the innovation (Trust), the technical performance of the innovation (Performance Expectancy), the ease-of-use of the innovation (Effort Expectancy), the degree of social pressure to use the innovation (Social Influence), the price of the innovation (Price Value), and the degree of resource- and infrastructural constraints impeding the use of the innovation (Facilitating Conditions) facilitate the intention to adopt frugal health innovations (Behavioural Intention). Interestingly, the synthesis revealed that Price Value, Facilitating Conditions, and Trust also act as a barrier in case they are not properly addressed by the frugal health innovation (Figure 0).

Ultimately, the conceptual framework was empirically validated in the context of frugal health innovations through semi-structured interviews with four frugal health innovation developers. Because developers were surveyed, in contrast to consumers by the studies from the literature review, the adoption, and not consumer-central behavioural intention to adopt, was studied. To increase the possibility of adoption, results suggest that trust between the developer and consumer should be established (Trust), the innovation should align with the preferences of the consumer (Lifestyle Compatibility), the innovation should be designed so that it is easy to use and install (Effort Expectancy), and the innovation should be priced appropriately to ensure affordability whilst maintaining a positive perceived price-quality relationship (Price Value). Further, results suggest that it is imperative to understand the context of the addressed health-related issues, as the performance of the frugal innovation must be superior to traditional health innovations if the latter shows poor performance or side effects, or can be inferior if they are used indicatively where the traditional innovation is used confirmatively (Performance Expectancy). Understanding the context is also of importance to determine whether the use of the frugal health innovation is not impeded by the lack of resources and/or infrastructure, or, appropriately addresses their absence, thereby providing a market opportunity (Facilitating Conditions). Additionally, results suggest that the severity of the health problem (Problem Severity) also affect the

adoption, whilst only relevant in case frugal health innovations are sold to governmental organizations (Figure 0). All in all, this exploratory research provides a first conceptual framework to study the adoption of frugal health innovations and opens up the debate on what is required for their adoption. Developers are advised to tailor frugal health innovations according to the principles observed in this research study, as doing so likely enhances the probability of adoption. However, considering the lack of a consumer-perspective in this research study, a logical next step is to further gather empirical findings on frugal health innovation adoption using the developed conceptual framework, to ensure a more robust image of the factors affecting the adoption of frugal health innovations.

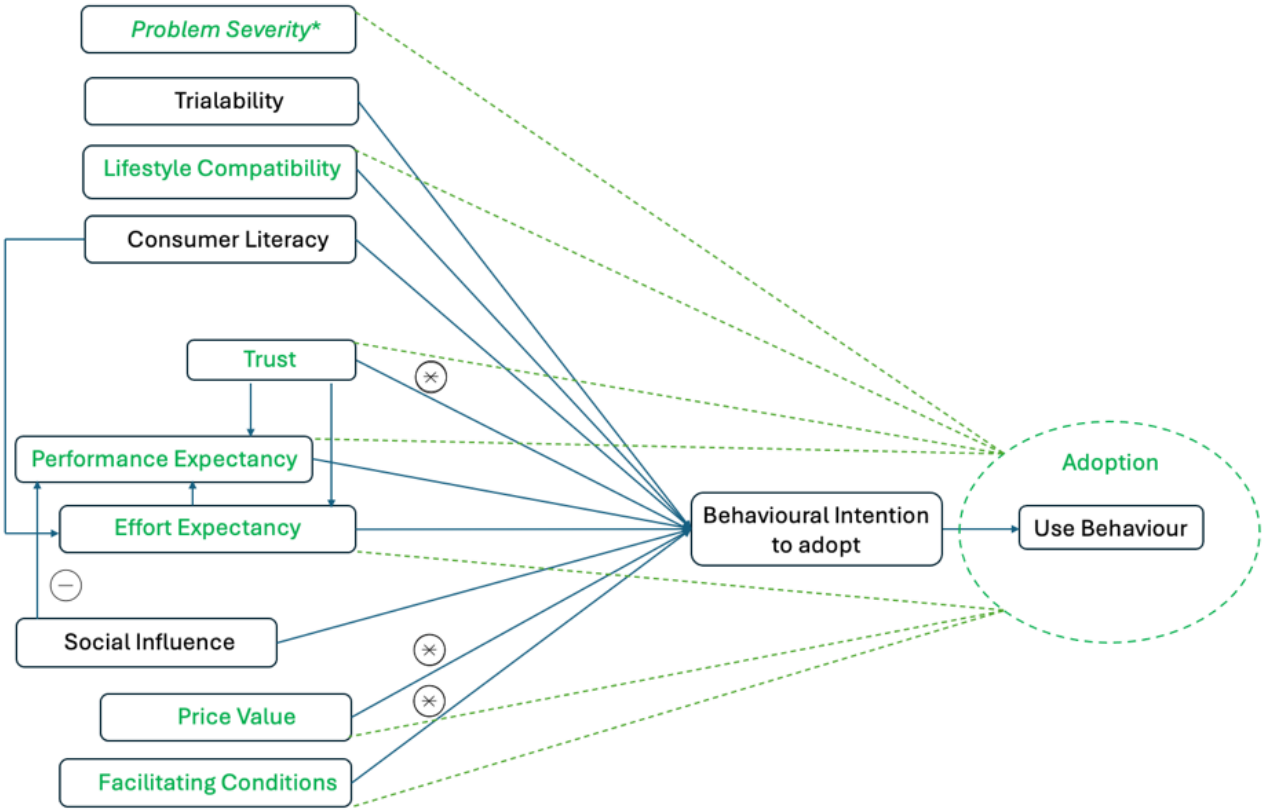

Figure 0. *Empirical findings on factors affecting the adoption of frugal health innovations aligned with the synthesized conceptual framework from the literature.* The synthesized framework from the literature is shown, with relationships between variables depicted by blue arrows. Negative correlations are represented by the minus sign, and the cross sign represents a positive and negative correlation simultaneously. Green-highlighted factors were observed in the interviews to affect the adoption of frugal health innovations, as depicted by the dotted green lines. The italicized Problem Severity was not previously observed in the literature. *: Problem Severity is only relevant in case frugal health innovations are sold to governmental institutions.

Keywords: Frugal health innovations, adoption, barriers, facilitators, Unified Theory of Acceptance and Use of Technology 2.

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Abbreviations

CATM	Consumer Acceptance of Technology Model
DoIT	Diffusion of Innovations Theory
FHI	Frugal health innovation
FI	Frugal innovation
TAM	Technology Acceptance Model
TPB	Theory of Planned Behaviour
TRA	Theory of Reasoned Action
UGT	Uses and Gratification Theory
UTAUT	Unified Theory of Acceptance and Use of Technology
VAM	Value-based Adoption Model

1 Introduction

1.1 Frugal health innovations

Today, society faces large challenges. On the one hand, security of basic needs such as food, energy, and health of about eight billion inhabitants must be met without exceeding resources. On the other hand, more than half of the world's population still does not have access to these basic needs due to resource limitations. In the past, innovations were developed without prioritizing resource limitations, but, in recent years, there is a shift to develop solutions that are *(i)* affordable; *(ii)* accessible; and *(iii)* make effective use of limited resources (Arshad, 2021; Prabhu, 2017). Different innovative approaches exist for doing so, such as grassroots innovation, sustainable innovation, and frugal innovation (FI). FI has emerged as a fruitful approach to tackle societal challenges with a high socio-economic impact, as it tailors to both the developed and underdeveloped world, in contrast to grassroots innovations, and includes the development of new innovations, in contrast to sustainable innovations (Agarwal, & Brem, 2017; Hossain et al., 2022).

One sector that can especially benefit from FI is the healthcare sector. Most healthcare solutions are developed under low resource constraints (Bianchi et al., 2017). However, the population in developed countries is ageing, resulting in a higher pressure on healthcare resources (Bianchi et al., 2017; De Meijer et al., 2013). Further, less than half of the world's global population is covered by essential healthcare services due to limiting resources, especially in underdeveloped countries, and, if nothing is changed, this trend continues (Bianchi et al., 2017; United Nations, 2020). As such, the healthcare sector requires innovative solutions to combat the increasing resource limitations and ensure that access to healthcare is guaranteed now, and in the future (Agarwal et al., 2016; Arshad, 2021; Bhatti et al., 2017; Sarkar, & Mateus, 2022). To that extent, frugal health innovations (FHIs) can provide a solution. The inherent philosophy of frugality, i.e. accessibility, affordability, and ease-of-use (Agarwal, & Brem, 2017; Dabić et al., 2022; Hindocha et al., 2021), suggests that more can be done, for more people, using less resources.

1.2 Adoption of frugal health innovations

There is an increasing commercial, social, and scientific interest in the development and use of FHIs to tackle healthcare problems under resource limitations (Bhatti et al., 2017; Sarkar, & Mateus, 2022). However, for FHIs to tackle healthcare issues, the innovation not only requires to be developed, but also to be adopted, i.e. identified, evaluated, and continuously used by organizations or individuals (Rogers, 1983, pp. 163 – 238; Wisdom et al., 2014). Some examples of successfully adopted FHIs include *(i)* low-cost and portable infant incubators not requiring electricity by using thermal fabric; *(ii)* low-cost and portable ultrasound machines using lower image resolution and providing readouts through mobile phones; *(iii)* sterile, reusable surgical drill covers allowing to conduct surgeries with a hardware-store drill; and *(iv)* low-cost prosthetic legs and feet made of rubber instead of expensive composites and polymers (Arshad, 2021; Bhatti et al., 2017; Hardon et al., 2019; Sarkar & Mateus, 2022) (Figure 1).

Figure 1. *Successfully adopted frugal healthcare innovations compared to traditional counterparts.* The top row presents frugal health innovations, and the bottom row presents traditional counterparts. The columns show, from left to right, an infant incubator, an ultrasound machine, a surgical drill, and a prosthetic leg and foot. Frugal infant incubator adapted from Mass Design Group (n.d.), frugal ultrasound machine adapted from Enraf Nonius (n.d.), frugal surgical drill adapted from Arbutus Medical (n.d.), and frugal prosthetic leg and foot adapted from Smithsonian Institution (n.d.).

Although successfully adopted FHIs exist, other FHIs fail to adopt. For example, the acceptability of flash heating breast milk using plastic jars, circumventing the need of using expensive baby formula, remains poor due to cultural believes, a lack of technical understanding of the process, and problems with finding the right equipment to conduct the practice (Israel-Ballard et al., 2006). Another example is given by the reluctance of clinical staff to adopt point-of-care diagnostics, which circumvent the use of expensive and complex diagnostic medical devices, as concerns regarding lower perceived technical performance, perceived undermining of physicians, and uncertainties regarding insurance reimbursements have been identified (Hardy et al., 2016).

Despite some evidence on why certain FHIs fail to adopt, there are plenty failed FHIs that have not yet been studied. One such example is given by solar-powered autoclaves. Although solar-powered autoclaves do not rely on electricity grids, making them more appropriate in rural, underdeveloped areas, they have only been adopted in a limited amount (Ituna-Yudonago et al., 2021). Another example includes the use of retail paper clips to stop bleeding during scalp incisions. Although the use of paper clips prevents the use of expensive Raney clips, thereby decreasing surgery costs, reports on surgical paper clips are limited to technical feasibility studies (Waknis, Prasad, & Wadje, 2013; Yagnick et al., 2019) suggesting that the practice has not been adopted. Another case is given by electromagnetic-induced light sources for medical examinations. Although this innovation does not rely on electricity grids, making them more appropriate in rural, underdeveloped areas, the producing company was dissolved after fourteen years in 2019 (Government of the United Kingdom, n.d.; Mandal, 2014) suggesting that the product was not successfully adopted. Going back to traditional innovations, the general trend for non-adoption follows that of high costs, lack of enabling infrastructure, and lack of user-required knowledge or skillsets (Tamvada et al., 2022). Interestingly, this contradicts with the paradigm of FHIs, which are developed to be cheaper, more accessible, and easier to use. Apparently, there is more to the adoption of FHIs than just ensuring resource limitations are considered during the design. How then, come that FHIs fail to adopt, or, are successfully adopted?

Despite some evidence on the reasons for (non)-adoption of certain FHIs, FI remains underexplored from a theoretical perspective (Agarwal et al., 2016; Hossain, 2017; Hossain, 2018). Although not specifically stated in the literature, it can thus also be argued that understanding what components, i.e. what factors, affecting the adoption of FHIs are underexplored from a theoretical perspective. Doing so, however, is important, as it helps to identify underlying principles at hand and build a conceptual framework that can be used for FHI developers to ensure adoption, and guide future research on FHI by theory. This seems to be especially relevant, considering that design mismatches between FHI adopters and developers are present (Miesler et al., 2020). By failing to understand the issue at hand, it is likely that the current trend of FHI non-adoption continues, thereby failing to decrease the pressure on healthcare systems.

1.3 Knowledge gap

1.3.1 Adoption of frugal health innovations has not been studied from a theoretical perspective

Claims have been made that FI remains underexplored from a theoretical perspective (Agarwal et al., 2016; Hossain, 2017; Hossain, 2018), from which it was argued that the factors affecting the adoption of FHIs are also underexplored from a theoretical perspective. Therefore, to determine whether this is indeed the case, a literature search was conducted (Appendix A). Shortly, literature studies were searched for that covered the adoption of FHIs from a theoretical perspective and that were published during or after 2010, to consider state-of-the-art literature. In total, 227 articles were retrieved from Scopus and six studies were retrieved from other sources. Most studies were removed because they focussed on other FIs, such as information and communications technologies, vehicles, or home appliances, considered organizational characteristics or business models to conduct the process of FI development, or covered analyses in the dental practice and oil- and gas industry due to the use of the abbreviation "BoP" in these fields, which was introduced in this literature search to represent Bottom-of-the-Pyramid.

Although the literature search was intended to retrieve articles analysing the adoption of FHIs from a theoretical perspective, there was a complete absence of studies doing so. Even though, six studies were still deemed relevant for the knowledge gap, as they provide an overview of the current state of the literature related to factors affecting the adoption of FHIs. The selected studies include one study that used a theoretical perspective to study the diffusion of FHIs, and thus not adoption, three case studies providing insight into why specific FHIs were successful, and two studies taking examples from the literature presenting factors affecting the scalability and use of FHIs.

1.3.2 Studying diffusion limits the individual-user perspective

The study by Arshad (2021) comes closest to studying factors affecting the adoption of FHIs from a theoretical perspective. Arshad (2021) used the Diffusion of Innovations Theory (DoIT) to study the diffusion of two FHIs in emerging markets, namely the low-cost prosthetic leg and foot (Figure 1) and a low-cost cardiac surgery process that uses payments from higher-income patients to subsidize surgeries for lower-income patients (Khanna, Rangan, & Manocaran, 2005). Through a combination of a literature review on factors affecting the diffusion of innovations in emerging markets and factors affecting the diffusion of health innovations, Arshad (2021) distilled factors affecting the diffusion of FHIs. Subsequently, Arshad (2021) confirmed their observations through interviews with hospital workers from Pakistan and found that factors facilitating the diffusion of FHIs include an entrepreneurial mindset, the availability of the product, and the recommendation by higher authorities, being hospital- owners and administrations, senior doctors, governments, and American- and European societies. Further, Arshad (2021) found that the factors hampering the diffusion of FHIs include a lack of product- awareness and availability, political hinderance, a lack of expertise or teamwork, a lack of long-term benefits from the FHIs, and higher-than-expected costs. Although Arshad (2021) provides insight into factors affecting the diffusion of FHIs, it should be noted that diffusion is different from adoption. Diffusion considers the spread of the innovation through a society as a systemic process, rather than the use and continued use of the innovation by an individual, as described by adoption (Rogers, 1983, pp. 163 – 238; Wisdom et al., 2014). Importantly, the adoption process is an individual decision-making process that can lead to diffusion as a systemic process if the correct diffusion-related components are in place, and is thus the first process to occur in the spread of innovations (Nilsen, 2015). By looking into the diffusion only, the individual factors and the initial process thus remain ignored. Therefore, prior to understanding what affects the diffusion of FHIs, it is paramount to take a step back and understand what affects the adoption of FHIs.

1.3.3 Empirical evidence on factors affecting the adoption of frugal health innovations is limited

Although it is evident that adoption of FHIs is not studied from a theoretical perspective, some empirically determined factors affecting the adoption of FHIs have been reported. These studies are highlighted here, to provide an overview of the current knowledge on factors affecting the adoption of FHIs.

Three case studies provide insights into why FHIs are successful. Nanath (2011) analyzed the case of LifeSpring Hospitals, a hospital chain providing cheap, but high-quality, maternal care to low-income customers in India. The success of LifeSpring Hospitals is mainly due to economic factors, as LifeSpring Hospitals focusses on sector specialization, hires less-trained midwives, leases land instead of buying land, outsources laboratory and pharmaceutical services, and optimizes bedspace. Besides, LifeSpring Hospitals locates their hospitals close to urban slums to reduce customer travel costs. Simultaneously, qualitative healthcare is provided through standardized procedures, and specialized outreach teams customize their communications to fit their service to the needs of their customers. Auma et al. (2023) conducted a case study on Knowledge for Change, a non-governmental organization focusing on changes in healthcare systems in Ugandan public health facilities for better healthcare access. Contrary to the inclusion of economic factors and the technological appropriateness found by Nanath (2011), Auma et al. (2023) highlighted the importance of stakeholder involvement and overcoming infrastructural dependencies. More specifically, Auma et al. (2023) found that task-shifting the responsibilities of healthcare workers to community health workers, using communication services as outreach tools, and applying point-of-care diagnostic tools could be attributed to the success of Knowledge for Change. Webb et al. (2022) conducted a case study on the adoption of gas insufflation-less laparoscopic surgery in India, a form of laparoscopic surgery that does not rely on the presence of CO_2. In contrast to Auma et al. (2023), but like Nanath (2011), Webb et al. (2022) found that the technical performance is of importance, as contextual needs and customer requirements need to be fulfilled. Similar to Auma et al. (2023), but in contrast to Nanath (2011), Webb et al. (2022) observed that infrastructural-dependencies are of importance, as the device should be maintained in low-resource areas, sterilized using present equipment, operated by a single person, and should be lightweight and portable. Although aforementioned case-studies provide a valuable insight in empirically determined factors affecting the adoption of FHIs, case-studies lack generalizability. This is exemplified by the differences observed between the case studies, where Nanath (2011) identified economic- and technical factors to be of importance, Auma et al. (2023) found social- and infrastructural factors to be of importance, and Webb et al. (2023) observed technical- and infrastructural factors to be of importance. Consequently, more empirical evidence is required to understand the factors that affect the adoption of FHIs.

Studying the adoption of FHIs using multiple sources of evidence is a solution to the lack of generalizability. To that extent, Lundin, and Dumont (2017) took examples from the literature and used anecdotal evidence to draw factors affecting the scalable implementation of mobile health image- and sensor systems, also known as telemedicine. Such telemedicine innovations are considered FHIs, as they increase accessibility to healthcare and decrease costs due to a reduction in overhead and expensive apparatus (Mishra, & Sharma, 2022). Accordingly, Lundin, and Dumont (2017) proposed eight factors affecting the scalable implementation of such FHIs, being technology alignment with existing infrastructure, solving real healthcare needs and understanding local settings, obtaining product feedback, involvement of all stakeholders during the design, ensuring sufficient long-term funding, ensuring funding from different partners, promoting standardized components and procedures, and ensuring local financial- and technical feasibility. A similar study was conducted by Miesler et al. (2020), who analyzed the current advantages and shortcomings of point-of-care diagnostics by taking examples from the literature. Miesler et al. (2020) found that decreased costs, user-friendliness and ease-of-use, due to the non-invasive character of the test, and low maintenance are advantages of point-of-care diagnostics. Yet, the shortcomings identified were a lack local context-fit of the innovations, a lack of trust and a presence of doubt toward the innovations due to lower pricing compared to traditional diagnostic innovations, a lack of affordability of post-diagnostic treatments, and a lack of superior, or at least equal, technical performance compared traditional diagnostic innovations. Lundin, and Dumont (2017) and Miesler et al. (2020) provide valuable insights into factors affecting the adoption of FHIs and ensure more generalizability than the case studies. This is exemplified by the technical-, economic-, social-, and infrastructural components identified by Lundin, and Dumont (2017) and Miesler et al. (2020), encompassing the identified components in the case studies. However, the study of Lundin, and Dumont (2017) lacks reliability as it is doubtful how the proposed factors were derived. This is exemplified by the fact that Lundin, and Dumont (2017) included a set of non-health related theoretical models in their references for the derivation of the proposed factors. As such, it can be assumed that the references, and thus evidence, used by Lundin, and Dumont (2017) is not appropriate. Consequently, the results from Lundin, and Dumont (2017) should be interpreted with care. Furthermore, valid empirically derived factors affecting

the adoption of FHIs from multiple sources is limited to one study by Miesler et al. (2020), further confirming that the empirical evidence is limited. Thus, to provide a better understanding of the factors affecting the adoption of FHIs, additional empirical evidence is required.

1.4 Research question

Understanding the factors that affect the adoption of FHIs from a theoretical perspective is important as it helps to find underlying principles and build conceptual frameworks, so that developers of FHIs can adequately develop customer-centric FHIs and ensure FHI adoption, thereby decreasing the resource pressure in the healthcare sector, and future studies on FHI adoption can be guided by theory. As shown, adoption of FHIs has not yet been studied from a theoretical perspective and empirical evidence on factors affecting the adoption of FHIs is limited. Therefore, the aim of this research is to understand the factors that affect the adoption of FHIs, by building a conceptual framework. Consequently, this research study asks the following main research question:

"What factors affect the adoption of frugal health innovations?"

As no theoretical perspectives have been applied in the literature to study the adoption of FHIs, it is paramount to understand which theoretical perspective is the most appropriate for doing so. Ideally, a conceptual framework is applied that encompasses theory and includes empirical evidence from the literature on the adoption of FHIs, so that the theoretical perspective is fitted to study the adoption of FHIs. However, as seen, empirical evidence on the adoption of FHIs is limited. Therefore, the following two sub-research questions are maintained:

(i) *"What theoretical framework is most appropriate to describe adoption of frugal health innovations?"*

(ii) *"What empirical evidence exists, that can give information on factors affecting the adoption of frugal health innovations?"*

To realize the aim of this study, and answer the research question, a qualitative study is conducted. During the study, the focus lies on the notion of frugality. First, a literature review is conducted to gather secondary data to better understand what theoretical perspectives have been used to study the adoption of FIs as a general concept. Although these results apply to FIs, and not FHIs per se, the observed theoretical perspectives are subjected to the context of FHIs to better understand their applicability and generalizability to study the adoption of FHIs. Consequently, the results of this literature review answer the first sub-research question, providing a framework that is most appropriate to study the adoption of FHIs, also referred to as framework 1.0. Second, the collected data from the literature review is further used to derive empirically determined factors that affect the adoption of FIs, thereby enriching framework 1.0 with empirical evidence and thus providing a conceptual adoption framework tailored to FIs. Similar to the previous step, the empirical evidence is put in the context of FHIs, thereby providing information on factors that can affect the adoption of FHIs, thus answering the second sub-research question. This conceptual framework is referred to as framework 2.0. Third, using conceptual framework 2.0, semi-structured interviews are conducted with developers of FHIs to gather primary data and determine the factors affecting the adoption of FHIs, validating the framework empirically, thereby answering the main research question.

By understanding what theoretical perspective is the most appropriate to describe the adoption of FHIs and what empirical evidence exists that can give information on factors affecting the adoption of FHIs, this study aggregates current empirical work in the literature into a conceptual framework, providing a first stepping stone to better understand the factors affecting the adoption of FHIs. Further, through verification of the developed framework via interviews with FHI experts, this study verifies the theoretical approach, allowing FHIs to be pushed towards adoption and providing the possibility to guide FHI research by theory in the future.

1.5 MSc Management of Technology

This research study is conducted as the MSc Thesis of the program Management of Technology at the faculty of Technology, Policy, and Management at the Delft University of Technology. This research study contains scientific and analytical components, i.e., aims to be replicable by stating the methodologies and analysis of the literature review and the interviews clearly, is multidisciplinary in nature, i.e., looks into FIs in the healthcare sector and the factors that affect the adoption of FHIs, and focusses on a technical application, i.e., FHIs are at the core of this research study. In conclusion, this study is in line with the requirements for an MSc Thesis of the Management of Technology program at the Faculty of Technology, Policy, and Management, Delft University of Technology (Delft University of Technology, n.d.).

2 Theoretical background

2.1 Frugal health innovations

Prior to understanding what FHIs are, it is imperative to understand what FIs are in general, as, in short, FHIs represent FIs that are used in the healthcare sector (Sarkar, & Mateus, 2022). FIs draw from many different engineering disciplines, including (bio-)chemical-, material-, and computational engineering, and are introduced in many different sectors (Dabić et al., 2022; Hindocha et al., 2021). FIs not only exist in the form of products, but are also provided as services, processes, and business models (Hossain, 2017; Prabhu, 2017). In general, FIs are loosely defined as innovations developed under resource-constraint conditions, e.g., financial-, material-, skills-, and infrastructural constraints (Hossain et al., 2022; Sarkar, & Mateus, 2022), that provide accessible, easy-to-use, cheap, and qualitative solutions to persisting societal problems (Agarwal, & Brem, 2017; Dabić et al., 2022; Hindocha et al., 2021). FIs therefore take resource-constraints into account whilst providing value to society. In terms of sales market, FIs are introduced both in developed and developing countries, where FIs aim to tackle resource-depletion and waste-generation in the former market and resource limitations in the latter market (Bhatti et al., 2017; Leliveld, & Knorringa, 2018; Pisoni, Michelini, & Martignoni, 2018).

As FIs touch upon resource-constraints and providing value to society, the concept of FI is similar to other constrained-based- and socially-driven innovations (Table 1). Notably, these innovation concepts are used interchangeably in the literature (Dabić et al., 2022; Hossain, 2017; Hossain, 2018; Molina-Maturano, Speelman, & De Steur, 2020). Amongst constrained-based innovations, Bottom-of-the-pyramid-, Jugaad-, and grassroot innovations are most closely related to FIs (Agarwal et al., 2016; Agarwal, & Brem, 2017), whereas socially-driven innovation is an umbrella term coined to include both FIs and social innovations, the latter being a sister-concept of FIs describing innovations that are social both in their ends and means (Khan, & Melkas, 2020).

Table 1. *Innovations overlapping with the concept of frugal innovation.* The innovation (Innovation) and description (Description) are presented.

Innovation	Description
Frugal innovation	Loose definition: Innovations developed under resource-constrains to provide accessible, easy-to-use, cheap, and qualitative solutions to persisting societal problems (Hindocha et al., 2021)
Constrained-based innovation	Definition: Innovations developed under conditions of scarcity, including (Agarwal et al., 2016): *Bottom-of-the-Pyramid innovation*: "Innovation developed in and targeting the large unserved segments of poor people inhabiting emerging economies" *Jugaad innovation*: "Fast, creative, and improvised way of solving problems in a resource-constrained environment at a lower cost" *Grassroot innovation*: "Society-based, value-based, social, and affordable innovations are community-led green initiatives"
Socially-driven innovation	Definition: Innovations providing societal value, including (Khan, & Melkas, 2020): *Social innovations*: "Innovations that are social both in their ends and in their means"

Because innovation concepts related to FI are used interchangeably with the concept of FI in the literature, it is imperative to demarcate FIs from other similar innovation types. To that extent, there are many different definitions of FIs (Hindocha et al., 2021). Pisoni et al. (2018) distinguish between product- and service-oriented definitions, characterizing the product- and service features of FIs, market- and process-oriented definitions, underlining the resource-constrained environment and the process of doing more with less, and criteria-based definitions, defining FIs according to a set of criteria. In general, criteria-based definitions are preferred, as they incorporate product- and service- and market- and process-oriented definitions. Rossetto et al. (2017) proposed a criteria-based definition by deducting FI concepts from the literature and verifying them with FI experts of both developed- and developing countries. However, the definition of Rossetto et al. (2017) regards the FI development process (Rossetto et al., 2023), rather than FI as a product or service, making the definition inadequate to identify FI products and services. In contrast, Weyrauch, and Herstatt (2016) developed a criteria-based definition of FI products and services, even

independent of geographical boundaries, type of innovation, and sector (Hossain, 2017; Hossain, 2018; Leliveld, & Knorringa, 2018; Sarkar, & Mateus, 2022). Through interviews with innovation managers and researchers, Weyrauch, and Herstatt (2016) identified seven attributes of FIs, characterized into three different overarching criteria, being *(i)* substantial cost reduction; *(ii)* concentration on core functionalities; and *(iii)* optimized performance level (Figure 2). Accordingly, FIs can be differentiated from traditional innovations and other types of constrained-based and socially-driven innovations when all three criteria are in place.

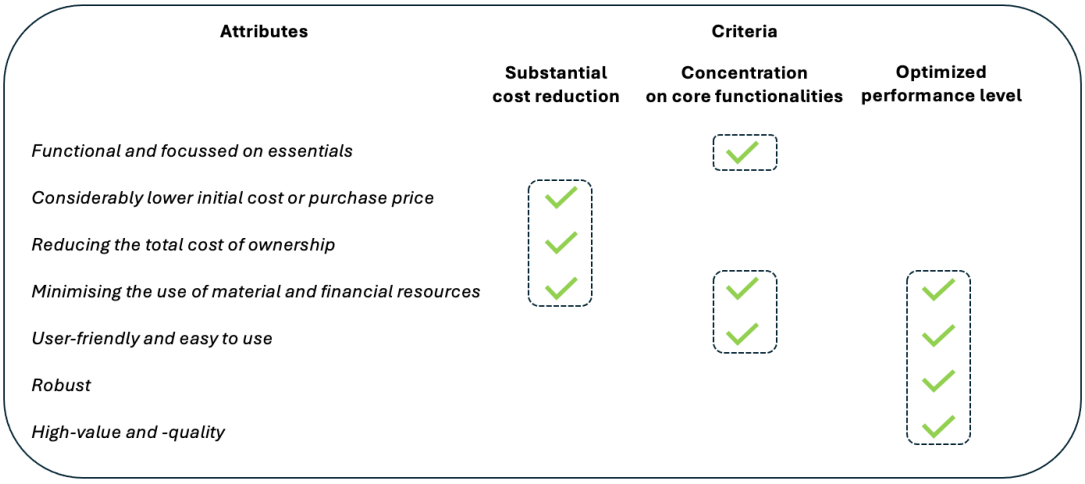

Figure 2. *Attributes and corresponding criteria of frugal innovations.* The attributes are shown on the left and the criteria are shown on the right. The attributes that align with a criterium are shown by a checkmark. Adapted from Weyrauch, and Herstatt (2016).

Coming back to FHIs, they can be demarcated according to the product type, being *(i)* preventative tools; *(ii)* diagnostic- and monitoring devices; *(iii)* surgical tools; and *(iv)* therapeutic- and rehabilitative devices (Sarkar, & Mateus, 2022). FHIs exist in many different forms and are sometimes referred to as a specific type of technology, such as point-of-care diagnostics as a way of diagnosing at the bedside (Miesler et al., 2020) or telemedicine as a way to communicate and/or diagnose from a distance (Mishra, & Sharma, 2022). The main reasons why FHIs are developed is due to inefficiencies, e.g. high costs and limiting resources, in healthcare systems. Their development process focusses on design, functionality, performance optimization, resource optimization, and cost reduction. Further, FHIs are often developed in cooperation with related experts to understand the contextual environment for the innovation, and their development can be stimulated by governmental- and hospital policies (Sarkar, & Mateus, 2022). Although Sarkar, and Mateus (2022) define the process of FHI development, no thorough definition of FHI products and/or processes exist. However, Weyrauch, and Herstatt (2016) applied their criteria to verify that the low-cost portable ultrasound machine (Figure 1) is a FI. Moreover, like FIs, FHIs also do not seem to be limited by market boundaries, as is exemplified by the spread of the low-cost portable ultrasound machine from India and China to the United States of America (Miesler et al., 2020). Although evidence is limited, it can be assumed that the criteria for FIs also apply to FHIs. Therefore, in this study, the term FHIs refer to FIs, as defined by Weyrauch, and Herstatt (2016), that are used to solve an issue in the healthcare sector. This is especially important to note as empirical evidence on FI adoption is richer than that of FHIs, as observed during the literature review for the knowledge gap. By stating that FHIs refer to FIs used to solve an issue in the healthcare sector, and putting the empirical evidence of FI adoption into the context of FHIs, information on factors affecting the adoption of FHIs can be derived.

2.2 Technology adoption

Technology adoption is a multiphase decision-making process characterized by the identification, evaluation, and continued usage of innovations by organizations or individuals (Rogers, 1983, pp. 163 – 238; Wisdom et al., 2014). Technology adoption therefore touches upon the usage of innovations by consumers. However, the concept of Technology adoption is often used interchangeably in the literature with overlapping, albeit different, concepts of technology usage, including technology diffusion, user-acceptance of technology, and technology implementation (Table 2) (De Vries, Tummers, & Bekkers, 2018; Kiwanuka, 2015). Being similar concepts, and being used

interchangeably in the literature, it is therefore paramount to distinguish between them. Innovation diffusion is a multiphase process characterized by the communication of the innovation among members of a social system through communication channels over time (Rogers, 1983, pp. 163 – 238). User-acceptance of technology, in contrast, is an attitude toward the innovation (Renaud, & Van Biljon, 2008, pp. 210 – 219; Taherdoost, 2018). Technology implementation, a term especially relevant to the healthcare sector, refers to the systematic and planned integration of new technologies within a certain setting and routine practices (Nilsen, 2015), thus being a planned approach. The difference in technology adoption compared to diffusion, user-acceptance, and implementation can therefore be understood as technology adoption being a consequence of a positive user-acceptance attitude toward the technology (Renaud, & Van Biljon, 2008, pp. 210 – 219), an individual decision-making process ultimately leading to the systemic process of diffusion (Kee, 2017), and being an unplanned process rather than the planned strategy of implementation (Nilsen, 2015). Because the adoption process is an individual decision-making process to actually use the innovation, ultimately leading to diffusion as a systemic process, and from which implementation strategies can be derived, it is paramount to understand what influences technology adoption. To that extent, components influencing technology adoption can be described as factors, which either enhance the likelihood of adoption, i.e., enablers, or decrease the likelihood of adoption, i.e., barriers (Nilsen, 2015; Niroumand et al., 2021).

Table 2. *Technology usage concepts overlapping with the concept of technology adoption.* The technology usage concept (Usage) and definition (Definition) are presented.

Usage	Definition
Technology adoption	The identification, evaluation, and continued usage of innovations by organizations or individuals (Rogers, 1983, pp. 163 – 238)
Technology diffusion	The communication of an innovation among the members of a social system through communication channels over time (Rogers, 1983, pp. 163 – 238)
User-acceptance of technology	The attitude toward the innovation (Renaud, & Van Biljon, 2008, pp. 210 – 219; Taherdoost, 2018)
Technology implementation	The systematic and planned integration of new technologies within a certain setting and routine practices (Nilsen, 2015)

2.3 Theoretical perspective

A theoretical perspective allows to study certain phenomena using theory. Notably, the notion of theory seems to be rather diffuse and is interpreted as different concepts in the literature. To that extent, the concepts of theories, models, and frameworks are used interchangeably in the literature, yet refer to different theoretical perspectives (Table 3). Practically speaking, theories are a set of ideas set out in a logical manner used to explain observations and are thus explanatory. Frameworks, in contrast, are purely descriptive tools to describe observations and are more generalizable than models, which are descriptive tools used for specific situations and often involve a deliberate simplification (Nilsen, 2015). As the main research question in this research is descriptive, a framework is the most ideal tool to study the adoption of FHIs in a general manner.

Table 3. *Theoretical perspective and encompassing concepts.* The theoretical perspective (Theoretical perspective) and definition (Definition) are presented.

Theoretical perspective	Definition
Theory	An explanatory perspective used to set out ideas in a logical manner (Nilsen, 2015)
Framework	A descriptive perspective used to describe observations in a general manner (Nilsen, 2015)
Model	A descriptive perspective tailored to specific situations using deliberate simplifications (Nilsen, 2015)

From the literature review in the knowledge gap, it became evident that the adoption of FHIs has not yet been studied from a theoretical perspective, and thus that adoption theories, models, and frameworks have not been developed to study the adoption of FHIs. Some frameworks do exist that have been developed to describe FIs, yet provide a conceptual understanding of the process of FI development rather than FI as a product or service (Hossain, 2018; Hossain 2020; Hossain et al., 2022; Niroumand et al., 2020; Niroumand et al., 2021). Therefore, these frameworks are

not suitable to study the adoption of FHIs. Theoretical perspectives to study the adoption of innovations, or a related concept, are abundant, however. For example, the review article by Adlung (n.d.) provides an overview of several theoretical perspectives that have been used to study medical device adoption and diffusion in low- and middle-income countries. Likewise, the review article by Nilsen (2015) presents several theoretical perspectives used to study technology implementation in the healthcare sector, and Taherdoost (2018) discusses some of the most used theoretical perspectives to study technology adoption and user-acceptance of technology. Without going into depth in the different theoretical perspectives, the three articles combined provide a total of 64 different theories, models, and frameworks, consisting of either individual theories, models, and frameworks (Appendix B, Table A3) or emerging models and frameworks (Appendix B, Table A4). Although likely not a complete overview of all possible theoretical perspectives that could be used to study the adoption of FHIs, the three articles combined do provide a thorough overview of theoretical perspectives used to study technology adoption, with a focus on the healthcare sector, thereby providing a relevant outline of useful theoretical perspectives for this research study.

3 Methodology

3.1 Research design

The aim of this study was to determine what factors affect the adoption of FHIs. To realize this aim, a qualitative study was conducted and the research question "What factors affect the adoption of frugal health innovations?" was asked. The sub-research questions "What theoretical framework is most appropriate to describe adoption of frugal health innovations?" and "What empirical evidence exists, that can give information on factors affecting the adoption of frugal health innovations?" were introduced to guide the research. Shortly, a literature review was conducted to gather secondary data on the theoretical frameworks used to study the adoption of FIs in the literature, from which the most suitable framework was identified to study the adoption of FHIs, i.e. framework 1.0, thereby answering sub-research question 1. Hereafter, secondary data was gathered from the same literature review to retrieve empirical evidence on the adoption of FIs that can give information on the adoption of FHIs to answer the second sub-research question. Using the empirical evidence and framework 1.0, a conceptual framework was synthesized to study the factors affecting the adoption of FHIs, i.e. framework 2.0. Ultimately, framework 2.0 was validated empirically using semi-structured interviews with FHI developers to provide insights into the factors affecting the adoption of FHIs, thereby answering the main research question (Figure 3).

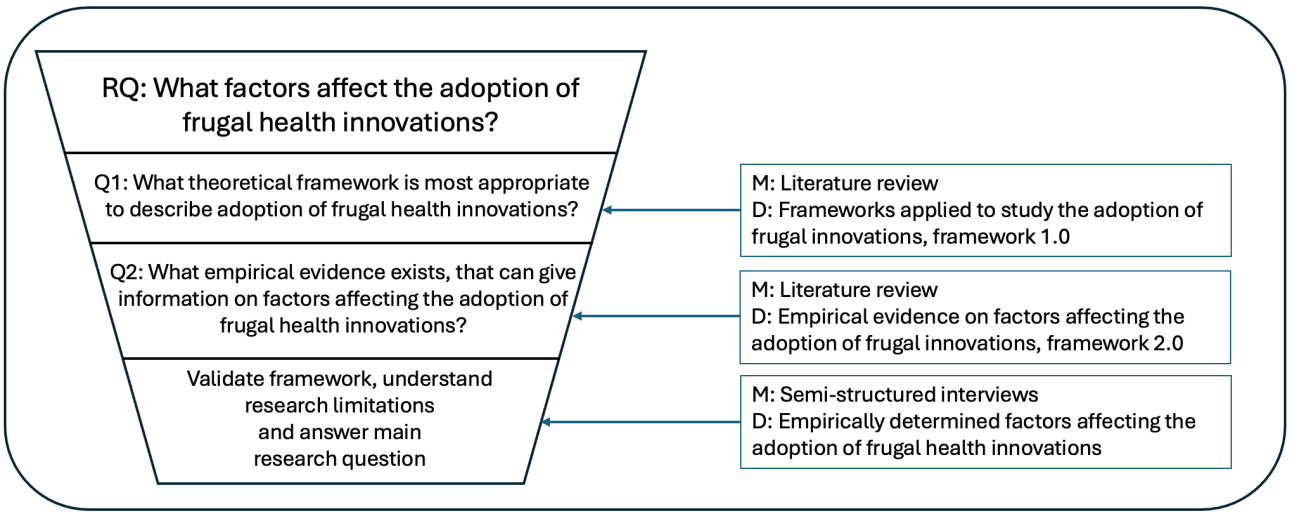

Figure 3. *Schematic representation of the research questions and research design used in this research study.* On the left, the research questions are shown, with the main research question at the top and the sub-research questions below. At the bottom, a final step is shown to validate the framework, understand the research limitations, and answer the main research question. On the right, the methods to answer the sub-research questions and the subsequent deliverables are shown. D: deliverable; M: method; Q: sub-research question; RQ: main research question.

3.2 Literature review

The purpose of the literature review was twofold. The first purpose was to determine what the most suitable theoretical framework is to study the adoption of FHIs, thereby providing framework 1.0 and answering sub-research question 1. The second purpose was to determine what empirical evidence exists on the adoption of FIs, that can give information on factors affecting the adoption of FHIs, thereby allowing the synthesis of a conceptual framework to study the adoption of FHIs, i.e. framework 2.0, and answering sub-research question 2.

3.2.1 Search methodology

The literature review was conducted in line with the Preferred Reporting Items for Systematic reviews and Meta-Analyses statement (Preferred Reporting Items for Systematic Reviews and Meta-Analyses, 2024). Literature studies were retrieved from Scopus, referred to as "search entry", or via alternative routes, e.g., via in-text references, referred

to as “others” (Figure 4). For the search entry, “search entry 1” was used to search for articles using specific keywords (Table 4) and “search entry 2” was used to search for articles that used specific references (Table 5) as some of the identified theories, models, and frameworks did not have a generic name (Appendix B, Table A3, Table A4). Scopus was used as the database as it contains a more exhaustive list of indexed journals than Webb of Science (Singh et al., 2021) and, in contrast to Google Scholar, only contains peer-reviewed articles (Bonato, 2016). A combination of FI, adoption, and names of theoretical perspectives identified (Appendix B, Table A3, Table A4), including overlapping concepts of FI (Table 1), adoption (Table 2), and theoretical perspectives (Table 3) was used as the search entry in Scopus. Besides the overlapping concepts of adoption, acquisition, roll-out, scaling up, absorptive capacity, and market introduction were considered as these terms may describe technology adoption from a market perspective, and failure, non-successful, and abandoned were included to consider studies on non-adopted innovations. After retrieval of the literature studies, articles published during or after 2010 were included. Subsequently, articles were included if they covered FIs, or a similar innovation concept, and, if not, articles were discarded. Hereafter, articles were included if they also covered adoption, or a similar technology use concept, and, if not, articles were discarded. Ultimately, articles were included if they studied the adoption of FIs from a theoretical perspective, and, if not, articles were discarded. Articles that were not accessible were excluded and duplications of articles obtained through the search entries and the alternative route were also removed.

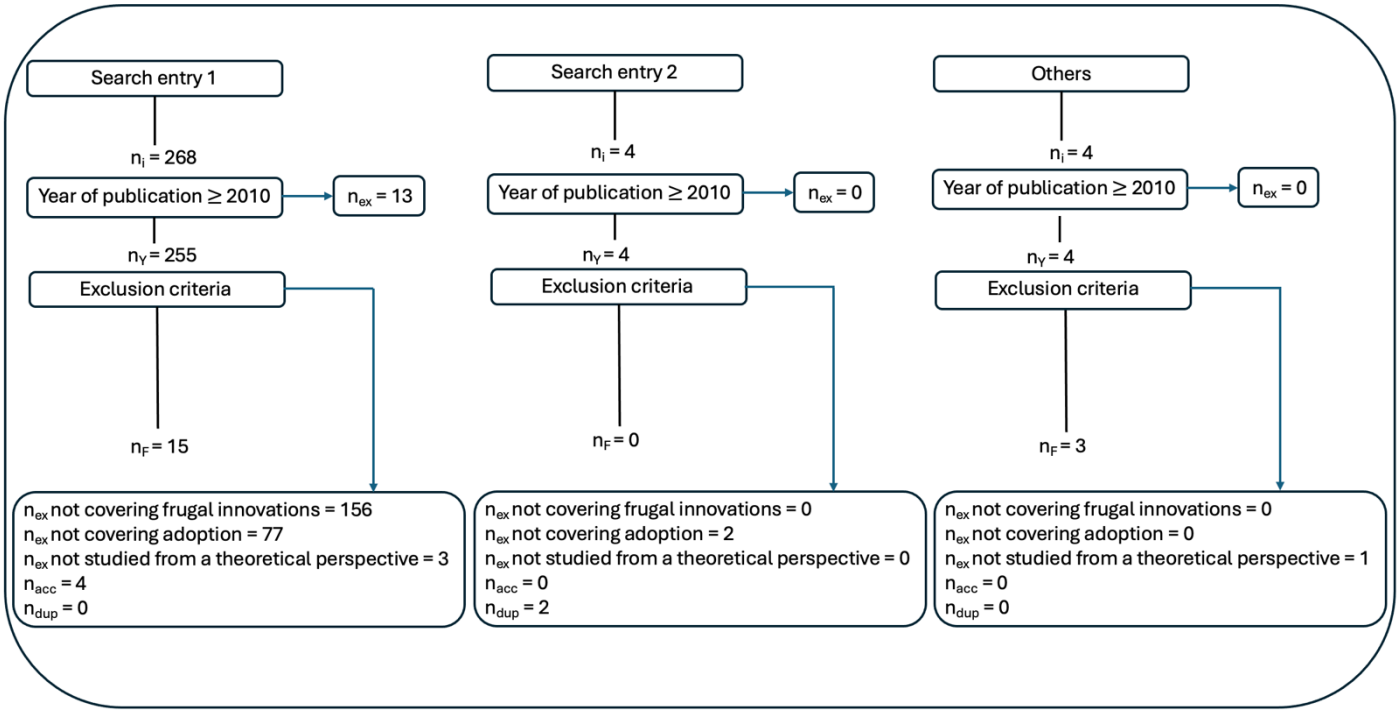

Figure 4. *Preferred Reporting Items for Systematic reviews and Meta-Analyses statement of the literature review.* Literature studies were retrieved through Scopus using the search entries (Search entry 1 for specific keywords and Search entry 2 for specific references) or through other sources, e.g. via in-text references (Others). The initial number of articles (n_i), number of articles retained after filtering on publication date (n_Y), and the final number of articles retained after filtering on the exclusion criteria (n_F) are indicated. The number of excluded articles (n_{ex}) is included with an explanation on the exclusion criteria, being exclusion because the article was not about frugal innovations, or a related innovation concept, not about adoption, or a related technology use concept, or not studied from a theoretical perspective. Furthermore, the number of articles removed due to inaccessibility (n_{acc}) and because of duplication (n_{dup}) are also indicated.

Table 4. *First search entry used to identify articles for the literature study based on specific keywords*. The search entry used to retrieve literature studies as used in Scopus (Search entry) and the number of initial articles retrieved (n_i) are indicated. The search field used was the title, abstract, and keywords (TITLE-ABS-KEY). Boolean operators (AND and OR) were used to include both sets of strings or a combination of strings, quotation marks (“”) were used to include the exact strings, and wildcards (*) were used to include any other string following that set of strings. For clarity, brackets are colour coded, with the highest order being blue, followed by orange, red, green, and then black.

Search entry	n_i
TITLE-ABS-KEY:("frugal innovat*" OR "frugal engineer*" OR "constrain*-based innovat*" OR "constrain* based innovat*" OR "bottom-of-the-pyramid" OR "bottom of the pyramid" OR "BoP" OR "Jugaad innovat*" OR "grassroot innovat*" OR "social* driven innovat*" OR "social-driven innovat*") **AND** TITLE-ABS-KEY:((“Absorptive Capacity” OR “Active Implementation” OR (“Capacity-Opportunities-Motivation-Behaviour” OR “Capacity Opportunities Motivation Behaviour” OR ((“Capacity, Opportunities, Motivation”) AND (“, and Behaviour” OR “ and Behaviour”))) OR “Cognitive Continuum” OR ((“Cognitive-Experiential” OR “Cognitive Experiential”) AND (“Self” OR “Self-“)) OR “Diffusion of Innovation*” OR “Dynamic Sustainability” OR “Igbaria” OR “Institutional” OR “Knowledge Translation” OR “Medical Research Council” OR “Motivational” OR “Network” OR “Normalization Process” OR (“Novice-Expert” OR “Novice Expert”) OR “Organizational Readiness” OR “Perceived Characteristics of Innovating” OR “*Promoting Action on Research Implementation in Health Services” OR ((“Reach, Effectiveness, Adoption, Implementation” OR “Reach Effectiveness Adoption Implementation”) AND (“ and Maintenance” OR “, and Maintenance” OR “ Maintenance”)) OR “Situated Change” OR “Social Cognitive” OR “Theoretical Domains” OR “Understanding-User-Context” OR “Understanding User Context” OR “Uses and Gratification” OR ((“Fit between Individuals, Task” OR “Fit between Individuals Task”) AND (“ and Technology” OR “, and Technology” OR “ Technology”)) OR “Self-efficacy” OR “Self Efficacy” OR “Technology-to-Performance Chain” OR “Technology to Performance Chain” OR “Reverse Innovation” OR “Kifle” OR “mHealth Readiness Conceptual” OR (“WHO*”AND “Implementation Research”) OR “Context-Mechanism-Outcome” OR “Context Mechanism Outcome” OR “Context, Mechanism, Outcome” OR ((“Idea, Development, Exploration, Assessment,” OR “Idea Development Exploration Assessment”) AND (“ Long-term Follow-up” OR “ Long term Follow up”)) OR “Levels of Change” OR “McLeroy” OR “Task-Technology Fit” OR “Task Technology Fit” OR “Task, Technology, Fit” OR “Fit-variability” OR “Fit variability”) ***AND*** (“Theory” OR “Model” OR “Framework”)) ***OR*** (((“Capability, Opportunity, Motivation,” OR “Capability Opportunity Motivation”) AND (“and Behaviour” OR “, and Behaviour” OR “ Behaviour”)) OR “*Technology Acceptance Model” OR “*Unified Theory of Acceptance and Use of Technology*” OR (“Compatibility Beliefs” AND “Technology Acceptance Research”) OR ((“Conceptual Model for Considering the Determinants of Diffusion, Dissemination, and Implementation” OR “Conceptual Model for Considering the Determinants of Diffusion, Dissemination and Implementation”) AND (“ of Innovations in Health Service Delivery and Organization”)) OR “Consolidated Framework for Implementation Research” OR “Implementation Climate” OR (“Leavitt” AND “Organizational Forces in Equilibrium”) OR “Model of PC Utilization” OR (“Strengths, Weaknesses, Opportunities” AND (“, and Threats Analysis” OR “ and Threats Analysis”)) OR ((“*Theory of”) AND (“Interpersonal Behaviour” OR “Planned Behavior” OR “Reasoned Action” OR “Structural Holes”)) OR ((“Political, Economic, Social, Technological, Environmental, Legal”) AND (“, and Infrastructural Topology” OR “ and Infrastructural Topology”)) OR (“Gladwell” AND “Tipping Point”) OR (“Berwick” AND “nurture innovation”) OR (“Govindarajan” AND “Trimble” AND “Innovation gaps”) OR ((“Medical Research Council” OR “WHO*”) AND (“Managing the Mismatch” OR “Medical Device Regulation”) AND (“Guidance” OR “Guidelines”)) OR (“WHO*” AND “Manual for Surgical Care”) OR “European Safety Regulations” OR “Training Programs in Radiation Therapy” OR (“ESTRO*” AND “Core Curricula”) OR (“AAPM*” AND “Report on Education and Training for Medical Physicists”) OR (“IAEA” AND “training” AND “Medical Physicist”) OR “Global Competency Framework for Clinical Research” OR (“WHO*” AND (“Medical Device Technical Series” OR “Health Technology Assessment of Medical Devices Guidelines”)) OR ((“National” OR “Regional” OR “Sectoral” OR “Technological”) AND “Innovation System approach”) OR “Patient Activation Measure” OR (“Consumer Health Informatics” AND “Levels of Service”)) **AND** TITLE-ABS-KEY:("adopt*" OR "diffus*" OR “user-accept*” OR “user accept*” OR "implement*" OR "fail*" OR "non-successful" OR "no success" OR "abandon*" OR "absor* capacit*" OR "use" OR "using" OR "acquisition" OR "acquire" OR "roll-out" OR "roll out" OR "market introduction" OR “scale-up” OR “scaling-up” OR “scale up” OR “scaling up”)	268

Table 5. *Second search entry used to identify articles for the literature study based on specific references*. The search entry used to retrieve literature studies as used in Scopus (search entry) and the number of initial articles retrieved (n_i) are indicated. The search field used was the title, abstract, and keywords (TITLE-ABS-KEY) or the references (REF). Boolean operators (AND and OR) were used to include both sets of strings or a combination of strings, quotation marks (“”) were used to include the exact strings, and wildcards (*) were used to include any other string following that set of strings. For clarity, brackets are colour coded, with the only order being blue.

Search entry	n_i
TITLE-ABS-KEY:("frugal innovat*" OR "frugal engineer*" OR "constrain*-based innovat*" OR "constrain* based innovat*" OR "bottom-of-the-pyramid" OR "bottom of the pyramid" OR "BoP" OR "Jugaad innovat*" OR "grassroot innovat*" OR "social* driven innovat*" OR "social-driven innovat*") **AND** REF:("Implementation matters: A review of research on the influence of implementation on program outcomes and the factors affecting implementation" OR "Artificial intelligence in health care: Laying the foundation for responsible, sustainable, and inclusive innovation in low-and middle-income countries" OR "Pathways of health technology diffusion: The United States and low-income countries" OR "Health informatics for development: A three-pronged strategy of partnerships, standards, and mobile Health" OR "Six critical actions for externally funded implementers to foster scale-up of maternal and newborn health innovations in low and middle-income countries" OR "Delivering together: A framework for sustainable ownership of early warning and health emergency surveillance technologies in low-and middle-income countries" OR "Primary care physicians' attitudes to the adoption of electronic medical records: A systematic review and evidence synthesis using the clinical adoption framework" OR "Clinical trial to implementation: Cost and effectiveness considerations for scaling up cervical cancer screening in low-and middle-income countries" OR "Mobile health and the performance of maternal health care workers in low-and middle-income countries: A realist review" OR "A model for 'reverse innovation' in health care" OR "Telemedicine Adoption and Sustainability in Extreme Resource Poor Countries" OR "What's in it for me? A process evaluation of the implementation of a mobile phone-supported intervention after stroke in Uganda" OR "Roadmap for design of surgical equipment for safe surgery worldwide" OR "Community readiness for adopting mHealth in rural Bangladesh: A qualitative exploration" OR "Introducing pulse oximetry for outpatient management of childhood pneumonia: An implementation research adopting a district implementation model in selected rural facilities in Bangladesh" OR "Disseminating technology in global surgery" OR "Explaining the impact of mHealth on maternal and child health care in low-and middle-income countries: A realist synthesis" OR "Disseminating technology in global surgery" OR "Using an integrated framework to investigate the facilitators and barriers of health information technology implementation in noncommunicable disease management: Systematic review" OR "Investigating the relationships between health and innovation systems to guide innovation adoption" OR "Mobile healthcare services adoption" OR "Barriers and facilitators to implementing evidence-based health innovations in low-and middle-income countries: A systematic literature review" OR "eHealth implementation issues in low-resource countries: model, survey, and analysis of user experience" OR "Development of an instrument for assessing the maturity of citizens for consumer health informatics in developing countries: The case of Chile, Ghana, and Kosovo") **AND** TITLE-ABS-KEY:("adopt*" OR "diffus*" OR “user-accept*” OR “user accept*” OR "implement*" OR "fail*" OR "non-successful" OR "no success" OR "abandon*" OR "absor* capacit*" OR "use" OR "using" OR "acquisition" OR "acquire" OR "roll-out" OR "roll out" OR "market introduction" OR “scale-up” OR “scaling-up” OR “scale up” OR “scaling up”)	4

3.2.2 Selection of framework 1.0

To select the most suitable framework to study the adoption of FHIs, i.e. framework 1.0, several steps were conducted using the selected articles from the literature review (Figure 5). First, empirical studies were selected, and non-empirical studies were discarded. Second, articles studying the adoption of innovations were selected and those studying other related technology use concepts, e.g., diffusion, were discarded. For this, the adoption definition of Rogers (1983, pp. 163 – 238) was used. Third, articles studying FIs were selected, and those studying other related innovation types were discarded. For this, the studied innovations were tested to the FI definition of Weyrauch, and Herstatt (2016). From these three steps, the theories, models, and frameworks used in the selected articles were put in the context of FHIs to determine their fit to study the adoption of FHIs, ultimately deriving framework 1.0.

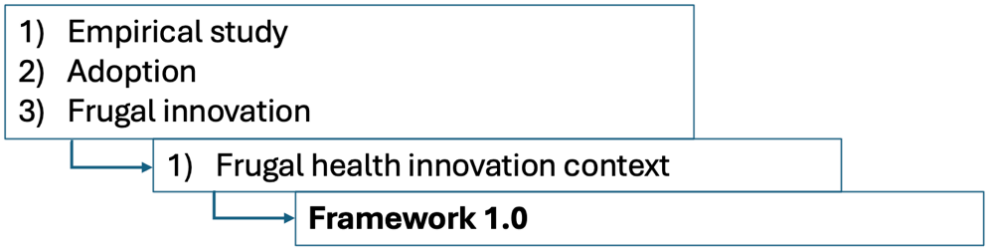

Figure 5. *Selection criteria for articles from the literature review to derive framework 1.0.* Three steps were conducted in a consecutive manner, followed by another step to ultimately derive framework 1.0. During the first step, empirical studies were selected. During the second step, studies analysing the adoption were selected. During the third step, studies analysing frugal innovations were selected. From the remaining studies, the used theories, models, and frameworks were analysed in terms of generalizability and limitations in the context of frugal health innovations, ultimately deriving framework 1.0.

3.2.3 Synthesis of framework 2.0

To retrieve empirical evidence on the barriers and enablers of the adoption of FIs that can give insight into the adoption of FHIs, i.e. to synthesize framework 2.0, several steps were conducted using the selected articles from the literature review (Figure 6). First, the quality of the selected studies was tested using the Mixed Methods Appraisal Tool (Hong et al., 2018) to derive reliable and valid empirical evidence, which is a critical appraisal tool to assess the quality of empirical studies, including qualitative, quantitative, and mixed methods research studies. To do so, two screening questions were answered to determine whether the study was appropriate for the Mixed Methods Appraisal Tool, and the type of research was identified using the proposed algorithm by Hong et al. (2018). Hereafter, a set of quality assessment questions corresponding to specific types of research were answered by adhering to the explanations provided by the Mixed Methods Appraisal Tool. From this quality assessment, the selected studies were further used to synthesize framework 2.0 by conducting six consecutive steps. During all six steps, the statistical significance of relationships and the correlation directionality between independent and dependent variables were considered. First, factors, i.e. constructs, from framework 1.0 were analyzed. Second, constructs from frameworks other than framework 1.0 were converted to constructs of framework 1.0 to reduce redundancy. Third, newly identified constructs were considered and integrated into the framework, either as new constructs or converted to constructs from framework 1.0 or other newly identified constructs, to reduce framework complexity and redundancy. Fourth, irrelevant constructs in the context of FHIs, ambiguous constructs, and moderating variables were removed to reduce framework complexity and increase framework relevancy. Fifth, the results of the previous four steps were synthesized, arriving at preliminary framework 2.0. Sixth, statistically insignificant relationships observed in the literature but still present in framework 1.0, relationships that proved to be statistically significant and insignificant for an equal number of times in the literature, and relationships from framework 1.0 that were not empirically verified in the literature were removed, and contradictory results on the correlation directionality between depended and independent variables were considered, arriving at framework 2.0.

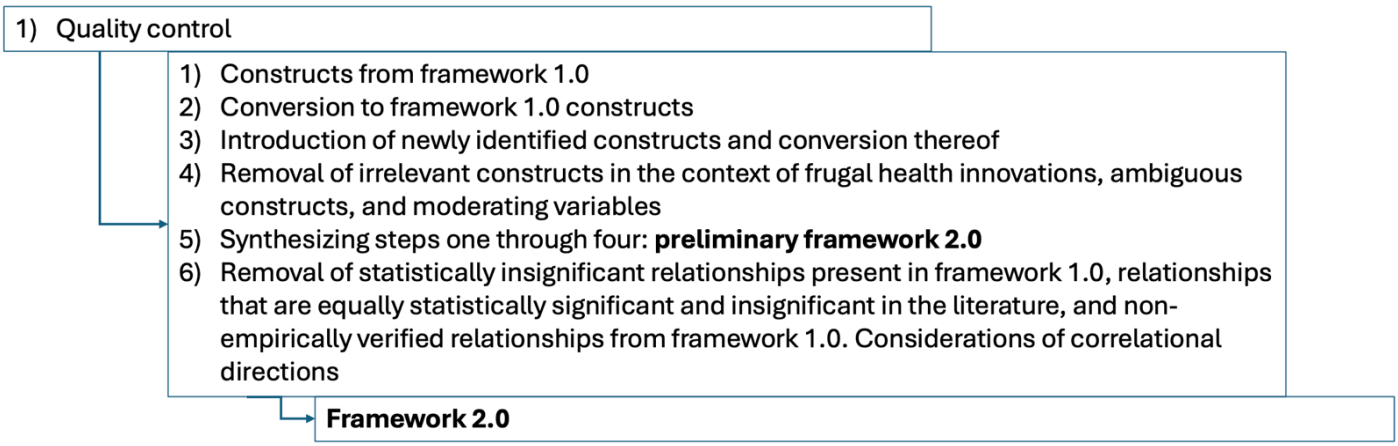

Figure 6. *Selection criteria for articles from the literature review and synthesis steps to arrive at framework 2.0.* One step was conducted to assess the quality of the literature studies using the Mixed Methods Appraisal Tool (Hong et al., 2018). Selected studies were subsequently used in six consecutive steps to synthesize framework 2.0 by considering statistically significant relationships and correlational directionalities between dependent and independent variables. During the first step, constructs from framework 1.0 were analysed. During the second step, constructs from frameworks other than framework 1.0 were converted to constructs of framework 1.0. During the third step, newly identified constructs were introduced, converted to constructs of framework 1.0 or converted to other newly identified constructs. During the fourth step, irrelevant constructs in the context of frugal health innovations were removed, as well as ambiguous constructs and moderating variables. During the fifth steps, the results of the previous four steps were synthesized to arrive at preliminary framework 2.0. During the sixth step, statistically insignificant relationships observed in the literature but still present in framework 1.0, relationships that were equally statistically significant and insignificant in the literature, and relationships from framework 1.0 that were not empirically verified in the literature were removed. Further, contradictory results on the correlation directionality between dependent and independent variables were considered, arriving at framework 2.0.

3.3 Interviews

The purpose of the interviews was to validate framework 2.0 and to determine what factors affect the adoption of FHIs empirically, thereby answering the main research question.

3.3.1 Interview design

Four semi-structured interviews were conducted according to the general interview guidelines presented by McGrath, Palmgren, and Liljedahl (2019). Interviews were conducted in a non-contrived setting, with open-ended questions, and in English through the online environment of Microsoft Teams (version 24295.606.3238.6194). The interviews were recorded and automatically transcribed through the built-in transcription software of Microsoft Teams, after which the audio recordings were separated from the video recordings and stored together with the transcripts. Interviews occurred between November 2024 and December 2024 in a cross-sectional manner and lasted 45 minutes. Interview questions were adjusted according to the stage of the innovation, i.e. being in the design stage, proof-of-concept stage, introduced into the market, or whether the innovation was abandoned or not. Interview saturation was achieved in three of the four interviews. Prior to conducting the interviews, a mock interview was conducted with a qualitative research expert, namely the advisor to this research study, who provided feedback on the interview protocol and -skills, which was incorporated subsequently. From the mock interview, it followed that two questions regarding concept definitions and finding higher order constructs needed to be removed, as it became evident that these questions resulted in interviews of approximately 75 to 90 minutes, which would prevent to ask follow-up or clarifying questions due to time constraints. Besides, these questions required the analysis of interview results on-the-spot, preventing the interviewers' ability to pay attention to the interview and ask relevant follow-up or clarifying questions. An overview of the interview protocol, including interview questions and the mock interview protocol, is provided in Appendix C.

3.3.2 Sampling design and ethical approval

For the interviews, non-probability, purposive sampling was conducted as no sampling frame of FHIs existed. Interview participants were invited because they had developed an FHI. Both innovations introduced in the market and abandoned innovations were considered as this provided a richer insight into the factors affecting the adoption

compared to considering only either of the two (Agarwal et al., 2016; Molina-Maturano et al., 2020). In total, twelve developers of FHIs were contacted through email, of which four agreed to interview, corresponding to a response rate of 33.3 %. Ethical approval of the participants was obtained through Informed Consent forms, as approved by the Delft University of Technology Human Research Ethics Committee, The Netherlands, under application number 4758.

3.3.3 Data coding process

After automatic transcription of the interview recordings, the transcriptions were anonymized and cleaned up by removing repeating words due to stuttering of the participants and interviewer or because of inaudible parts. Additionally, non-verbal cues, where relevant, were included, i.e. in the case of nodding when asked a question or when using visible quotation marks. Any other body language was not interpreted. Adjustments, except for the removal of duplicated words due to stuttering, the use of expletives, or incorrect grammar, were included in the transcript using square brackets ([]). After cleaning of the transcripts, the transcripts were aligned one more time with the audio files to ensure that the transcripts still aligned with the audio.

Coding of the interviews was done according to the general coding guidelines presented by Skjott Linneberg, and Korsgaard (2019) in Atlas.ti (version 24.2.1) using the cleaned-up transcripts. Prior to coding the results, a mock coding session was conducted with a qualitative research expert, namely the advisor to this research study, who provided feedback on the coding session, which was incorporated subsequently. From the mock coding session, it was determined that assigning codes in a deductive manner was deemed suitable for the interviews if the concepts from the interviews aligned with the constructs from framework 2.0, and that inductive coding was suitable if this was not the case. Interview questions were highlighted, and coding was done according to overlapping themes in a bottom-up manner over two iterations. During the first iteration, coding was conducted separately for each interview. Hereafter, coding was conducted again during a second iteration by considering the data of all the interviews. During the coding, specific attention was given to the quality of the statements, in the sense that statements where the participant vocally doubted were not considered. Additionally, if follow-up questions showed a particular concept to be not considered in practice, but rather a flow of thought or something to be considered in the future, the statements were also not considered. To represent interview quotes in a clear manner in this research study, non-sensical expletives were removed and subjective interpretations by the researcher of this research study were used in case there was a vague reference to a certain concept, e.g. “they” referring to the FHI. Adjustments in the quotes are presented by square brackets ([]). Further, as developers of FHIs were interviewed, and not consumers of FHIs, differentiations were made between developer-centric issues and consumer-centric issues by considering whether the discussed concepts mattered for the development of the FHI or for the introduction of the FHI in the market. This allowed to retrieve consumer-centric concepts, thus providing an insight into the adoption and answering the research question of this research study.

4 Results – Theoretical perspectives used to study the adoption of frugal innovations

To determine what theoretical perspective is the most suitable to study the adoption of FHIs, i.e. identify framework 1.0, a literature review was conducted. Prior to conducting the literature review to select framework 1.0, the literature review conducted to derive the knowledge gap (Appendix A) already showed that no theoretical perspectives have been used to study the adoption of FHIs. Therefore, it was deemed necessary to synthesize a conceptual framework that allows to study the adoption of FHIs, for which framework 1.0 provided the basis.

4.1 The literature review yielded eleven previously used theoretical perspectives

The literature review focussed on the retrieval of articles that discuss FIs, or a related concept used interchangeably in the literature (Table 1) (Dabić et al., 2022; Hossain, 2017; Hossain, 2018; Molina-Maturano et al., 2020), and the adoption thereof, or a related concept used interchangeably in the literature (Table 2) (De Vries et al., 2018; Kiwanuka, 2015), from a theoretical perspective (Table 3) (Nilsen, 2015). This allowed to retrieve as much relevant data. A preliminary literature search conducted by not considering specific theories, models, and frameworks, and merely searching for "framework, theory, and model" in the context of above concepts yielded an explosion of results with more than 2500 articles retrieved. Therefore, to maintain focus, it was decided to search specifically for the theories, models, and frameworks presented in three review articles by Adlung (n.d.), Nilsen (2015), and Taherdoost (2018). In total, 64 different theories, models, and frameworks were identified and fed into the literature search. More specifically, theories, models, and frameworks used to analyse technology adoption and user-acceptance of technology (Taherdoost, 2018), medical device adoption and diffusion in low- and middle income countries (Adlung, n.d.), and technology implementation in the healthcare sector (Nilsen, 2015) were consulted, consisting of either individual theories, models, and frameworks (Appendix B, Table A3) or emerging models, and frameworks (Appendix B, Table A4).

In total, 276 articles were retrieved, after which eighteen articles were deemed relevant. Most studies were removed because they focussed on organizational characteristics or business models to conduct the process of FI development, or covered analyses in the dental practice and oil- and gas industry due to the use of the abbreviation "BoP" in these fields, which was introduced in this literature search to represent Bottom-of-the-Pyramid. Of the eighteen selected articles, eleven different theoretical perspectives were used to study the adoption of FIs, or a related concept (Figure 7), of which the Technology Acceptance Model (TAM), DoIT, and Unified Theory of Acceptance and Use of Technology (UTAUT) (2) were the most frequently used tools. Compared to the previous observed theories, models, and frameworks from Adlung (n.d.), Nilsen (2015), and Taherdoost (2018), four newly identified theoretical tools were observed, being the Bass Model, the Consumer Acceptance of Technology Model (CATM), the Nonadoption, Abandonment, Scale-up, Spread, and Sustainability Framework, and the Value-based Adoption Model (VAM).

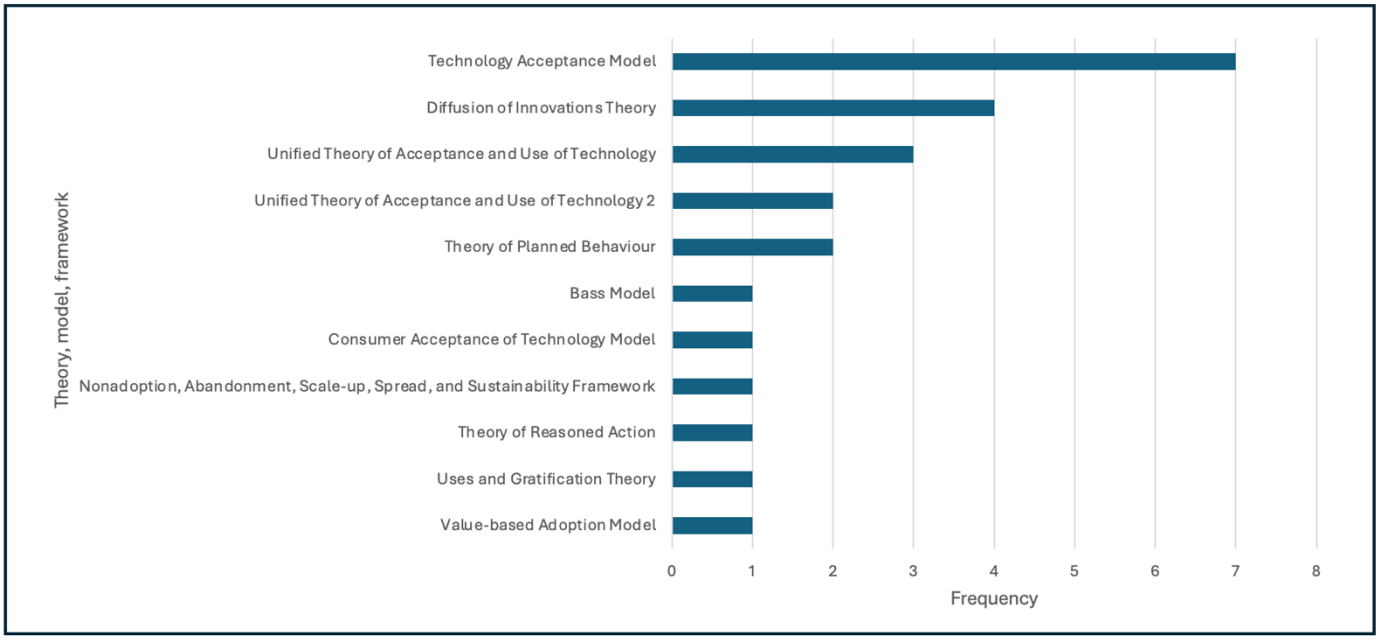

Figure 7. *Frequency of theories, models, and frameworks used to analyse the adoption, diffusion, or user-acceptance of technology of constrained-based- or socially-driven innovations.* The used theories, models, and frameworks are represented on the y-axis, and the frequency of application in the literature is shown on the x-axis.

4.2 Selecting framework 1.0

Because the eleven observed theoretical perspectives were used to study either the adoption, diffusion, or user-acceptance of FIs, or a related innovation concept, the literature data was further analysed to ensure that only studies considering the adoption of FIs remained. To do so, the technology usage concept in the literature studies was analysed by considering the definition of adoption by Rogers (1983, pp. 163 – 238). Additionally, the innovations studied in the literature studies were analysed to determine if they are a FI by considering the definition of Weyrauch, and Herstatt (2016). From the remaining studies, the used theories, models, and frameworks were put into the context of FHIs, from which the most suitable framework to study the adoption of FHIs, i.e. framework 1.0, was selected.

4.2.1 Applying the criteria of frugal innovation and adoption ensures that other related, but interchangeably used concepts are excluded

Four studies explicitly considered the diffusion of innovations, either by studying the spread of the innovation through social systems (Arshad, 2021; Ratcliff, & Doshi, 2016; Zhang, 2018) or the catalysation of adoption through a society (Marinakis, Walsh, & Harms, 2016). Diffusion of innovations differs from adoption, as it considers the trajectory of the innovation beyond individual adoption into a societal system (Rogers, 1983, pp. 163 – 238). As such, these studies were considered irrelevant (Table 6). Most studies investigated the behavioural intention to adopt an innovation (Ashoer et al., 2024; Costa, Teixeira, & Brochado, 2021; Hasan, Lowe, & Petrovici, 2020; Hussain et al., 2019; Joshi, 2024; Pipitwanichakarn, & Wongtada, 2019; Purohit, & Arora, 2023; Sodhay et al., 2024; Wentzel, Diatha, & Yadavalli, 2013). Briefly, the behavioural intention to adopt an innovation stems from the Theory of Reasoned Action (TRA), which states that an individual's behavioural intention ultimately results in a certain behaviour (Fishbein, & Ajzen, 1975). Specifically, behavioural intention to adopt an innovation has been defined as the extent to which an individual is willing to use an innovation in adoption- and user acceptance theories, models, and frameworks (Taherdoost, 2018). Although the behavioural intention to adopt an innovation is not the same as actual adoption, as it does not consider the continued usage of the innovation (Rogers, 1983, pp. 163 – 238), the intention to adopt ubiquitously results in adoption (Davis, 1989; Venkatesh et al., 2003; Venkatesh, Thong, and Xu, 2012). Consequently,

studies examining the behavioural intention to adopt an innovation were considered relevant for this research study (Table 6). Osakwe, and Okeke (2016) studied the factors that affect the perceived usefulness of an innovation. Briefly, the perceived usefulness is the degree to which a consumer believes the innovation enhances a particular activity, which ubiquitously results in a positive behavioural intention to use an innovation (Davis, 1989), and thus adoption as argued before. Therefore, the study by Osakwe, and Okeke (2016) was considered relevant (Table 6). Four studies specifically considered the adoption of innovations, by examining the willingness to use an innovation as well as the continued use of the innovation (Baishya, & Samalia, 2020; Greenhalgh et al., 2017; Kumra, Khalek, & Samanta, 2021; Verma, 2024). Consequently, these studies were deemed relevant for this research study (Table 6).

From the studies that examined the behavioural intention to adopt or the adoption, three studies did not consider FIs. Baishya, and Samalia (2020) studied the adoption of smartphones as a general technology, which does not compare to any other traditional innovations. Besides, specific frugal smartphones that are downgraded in price and functionality and that are easier to use exist (Businesswire, 2023). As such, Baishya, and Samalia (2020) did not study the adoption of FIs, and this study was excluded (Table 6). Furthermore, Greenhalgh et al. (2017) studied the adoption of several different health innovations. However, adopters of the innovations were reluctant due to, e.g., a lack of personal interaction between patients and healthcare workers to adopt the studied innovations (Greenhalgh et al., 2017). As such, the third criterium by Weyrauch, and Herstatt (2016), i.e. optimized performance level, does not apply, and Greenhalgh et al. (2017) did not study FIs. Consequently, this study was excluded (Table 6). Moreover, Verma (2024) studied the adoption of mobile agriculture services, which enable users to obtain real-time agricultural information such as crop prices and weather forecasts. Compared to the traditional innovation of the radio through which farmers obtain weather- and market-related information, mobile agriculture services require a premium to be paid (Arinloye et al., 2015), thus showing no substantial cost reduction. As such, the first criterium by Weyrauch, and Herstatt (2016), i.e. substantial cost reduction, does not apply, and Verma (2024) did not study FIs. Consequently, this study was considered irrelevant (Table 6).

The remaining eleven studies did study FIs. Most studies examined the adoption of mobile finance technologies (Ashoer et al., 20204; Wentzel et al., 2013), including mobile banking (Hasan et al., 2020; Kumra et al., 2021; Pipitwanichakarn, & Wongtada, 2019; Purohit, & Arora, 2023), and mobile-payment (Hussain et al., 2019; Joshi, 2024; Osakwe, & Okeke, 2016; Sodhay et al., 2024) (Table 6). Mobile finance technologies allow to conduct financial services using mobile phones, with mobile banking referring to the conduct of banking and mobile payment referring to the conduct of payments (David-West, Iheanachor, & Umukoro, 2019). Compared to traditional financial services, mobile finance technologies reduce costs by removing intermediaries and infrastructure, thus showing substantial cost reduction, reduce material and financial requirements and provide easy and secure access, thus focusing on the core essentials of the technology, and are more economic, efficient, faster, and accessible, thus showing optimized performance (David-West et al., 2019; Hasan et al., 2020; Joshi, 2024; Kumra et al., 2021; Sodhay et al., 2024). Consequently, mobile finance technologies, and thus mobile banking, and mobile payment, are FIs (Weyrauch, & Herstatt, 2016). As such, these studies were considered relevant (Table 6). Other innovations studied include the Tata Nano car (Costa et al., 2021) and the Union Information and Service Center (Hasan et al., 2020). The Tata Nano car is substantially cheaper than traditional cars, focusses on core essentials by decreasing materials, and focusses on optimized performance by ensuring a higher maneuverability than traditional cars (Ray, & Ray, 2011), and is thus considered an FI (Weyrauch, & Herstatt, 2016). Therefore, the study by Costa et al. (2021) was included (Table 6). The Union Information and Service Center is a public service designed to bring governmental services to the poor using information technology, which omit travel costs, thus showing substantial cost reduction, provides only necessary services and stripping away complicated processes and waiting time, thus focusing on core essentials, and provides technical assistance and more efficient service processing, thus showing optimized performance (Prime Minister's Office Bangladesh, 2022). Consequently, the Union Information and Service Center is an FI (Weyrauch, & Herstatt, 2016), and the study by Hasan et al. (2020) was included (Table 6).

Table 6. *Literature studies on adoption, diffusion, and user-acceptance of technology of constrained-based- or socially-driven innovations.* The study (Study), technology use concept (Use concept), innovation (Innovation), theory, model, or framework used (Theory, model, framework), and the market (Market) are presented. Red text corresponds to exclusion criteria where studies either did not study adoption or the behavioural intention to adopt, or did not study a frugal innovation. Green highlighted text represents studies deemed relevant, as they study the adoption or behavioural intention to adopt of a frugal innovation.

Study	Use concept	Innovation	Theory, model, framework	Market
Arshad (2021)	Diffusion	Jaipur foot and Narayana Hurdayala Heart Hospital	Diffusion of Innovations Theory	Pakistan
Marinakis et al. (2016)	Diffusion	Mud fuel stoves, M-Pesa, Tata Nano car	Technology Acceptance Model	Sudan, Kenya, India
Ratcliff, & Doshi (2016)	Diffusion	Patrimonio Hoy, e-Choupal, and Grameen's Village Phone	Diffusion of Innovations Theory + Bass Model	Mexico, India, and Bangladesh
Zhang (2018)	Diffusion	Frugal innovation communication technologies	Diffusion of Innovations Theory	United States of America, China
Baishya, & Samalia (2020)	Adoption	Smartphones	Unified Theory of Acceptance and Use of Technology	India
Greenhalgh et al. (2017)	Adoption	Various healthcare innovations	Nonadoption, Abandonment, Scale-up, Spread, and Sustainability Framework	United Kingdom
Verma (2024)	Adoption	Mobile agriculture services	Unified Theory of Acceptance and Use of Technology	India
Ashoer et al. (2024)	Behavioural Intention to adopt	Mobile finance technologies	Technology Acceptance Model	Indonesia
Costa et al. (2021)	Behavioural Intention to adopt	Tata Nano car	Unified Theory of Acceptance and Use of Technology	Portugal
Hasan et al. (2020)	Behavioural Intention to adopt	bKash, Union Information and Service Centre	Theory of Reasoned Action, Theory of Planned Behaviour, Diffusion of Innovations Theory, Technology Acceptance Model, Value-based Adoption Model, Consumer Acceptance of Technology Model	Bangladesh
Hussain et al. (2019)	Behavioural Intention to adopt	Mobile payment	Unified Theory of Acceptance and Use of Technology 2	Bangladesh
Joshi (2024)	Behavioural Intention to adopt	Unified Payment Interface	Unified Theory of Acceptance and Use of Technology 2	India
Pipitwanichakarn, & Wongtada (2019)	Behavioural Intention to adopt	Mobile banking	Technology Acceptance Model	Thailand
Purohit, & Arora (2023)	Behavioural Intention to adopt	Mobile banking	Technology Acceptance Model	India
Sodhay et al. (2024)	Behavioural Intention to adopt	Mobile payment	Uses and Gratification Theory	India
Wentzel et al. (2013)	Behavioural Intention to adopt	Mobile finance technologies	Technology Acceptance Model	South Africa
Osakwe, & Okeke (2016)	Perceived usefulness	Mobile payment	Technology Acceptance Model	Nigeria
Kumra et al. (2021)	Adoption	Online peer-to-peer lending platforms	Theory of Planned Behaviour	India

4.2.2 *Most theories, models, and frameworks are inappropriate to study the adoption of frugal health innovations*

After the selection of relevant studies on the adoption of FIs, eleven studies remained, which used a variety of theories, models, and frameworks (Table 6). To determine which theory, model, or framework is most appropriate for studying the adoption of FHIs, the underlying limitations of the theories, models, and frameworks in the context of FHIs were considered. The theories, models, and frameworks can be divided into four categories, being *(i)* diffusion theories, i.e. the DoIT; *(ii)* gratification theories, i.e. the Uses and Gratification Theory (UGT); *(iii)* behavioural intention models and frameworks, i.e. the TRA, Theory of Planned Behaviour (TPB), TAM, CATM, and VAM; and *(iv)* unified theories, i.e. the UTAUT, and UTAUT 2. A complete overview of the theories, models, and frameworks, except for the UTAUT (2), is given in Appendix D.

The DoIT focusses primarily on the diffusion of innovations (Rogers, 1983, pp. 163 – 238) by stating that customers form a positive or negative attitude toward the innovation during the persuasion stage, depending on the perceived characteristics of the innovation, ultimately affecting the rate of adoption, which are then communicated through a social system through time, thereby affecting the diffusion. Besides being a diffusion theory, making the DoIT less applicable to study adoption, there are several limitations in the context of FHIs (Table 7). First, the theory does not address sociocultural factors, which are important in collectivistic markets where FIs are often sold. Here, the influence from others and cultural believes are important to ones' decision (Arshad, 2021; Leonard, De Kock, & Bam, 2020; Mills, 2014; Sarkar, & Mateus, 2022; Sheth, 2011; Zanello et al., 2016). Second, the DoIT assumes a homogeneous market without sociopolitical governance driven by the diversity of needs, wants, and aspirations. Such homogeneity does not apply to markets where FIs are often introduced, especially in the context of healthcare in developing countries. Here, socio-economic inequalities, resource constraints, infrastructural constraints, and the influence of sociopolitical institutions are relevant (Arshad, 2021; Leonard et al., 2020; Mills, 2014; Sarkar, & Mateus, 2022; Sheth, 2011; Zanello et al., 2016). Third, organizational factors, e.g., healthcare policy alignment and disease priorities are not considered in the DoIT, which are important in the context of healthcare innovations, both in developed and developing economies (Greenhalgh et al., 2017; Leonard et al., 2020; Mills, 2014; Sarkar, & Mateus, 2022; Zanello et al., 2016).

The UGT theorizes that gratification from using innovations results in the adoption of the innovation (Katz, Blumler, & Gurevitch, 1973). Developed to understand why individuals use certain types of media, the UGT argues that specific needs must be met to fulfil the gratification. These needs include the alignment of cognitive needs, expression of emotions, expression of values and identity, experience of social connections, and experience of relaxation. As the UGT only focusses on the fulfilment of specific needs, it fails to address the same issues as the DoIT in the context of FHIs, with the addition of not including product-specific factors and lower literacy levels of FI users that may affect the decision, or at least the ability, to use an innovation (Arshad, 2021; Greenhalgh et al., 2017; Leonard et al., 2020; Mills, 2014; Sarkar, & Mateus, 2022; Sheth, 2011; Zanello et al., 2016) (Table 7).

Behavioural intention models and frameworks trace back to the TRA, which theorizes that behaviour is affected by the intention to conduct that behaviour, i.e. the behavioural intention (Fishbein, & Ajzen, 1975). In the TRA, the attitude toward an innovation and the desire to comply with the social system of the user affect the behavioural intention. However, the TRA does not include external conditions. In contrast, the TPB aims to overcome this limitation by introducing factors relating to the perceived ease in performing a particular behaviour (Ajzen, 1991). The main limitation of both the TRA and TPB is their generalizability, considering that the theories describe a particular socio-psychological process that results in some sort of behaviour, thereby excluding contextual factors (Table 7). The TRA and TPB do include social factors, and the perceived ease from the TPB may translate to resource constraints, infrastructural constraints, and consumer literacy, however, in the context of FHIs, both theories do not acknowledge product characteristics, socio-economic inequalities, sociopolitical influence, and policy alignment (Arshad, 2021; Greenhalgh et al., 2017; Leonard et al., 2020; Mills, 2014; Sarkar, & Maetus, 2022; Sheth, 2011; Zanello et al., 2016).

The VAM and the TAM are derivatives of the TRA and TPB, developed to study the adoption of information and communications technologies in the consumer market (Kim, Chan, & Gupta, 2007) and in organizations (Davis, 1989), respectively. Both models translate behavioural intention and behaviour to the intention to adopt and the actual

adoption, respectively. The VAM states that the intention to adopt stems from maximizing the perceived value of the innovation, which is a continuous trade-off between the benefits of the technology and sacrifices required to use the innovation. Particularly, the usefulness, enjoyment, technicality, and fee of the technology determine the perceived value. The TAM, in contrast, introduces perceived usefulness and perceived ease-of-use of the innovation. In the context of FHIs, (perceived) usefulness, technicality, and perceived ease-of-use in the VAM and TAM may cover product-specific characteristics and consumer literacy, and fee in the VAM may cover socio-economic inequalities, but both models fail to include sociocultural factors, resource constraints, infrastructural constraints, sociopolitical influence, and policy alignment (Arshad, 2021; Greenhalgh et al., 2017; Leonard et al., 2020; Mills, 2014; Sarkar, & Mateus, 2022; Sheth, 2011; Zanello et al., 2016) (Table 7). The CATM extends the TAM by including hedonic factors, i.e. pleasure and arousal, to describe the adoption of information and communication technologies (Kulviwat et al., 2007). Consequently, the CATM fails to address the same issues as the TAM (Arshad, 2021; Greenhalgh et al., 2017; Leonard et al., 2020; Mills, 2014; Sarkar, & Mateus, 2022; Sheth, 2011; Zanello et al., 2016) (Table 7).

Table 7. *Limitations of the theories, models, and frameworks observed in the literature to study the adoption in the context of frugal health innovations.* The theory, model, or framework (Theory, model, framework) and its' limitations in the context of frugal health innovations (Limitations) are indicated. Here, the context of frugal health innovations refers to sociocultural influence, socio-economic inequalities, resource constraints, consumer literacy, infrastructural constraints, the influence of sociopolitical institutions, and the technical product features.

Theory, model, framework	Limitations
Diffusion of Innovations Theory	Diffusion theory. Excludes sociocultural factors, socio-economic inequalities, resource constraints, infrastructural constraints, sociopolitical influence, and policy alignment
Uses and Gratification Theory	Excludes product-specific factors, sociocultural factors, socio-economic inequalities, resource constraints, infrastructural constraints, sociopolitical influence, consumer literacy, and policy alignment
Theory of Reasoned Action	Assumes complete voluntariness, excludes product characteristics, socio-economic inequalities, resource constraints, infrastructural constraints, sociopolitical influence, consumer literacy, and policy alignment
Theory of Planned Behaviour	Excludes product characteristics, socio-economic inequalities, sociopolitical influence, and policy alignment
Value-based Adoption Model	Excludes sociocultural factors, resource constraints, infrastructural constraints, sociopolitical influence, and policy alignment
Technology Acceptance Model	Excludes sociocultural factors, socio-economic inequalities, sociopolitical influence, and policy alignment
Consumer Acceptance of Technology Model	Excludes sociocultural factors, socio-economic inequalities, sociopolitical influence, and policy alignment

4.2.3 *The Unified Theory of Acceptance and Use of Technology 2 is the most appropriate framework to study the adoption of frugal health innovations*

As observed, the DoIT, UGT, TRA, TPB, VAM, TAM, and CATM fail to scale to the context of FHIs. Indeed, Hasan et al. (2020) validated these theories, models, and frameworks to study the adoption FIs at the Bottom-of-the-Pyramid, except for the UGT, and found that not one model is superior. In the case of FIs, products must be compatible with the existing lifestyle and consumer literacy, infrastructure and resources, and behaviours of users, and innovations should be easy to use. Besides, it is important that FIs also align with the social environment of their users. Furthermore, economic factors, including the perceived value and the perceived fee of the innovation, are relevant, and hedonic factors are also important, as the enjoyment experienced from an innovation is likely the result from the alignment of the innovation with current lifestyles and constraints (Hasan et al., 2020). Consequently, Hasan et al. (2020) argues that a hybrid model based on the behavioural intention to adopt that includes *(i)* innovation characteristics; *(ii)* factors related to the ease-of-use of the innovation; *(iii)* factors related to the facilitating conditions; *(iv)* social factors; *(v)* economic factors; *(vi)* hedonic factors; and *(vii)* factors related to the trialability of the innovation is most suitable to study the adoption of FIs. To that extent, the UTAUT 2, which is an extension of the UTAUT, is an empirically validated framework that may be the most appropriate to study the adoption of FHIs.

The UTAUT was developed by Venkatesh et al. (2003) to explain the behavioural intention to adopt information and communication technologies in a voluntary and organizational setting, by synthesizing constructs

from eight different theories, models, and frameworks, including the TAM, TRA, TPB, and DoIT (Figure 8A). In short, the UTAUT translates the behavioural intention and behaviour from the TRA to the Behavioural Intention to adopt and Use Behaviour, respectively. Behavioural Intention to adopt refers to the willingness of an individual to adopt the innovation and Use Behaviour refers to the use and continued usage of the innovation, i.e. adoption. Venkatesh et al. (2003) found that the performance of the innovation, the ease-of-use of the innovation, and social factors affect Behavioural Intention to adopt, and that external facilitating conditions affect Use Behaviour. More specifically, Behavioural Intention to adopt is affected by the Performance Expectancy of the innovation, Effort Expectancy of the innovation, and Social Influence on the user, where Performance Expectancy refers to "the degree to which an individual believes that using the system will help him or her to attain gains in job performance", Effort Expectancy refers to "the degree of ease associated with the use of the system", and Social Influence refers to "the degree to which an individual perceives that important others believe he or she should use the new system" (Venkatesh et al., 2003). Additionally, the Facilitating Conditions of the innovation, which refer to "the degree to which an individual believes that an organizational and technical infrastructure exists to support use of the system" (Venkatesh et al., 2003), affect Use Behaviour. Besides these independent variables, Venkatesh et al. (2003) also studied the effect of moderating variables, being Gender, Age, Experience, and Voluntariness of Use. However, to maintain parsimony, and because, as shown in section 5.2, no relevant empirical evidence on moderating variables was observed in the literature, it was decided to exclude these moderating effects.

Venkatesh et al. (2012) developed the UTAUT 2 to study the adoption of information and communication technologies in a voluntary consumer context. The UTAUT 2 extends the UTAUT by including hedonic factors, economic factors, and habits, excludes the moderating variable Voluntariness of Use, and introduces a relationship between Facilitating Conditions and Behavioural Intention to adopt (Figure 8B). Venkatesh et al. (2012) maintained the same definitions for Effort Expectancy and Social Influence as Venkatesh et al. (2003) but adjusted the definitions for Performance Expectancy and Facilitating Conditions to "the degree to which using a technology will provide benefits to consumers in performing certain activities" and "the consumers' perceptions of the resources and support available to perform a behaviour" to represent the consumer setting, respectively. Venkatesh et al. (2012) verified the original relationships of the UTAUT, and additionally found that Hedonic Motivation, Price Value, and Habit affect Behavioural Intention to adopt, which refer to "the fun or pleasure derived from using a technology", "the cognitive trade-off between the perceived benefits of the applications and the monetary cost for using them", and "the extent to which people tend to perform behaviours automatically because of learning", respectively (Venkatesh et al., 2012). Further, Venkatesh et al. (2012) also found that Facilitating Conditions affect Behavioural Intention to adopt, as facilitating conditions are not ubiquitously present in a consumer context in contrast to organizational contexts, and that Habit affects Use Behaviour. For the moderating variables, Venkatesh et al. (2012) observed the same relationships as introduced in the UTAUT by Venkatesh et al. (2003), except for Voluntariness of Use as individuals are completely independent to choose to use the innovation and have no organizational mandate. Additionally, Venkatesh et al. (2012) studied the effects of the moderating variables Gender, Age, and Experience on the newly identified relationships. However, for the same reasons as provided earlier, it was decided to exclude moderating effects in this research.

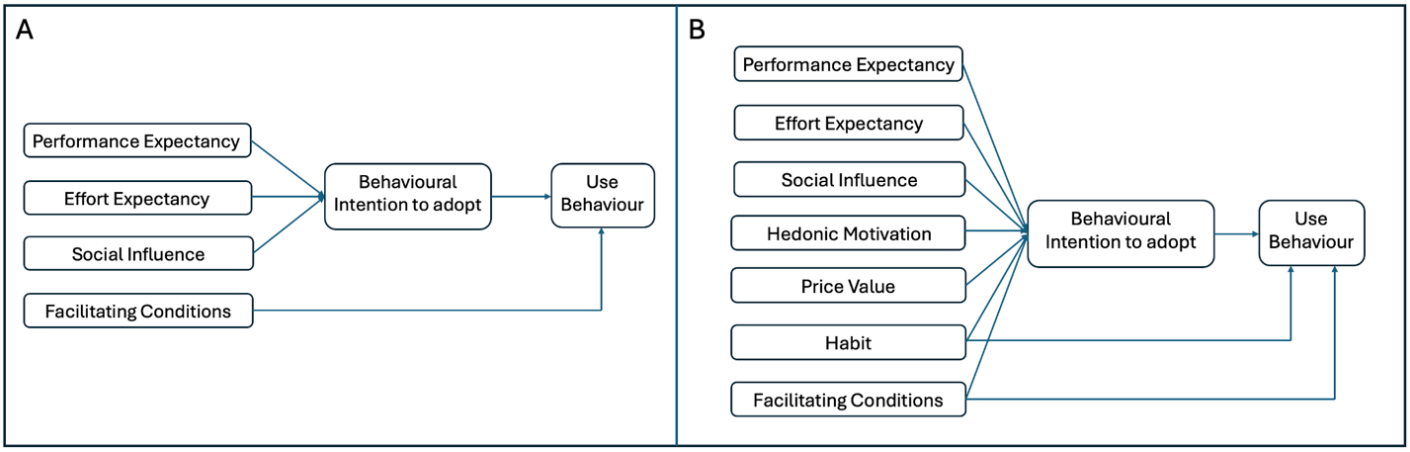

Figure 8. *Schematic representation of the Unified Theory of Acceptance and Use of Technology (2).* **A:** The Unified Theory of Acceptance and Use of Technology. Behavioural Intention to adopt affects the Use Behaviour, whereas Performance Expectancy, Effort Expectancy, and Social Influence affect Behavioural Intention to adopt and Facilitating Conditions directly affects Use Behaviour. Adapted from Venkatesh et al. (2003). **B:** The Unified Theory of Acceptance and Use of Technology 2. The relationships from the original Unified Theory of Acceptance and Use of Technology remain present, but the framework is expanded upon by including Hedonic Motivation, Price Value, Habit, and Facilitating Conditions that affect Behavioural Intention to adopt, and Habit that affects the Use Behaviour. Adapted from Venkatesh et al. (2012).

As presented, the UTAUT and UTAUT 2 provide a unified theory to study the adoption of innovations. Indeed, the UTAUT, and thus UTAUT 2, include constructs from the TAM, DoIT, TRA, and TPB, except for Attitude from the TRA and TPB and Trialability from the DoIT (Venkatesh et al., 2003) (Appendix D, Table A6). Attitude, referring to the way the individual feels toward the behaviour (Fishbein, & Ajzen, 1975), was only significantly affecting the intention to adopt in case Performance Expectancy and Effort Expectancy were not considered, and hence was excluded (Venkatesh et al., 2003). In contrast, however, Venkatesh et al. (2003) did not elaborate on the exclusion of Trialability, which refers to the ability to do experiments on a limited basis with the innovation (Rogers, 1983, pp. 163 – 238). Notably, Venkatesh et al. (2003) did not consider the VAM, CATM, and UGT, however, it is likely that the UTAUT 2 also cover the respective constructs (Appendix D, Table A6).

As the UTAUT and UTAUT 2 likely cover the constructs of all the theories, models, and frameworks observed in the literature to study the adoption of FIs, these frameworks are likely to be the most appropriate to study the adoption of FHIs. Going back to the propositions of Hasan et al. (2020) for the development of a hybrid framework to study the adoption of FIs, the UTAUT 2 covers *(i)* innovation characteristics by including Performance Expectancy; *(ii)* factors related to the ease-of-use of the innovation by including Effort Expectancy; *(iii)* factors related to the facilitating conditions by including Facilitating Conditions; *(iv)* social factors by including Social Influence; *(v)* economic factors by including Price Value; and *(vi)* hedonic factors by including Hedonic Motivation (Table 8). Indeed, in the context of FHIs, Social Influence may represent social factors relevant in the collectivistic markets of FHIs, Price Value may represent socio-economic inequalities, Facilitating Conditions may represent resource constraints and infrastructural constraints, Performance Expectancy may represent product characteristics, and Effort Expectancy may represent ease-of-use of the technology and the consumers' literacy levels (Arshad, 2021; Leonard et al., 2020; Mills, 2014; Sarkar, & Mateus, 2022; Sheth, 2011; Zanello et al., 2016) (Table 8). Yet, Habit in the UTAUT 2 could not be related to the FHI context as a literature search on habit and FHIs did not yield any results. All in all, compared to the previous theories, models, and frameworks that have been used in the literature to study the adoption of FIs, the UTAUT 2 is likely the most suitable framework to study the adoption of FHIs. Important to note, however, is that the definitions of Performance Expectancy must be adjusted to allow the study of adoption among FHIs as Performance Expectancy is specifically defined in terms of job performance by Venkatesh et al. (2003) and in terms of performing consumer-related activities by Venkatesh et al. (2012). Similarly, Facilitating Conditions requires to be adjusted as FHIs are developed under resource constraints and thus already take such constraints into account, whereas Facilitating Conditions is defined in terms of the existence of support and knowledge by Venkatesh et al. (2003) and Venkatesh et al. (2012) (Table 8).

Table 8. *Constructs of the Unified Theory of Acceptance and Use of Technology 2 in the context of frugal health innovations*. The constructs of the Unified Theory of Acceptance and Use of Technology 2 (Construct), what the constructs may represent in the context of frugal health innovations (Context), and the definition of the constructs for frugal health innovations (Frugal health innovation definition) are presented. Here, the context of frugal health innovations refers to sociocultural influence, socio-economic inequalities, resource constraints, consumer literacy, infrastructural constraints, the influence of sociopolitical institutions, and the technical product features. *: Habit does not seem to be related to the context of frugal health innovations.

Construct	Context	Frugal health innovation definition
Performance Expectancy	Product characteristics	The degree to which the innovation provides healthcare benefits
Effort Expectancy	Ease-of-use, consumer literacy	"The degree of ease associated with the use of the system" (Venkatesh et al., 2003)
Social Influence	Social factors	"The degree to which an individual perceives that important others believe he or she should use the new system" (Venkatesh et al., 2003)
Hedonic Motivation	Hedonic factors	"The fun or pleasure derived from using a technology" (Venkatesh et al., 2012)
Price Value	Socio-economic inequalities	"The cognitive trade-off between the perceived benefits of the applications and the monetary cost for using them" (Venkatesh et al., 2012)
Habit	*	"The extent to which people tend to perform behaviours automatically because of learning" (Venkatesh et al., 2012)
Facilitating Conditions	Resource constraints and infrastructural constraints	The degree to which resource constraints and infrastructural constraints do not impede the use of the innovation

As argued, the UTAUT 2 is likely the most appropriate framework to study the adoption of FHIs. However, in the context of FHIs, several important components are not included. For example, the influence of political institutions is not represented. For both developing and developed economies, policies of political institutions can affect the adoption of health innovations (Greenhalgh et al., 2017; Leonard et al., 2020; Mills, 2014; Zanello et al., 2016), and it has been shown that recommendations by authorities makes the diffusion of FHIs more likely amongst consumers (Arshad, 2021). Further, despite the inclusion of Social Influence, cultural influences, and more specifically, differences between cultural values of FHI developers in developed markets and consumers in developing markets, resulting in misalignment of addressable needs, are not represented (Arshad, 2021; Mills, 2014; Sarkar, & Mateus, 2022; Zanello et al., 2016). As such, it is important to understand what factors have been identified empirically that affect the adoption of FIs, which can give insight into the factors affecting the adoption of FHIs.

5 Results – Empirical evidence on factors affecting the adoption of frugal innovations

To determine what empirical evidence exists on factors affecting the adoption of FIs, the findings of the selected research studies on the adoption, or behavioural intention to adopt, of FIs (Table 6) were further extracted. To subsequently scrutinize the results further, the quality of the selected studies was assessed using the Mixed Methods Appraisal Tool (Hong et al., 2018) as it is important that the findings are reliable and valid. Hereafter, the remaining studies were used to synthesize framework 2.0, by considering the statistical relevance of relationships and the correlational directionality, the relevance of factors in the context of FHIs, and the redundancy of constructs, ambiguity of constructs, and non-empirically verified relationships as present in framework 1.0. As all studies used different theories, frameworks, and models, it was deemed necessary to merge constructs to constructs of framework 1.0 or newly identified constructs in the literature to reduce framework complexity, where relevant. Further, as all studies were on the adoption of FIs different from FHIs, it is possible that relevant factors were innovation-specific, and thus the factors were considered in the context of FHIs. During all steps, independent variables statistically significant affecting Behavioural Intention to adopt, or another dependent variable, were interpreted as factors affecting the adoption of FIs, or the other dependent variable, and independent variables statistically insignificant affecting Behavioural Intention to adopt, or another dependent variable, were interpreted as factors not affecting the adoption of FIs, or the other dependent variable. Further, positive correlation coefficients were interpreted as facilitators, whereas negative correlation coefficients were interpreted as barriers. The analysis of the quality assessment of the literature studies is presented in Appendix E and the entire synthesis of framework 2.0 is presented in Appendix F.

5.1 Study quality assessment shows a lack of generalizability

Some research studies did not clearly state a research question, but did state a research objective (Ashoer et al., 2024; Joshi, 2024; Pipitwanichakarn, & Wongtada, 2019; Wentzel et al., 2013) (Table 9). According to the Mixed Methods Appraisal Tool, these studies should not be considered. However, bearing in mind the limited number of literature studies available for this research study, it was decided to include these studies, nonetheless. For the mixed methods studies, the main limitation was the absence of the qualitative analysis (Joshi, 2024; Pipitwanichakarn, & Wongtada, 2019) (Table 9). However, considering that the quantitative analysis, which was of high quality, is relevant to this research study as it dives into the factors affecting the adoption of FIs, it was decided to keep these studies. The main limitation observed for all, but the study by Kumra et al. (2021), was the lack of generalizability (Table 9). Research questions or objectives were stated for multiple regions, i.e. the Bottom-of-the-Pyramid or emerging markets, whilst samples were obtained from regions in one particular country or, when the research questions or objectives were stated for specific countries, certain demographics were not sampled. However, considering that this was the case for all research studies, it was decided to include the studies nonetheless to prevent a complete absence of research studies. Notably, the quality of two research studies was much lower than that of the other studies, namely those conducted by Osakwe, and Okeke (2016) and Wentzel et al. (2013). Osakwe, and Okeke (2016) did not operationalize their measurements and as such there is likely a high operationalization bias. Considering that such a bias prevents certainty of data interpretation, it was decided to exclude the study by Osakwe, and Okeke (2016) (Table 9). Wentzel et al. (2013), in contrast, did not state any research questions, research objectives, or hypotheses, and their measurement

items seemed to cover a different topic than their topic of interest and relevant to this research study. Therefore, it was decided to omit the study by Wentzel et al. (2013) (Table 9). Although the study by Kumra et al. (2021) is not of bad quality, it was still decided to exclude it from the analysis. This was done because the study by Kumra et al. (2021) is a qualitative study, and quantitative evidence was prioritized as it allowed to derive a conceptual framework more readily from the observed statistical relationships.

Table 9. *Quality assessment of studies considered for the literature review to retrieve empirical evidence on factors affecting the adoption of frugal innovations.* The study (Study), whether the study is included or not in the literature review (Included), and a brief explanatory comment (Comment) are presented.

Study	Included	Comment
Ashoer et al. (2024)	Yes	Only stated a research objective. Not generalizable. Measurements and statistical analyses were adequate
Costa et al. (2021)	Yes	Stated clear research questions. Not generalizable. Measurements and statistical analyses were adequate
Hasan et al. (2020)	Yes	Stated clear research questions. Not generalizable. Measurements and statistical analyses were adequate
Hussain et al. (2019)	Yes	Stated a clear research question. Not generalizable. Measurements and statistical analyses were adequate
Joshi (2024)	Yes	Only stated a research objective. Not generalizable. Qualitative analysis was excluded. Measurements and statistical analyses were adequate
Pipitwanichakarn, & Wongtada (2019)	Yes	Only stated a research objective. Not generalizable. Qualitative analysis was excluded. Measurements and statistical analyses were adequate
Purohit, & Arora (2023)	Yes	Stated a clear research question. Not generalizable. Measurements and statistical analyses were adequate
Sodhay et al. (2024)	Yes	Only stated a research objective. Not generalizable. Measurements and statistical analyses were adequate
Wentzel et al. (2013)	No	No research question or objective. No hypotheses. Statistical analysis was not adequate as different concepts than the subject of interest were measured
Osakwe, & Okeke (2016)	No	Stated a clear research question. Not generalizable. Statistical analysis was not adequate as constructs were not operationalized
Kumra et al. (2021)	No	Stated clear research questions. Qualitative design and analysis of the results allowed to answer the research questions, but as a qualitative study it lacks statistical testing of hypotheses

5.2 Trialability, Lifestyle Compatibility, Consumer Literacy, and Trust also affect the adoption of frugal innovations

For FIs, the Behavioural Intention to adopt does affect the actual adoption, i.e. Use Behaviour (Ashoer et al., 2024) (Figure 9A). As such, it is assumed that factors affecting the Behavioural Intention to adopt affect the actual adoption. This is an important assumption, as all other studies only determined the effects of factors on Behavioural Intention to adopt, and not the relationship between Behavioural Intention to adopt and Use Behaviour.

Product-specific components observed in the UTAUT 2, i.e. framework 1.0, all influence the intention to adopt FIs (Figure 9A, Figure 9B). To that extent, Performance Expectancy, referring to alignment of innovation performance to consumer needs, acts as a facilitator of Behavioural Intention to adopt (Ashoer et al., 2024; Costa et al., 2021; Hussain et al., 2019; Joshi, 2024; Pipitwanichakarn, & Wongtada, 2019; Purohit, & Arora, 2023) (Figure 9A). Further, the ease-of-use of the innovation also affects Behavioural Intention to adopt as a facilitator, as outlined by the relevance of Effort Expectancy (Ashoer et al., 2024; Costa et al., 2021; Pipitwanichakarn, & Wongtada, 2019; Purohit, & Arora, 2023) (Figure 9A). Interestingly, the ease-of-use does not affect the intention to adopt FIs in case consumers

are already familiar with the innovation (Joshi, 2024). Additionally, the perceived benefits compared to the costs of the innovations, as represented by Price Value, also affect Behavioural Intention to adopt, yet either as a facilitator (Joshi, 2024) or as a barrier (Ashoer et al., 2024). As such, there exists a bi-directional correlation, i.e. both a negative and positive correlation simultaneously, between Price Value and Behavioural Intention to adopt (Figure 9A).

Besides product-specific components, all external components observed from framework 1.0 also affect the intention to adopt FIs (Figure 9A, Figure 9B). Social factors, i.e. the effect of significant others on the adoption intention as encapsulated by Social Influence, affect Behavioural Intention to adopt as a facilitator (Hussain et al., 2019; Joshi, 2024; Purohit, & Arora, 2023; Sodhay et al., 2024) (Figure 9A), except for the adoption of FIs in developed countries (Costa et al., 2021). Further, external conditions required to be present to effectively use the innovation, i.e. Facilitating Conditions, do affect Behavioural Intention to adopt, yet in some cases act as a facilitator (Costa et al., 2021; Joshi, 2024) and in other cases act as a barrier (Purohit, & Arora, 2023). As such, there exists a bi-directional correlation between Facilitating Conditions and Behavioural Intention to adopt (Figure 9A). However, there is no empirical evidence on the effect of Facilitating Conditions on the actual use, i.e. Use Behaviour (Figure 9A, Figure 9B).

In contrast, personal factors observed in framework 1.0 (Figure 9B), including learned past behaviours, i.e. Habit (Joshi, 2024) and achieved enjoyments from the innovations, i.e. Hedonic Motivation (Hussain et al., 2019), do not affect the intention to adopt FIs (Figure 9A), except for one instance where Habit affects Behavioural Intention to adopt (Hussain et al., 2019). As Habit affected the Intention to Adopt statistically significant and insignificant in an equal amount of time, it was decided to not include it in the conceptual framework as there was no dominating trend observed in the empirical evidence. Additionally, there is no empirical evidence on the effect of Habit on the actual use of FIs, i.e. Use Behaviour (Figure 9A, Figure 9B).

In the context of FIs, some factors not represented in framework 1.0 were observed to be of importance to the adoption. To that extent, Trialability, referring to the possibility to experience with the innovation on a limited basis (Rogers, 1983, pp. 163 – 238) (Table 10), is a facilitator of Behavioural Intention to adopt (Hasan et al., 2020) (Figure 9A). Indeed, the ability to try out FHIs prior to full dedication to the innovation results in an increased willingness to use FHIs (Arshad, 2021). Further, Lifestyle Compatibility, referring to the compatibility between the values offered by the innovation and the lifestyle values, experiences, and preferences of the consumers (Hussain et al., 2019; Lin, 2011) (Table 10), is a facilitator of Behavioural Intention to adopt (Hussain et al., 2019; Joshi, 2024) (Figure 9A). Indeed, especially in developing economies, value alignment between producer and consumer is imperative (Arshad, 2021; Mills, 2014; Sarkar, & Mateus, 2022; Zanello et al., 2016). In one case, however, Lifestyle Compatibility did not affect Behavioural Intention to adopt (Sodhay et al., 2024). Additionally, Consumer Literacy, referring to the required knowledge, skills, and understanding to utilize the innovation safely and effectively (Ashoer et al., 2024; Joshi, 2024; Purohit, & Arora, 2023) (Table 10), is also a facilitator of Behavioural Intention to adopt (Joshi, 2024) (Figure 9A). Indeed, the lack of knowledge to use FHIs is a constraint that must be overcome, especially in developing economies (Arshad, 2021; Leonard et al., 2020; Mills, 2014; Sarkar, & Mateus, 2022). Interestingly, Trust, referring to the consumers' confidence in the suppliers' reliability and integrity and lack of risk to lose information, funds, innovation performance, and social status (Lee, 2009; Lee, & Song, 2013; Morgan, & Hunt, 1994; Pipitwanichakarn, & Wongtada, 2019; Purohit, & Arora, 2023) (Table 10), is either a facilitator of Behavioural Intention to adopt (Pipitwanichakarn, & Wongtada, 2019), a barrier of Behavioural Intention to adopt (Joshi, 2024; Purohit, & Arora, 2023), or, in one instance, does not affect Behavioural Intention to adopt (Sodhay et al., 2024). Indeed, trust is an important consideration in the distribution of healthcare innovations, especially in marginalized communities (Schmidt-Sane et al., 2023). As Trust acts both as a facilitator and a barrier, there exists a bidirectional relationship between Trust and Behavioural Intention to adopt (Figure 9A).

Besides factors directly affecting the Behavioural Intention to adopt, several complex relationships were observed. Separating the antecedents from the factors affecting Behavioural Intention to adopt, four complex relationships were observed all centring around Performance Expectancy and Effort Expectancy. First, Effort Expectancy is a facilitator of Performance Expectancy (Ashoer et al., 2024; Pipitwanichakarn, & Wongtada, 2019), which, in turn, is a facilitator of Behavioural Intention to adopt as seen before (Figure 9A):

$$Effort\ Expectancy \rightarrow Performance\ Expectancy \rightarrow Behavioural\ Intention\ to\ adopt$$

Second, Consumer Literacy is a facilitator of Effort Expectancy, yet does not affect Performance Expectancy (Ashoer et al., 2024; Purohit, & Arora, 2023). In turn, Effort Expectancy facilitates both Performance Expectancy and Behavioural Intention to adopt, after which Performance Expectancy facilitates Behavioural Intention to adopt again as observed before (Figure 9A):

$$Consumer\ Literacy \rightarrow Effort\ Expectancy \begin{matrix} \nearrow Performance\ Expectancy \rightarrow Behvarioural\ Intention\ to\ adopt \\ \searrow Behavioural\ Intention\ to\ adopt \end{matrix}$$

Third, Trust is a facilitator of Performance Expectancy and Effort Expectancy (Pipitwanichakarn, & Wongtada, 2019). In turn, Performance Expectancy and Effort Expectancy facilitate the Behavioural Intention to adopt, and Effort Expectancy again facilitates Performance Expectancy, which then facilitates Behavioural Intention to adopt as seen before (Figure 9A):

$$Trust \begin{matrix} \nearrow Performance\ Expectacny \rightarrow Behavioural\ Intention\ to\ adopt \\ \searrow Effort\ Expectancy \begin{matrix} \nearrow Performance\ Expectancy \rightarrow Behvarioural\ Intention\ to\ adopt \\ \searrow Behavioural\ Intention\ to\ adopt \end{matrix} \end{matrix}$$

Fourth, Social Influence is a barrier to Performance Expectancy (Purohit, & Arora, 2023), which, in turn, is a facilitator of Behavioural Intention to adopt (Figure 9A):

$$Social\ Influence \overset{\ominus}{\rightarrow} Performance\ Expectancy \rightarrow Behavioural\ Intention\ to\ adopt$$

To that extent, Effort Expectancy, Consumer Literacy, and Trust are facilitating antecedents of the intention to adopt FIs, whilst Social Influence is a hampering antecedent, albeit less strong than its' facilitating character toward the intention to adopt FIs (Purohit, & Arora, 2023).

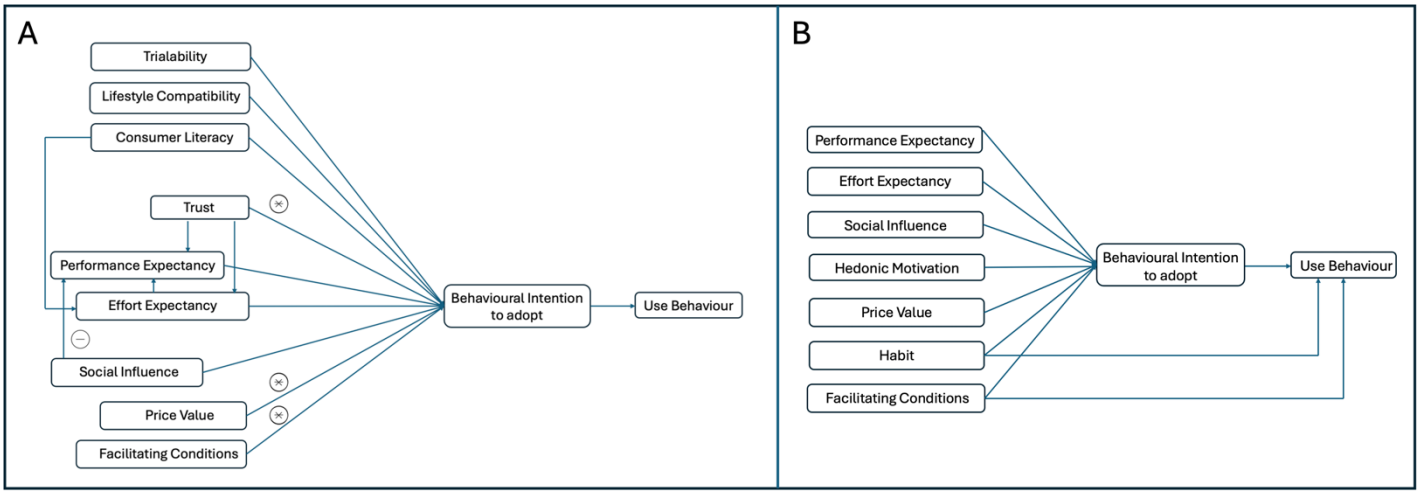

Figure 9. *Schematic representation of framework 2.0 and framework 1.0.* **A:** Framework 2.0. The synthesized framework presents empirical evidence on the factors affecting the adoption of frugal innovations. Behavioural Intention to adopt is a facilitator of Use Behaviour. Trialability, Lifestyle Compatibility, Consumer Literacy, Performance Expectancy, Effort Expectancy, and Social Influence are facilitators of Behavioural Intention to adopt. Trust, Price Value, and Facilitating conditions are both a facilitator and a barrier to the Behavioural Intention to adopt. Effort Expectancy is an antecedent of Performance Expectancy, Consumer Literacy is an antecedent of Effort Expectancy, and Trust is an antecedent of Performance Expectancy and Effort Expectancy, whilst Social Influence is a hampering antecedent of Performance Expectancy. Negative correlations are represented by the minus sign, and the cross sign represents a positive and negative correlation simultaneously. **B:** Framework 1.0, i.e. the Unified Theory of Acceptance and Use of Technology 2. Behavioural Intention to adopt affects the Use Behaviour, whereas Performance Expectancy, Effort Expectancy, Social Influence, Hedonic Motivation, Price Value, Habit, and Facilitating Conditions affect Behavioural Intention to adopt and Habit and Facilitating Conditions also directly affect Use Behaviour. Adapted from Venkatesh et al. (2012).

Table 10. *Newly identified constructs retrieved from the empirical evidence on the factors affecting the adoption of frugal innovations not yet present in the Unified Theory of Acceptance and Use of Technology 2, i.e. framework 1.0.* The newly introduced constructs (Construct), study in which the newly introduced constructs were identified (Study), and the definition of the constructs for frugal health innovations (Frugal health innovation definition) are presented.

Construct	Study	Frugal health innovation definition
Trialability	Hasan et al. (2020)	"The degree to which an innovation may be experimented with on a limited basis" (Rogers, 1983, pp. 163 – 238)
Lifestyle Compatibility	Hussain et al. (2019), Joshi (2024), Sodhay et al. (2024)	The compatibility between the values offered by the innovation and the lifestyle values, experiences, and preferences of the consumers (Hussain et al., 2019; Lin, 2011)
Consumer Literacy	Ashoer et al. (2024), Joshi (2024), Purohit, & Arora (2023)	The required knowledge, skills, and understanding of the innovation to utilize the innovation safely and effectively (Ashoer et al., 2024; Joshi, 2024; Purohit, & Arora, 2023)
Trust	Joshi (2024), Pipitwanichakarn, & Wongtada (2019), Sodhay et al. (2024)	The consumers' confidence in the suppliers' reliability and integrity and lack of risk to lose information, funds, innovation performance, and social status (Lee, 2009; Lee, & Song, 2013; Morgan, & Hunt, 1994; Pipitwanichakarn, & Wongtada, 2019; Purohit, & Arora, 2023)

As seen, there are a number of empirically verified factors affecting the adoption of FIs, some of which are represented by the UTAUT 2, i.e. framework 1.0. More importantly, the relevance of the factors to FHIs was analysed (Appendix F), from which it can be suggested that the conceptual framework 2.0 gives information on the adoption of FHIs. Importantly, it is likely that product-specific factors from framework 1.0 facilitating the Behavioural Intention to adopt FHIs include Performance Expectancy and Effort Expectancy, whereas the product-specific factor Price Value from framework 1.0 acts simultaneously as a facilitator and barrier to Behavioural Intention to adopt FHIs. Further, external factors from framework 1.0 act either as a facilitator to the Behavioural Intention to adopt FHIs, as is the case for Social Influence, or simultaneously as a facilitator and a barrier to the Behavioural Intention to adopt FHIs, as is the case for Facilitating Conditions. In contrast to framework 1.0, however, results suggest that personal factors, i.e. Habit and Hedonic Motivation, do not affect the adoption of FHIs. Further, to understand the adoption of FHIs, additional facilitators are likely required, including Trialability, Lifestyle Compatibility, and Consumer Literacy, whereas the simultaneous facilitator and barrier Trust should also be considered for the adoption of FHIs.

Although framework 2.0 provides a synthesized overview of factors that likely affect the adoption of FHIs, the main limitation is that the conceptual framework 2.0 has not yet been verified for the adoption of FHIs. To that extent, it is possible that different factors affect the adoption of FHIs, or even different relationships should be considered for the adoption of FHIs. Therefore, to validate the framework in the context of FHIs, interviews were conducted with developers of FHIs.

6 Results – Factors affecting the adoption of frugal health innovations

To verify whether the identified factors affecting the adoption of FIs (Figure 9A) affect the adoption of FHIs, semi-structured interviews were conducted with FHI developers. To determine whether the innovation was an FHI, a select number of health innovations were tested according to the FI criteria proposed by Weyrauch, and Herstatt (2016).

6.1 Applying the frugal innovation criteria resulted in the removal of irrelevant innovations

Nineteen health innovations were selected based on accessibility and price reduction. Subsequently, the innovations were compared to their traditional counterparts, resulting in the removal of seven innovations. Most notably, these innovations did not show optimized performance levels, and in some instances, there was no traditional innovation that the health innovations could be compared to. From the twelve identified FHIs, four developers agreed to participate in the interviews. The innovations considered include a mosquito-killing algae, a point-of-care tuberculosis diagnostic kit, a portable Polymerase Chain Reaction workstation, and a low-cost Magnetic Resonance Imaging scanner.

Compared to traditional mosquito sprays innovation (Fradin, 1998), the mosquito-killing algae attract and kill mosquitos through bioluminescence. Although the innovation was still in the design phase, the innovation did not rely on electricity, thereby decreasing the total costs of ownership, and, as such, showing substantial cost reduction. Further, the mosquito-killing algae were easy to use according to the developer, and focussed on killing mosquitos, thereby showing concentration on core functionalities. It should be noted, however, that the traditional mosquito sprays are also easy to use, as they are simply plugged into sockets, and focus on killing mosquitos, thereby making it slight diffuse as to whether the second criterium of FIs applies. Additionally, by utilizing non-toxic biological components instead of chemicals as done in the traditional mosquito sprays, the mosquito-killing algae were of high value and high quality as they omitted possible allergic reactions and reduced resistance of the mosquitos according to the developer. As such, the mosquito-killing algae showed optimized performance level, and the innovation is thus an FHI (Table 11).

Compared to traditional Polymerase Chain Reaction-based tests to diagnose patients with tuberculosis (Sachdeva, & Shrivastava, 2018; Sciaudone et al., 2023), the point-of-care tuberculosis diagnostic kit uses molecular biology as a tool to achieve a colorimetric readout and detect the presence of tuberculosis genetic material. A proof-of-concept of the diagnostic tool was achieved, but the product development was abandonment. Compared to the traditional diagnosis methods, the point-of-care kit does not rely on infrastructure, such as electricity or readout devices, and, as such, is cheaper according to the developer, thereby showing substantial cost reduction. Further, a simple binary readout was provided, indicating whether tuberculosis was present or not. This contrasts traditional innovations, where antimicrobial susceptibility data is also provided, i.e. the provision of information regarding the susceptibility of tuberculosis to antibiotics (Sciaudone et al., 2023). As such, the point-of-care tuberculosis kit showed a focus on core essentials. Further, the innovation used less material compared to the traditional innovations, because the innovation did not need readout devices and electricity, and showed ease-of-use in the form of a simple colorimetric readout and no requirement of specialized labour, thereby showing optimized performance level. As such, the point-of-care tuberculosis diagnostic kit was deemed an FHI (Table 11).

Compared to traditional Polymerase Chain Reaction workstations (Sigma Aldirch, n.d.), the portable Polymerase Chain Reaction workstation is a low-cost and portable variant. A final product was developed, introduced

in the market, and adopted by customers. The costs of the portable Polymerase Chain Reaction workstation were estimated to be about three times lower than traditional Polymerase Chain Reaction workstations, thereby showing substantial cost reduction. Further, the portable Polymerase Chain Reaction workstation provides the tools necessary to conduct the Polymerase Chain Reaction and decreases materials in order to make the innovation portable, thereby showing concentration on core functionalities. Although the portable Polymerase Chain Reaction workstation is not necessarily easier to use than traditional Polymerase Chain Reaction workstations, as knowledge on Polymerase Chain Reaction is still required to conduct the work, material input is minimized, and the technical quality of the innovation in terms of temperature accuracy, -uniformity, and -maximum required to conduct the Polymerase Chain Reaction is sufficient to do so accurately and efficiently, thereby showing optimized performance. It should be noted, however, that compared to traditional Polymerase Chain Reaction workstations, the portable Polymerase Chain Reaction workstation showed similar technical properties. Further, according to the developer, the portable Polymerase Chain Reaction workstation is primarily used to conduct in-field sequencing, and not necessarily as a healthcare tool. However, considering that Polymerase Chain Reaction can be used to detect infectious bacteria (Tkadlec et al., 2019), the portable Polymerase Chain Reaction workstation was considered an FHI (Table 11).

Compared to traditional Magnetic Resonance Imaging scanners (Wald et al., 2020), the low-cost Magnetic Resonance Imaging scanner uses simpler magnets and developments are conducted to further reduce the complexity of the equipment. The low-cost Magnetic Resonance Imaging scanner was in development with a first version produced. By reducing the superconducting magnets to smaller magnets and reducing the size of the low-cost Magnetic Resonance Imaging scanner, the developer argued that the costs of the low-cost Magnetic Resonance Imaging scanner is being reduced, thereby showing substantial cost reduction. Further, the low-cost Magnetic Resonance Imaging scanner focusses on the ability to conduct Magnetic Resonance Imaging scans and does not provide any additional functionalities, thereby showing concentration on core functionalities. Additionally, algorithms are being developed to reduce the signal-to-noise ratio due to the lower quality magnets, and infrastructure is being implemented for portable readouts of the scan making the low-cost Magnetic Resonance Imaging scanner easier to use, thereby showing optimized performance level. As such, the low-cost Magnetic Resonance Imaging scanner was deemed an FHI (Table 11).

Table 11. *Frugal health innovations considered during the interviews.* The innovation (Innovation), stage of the innovation (Stage), and frugal innovation criteria by Weyrauch, and Herstatt (2016) including relevant attributes of the innovations (Criteria) are presented.

Innovation	Stage	Criteria
Mosquito-killing algae	Design phase, continuing	*Substantial cost reduction*: Removal of electricity necessity *Concentration on core functionalities*: Easy to use, focussed on killing mosquitos *Optimized performance level*: Prevents allergic reactions and mosquito resistance against chemicals
Point-of-care tuberculosis diagnostic kit	Proof-of-concept, abandoned	*Substantial cost reduction*: Does not rely on infrastructure, such as electricity or readout devices *Concentration on core functionalities*: A binary readout for tuberculosis presence was provided *Optimized performance level*: Decreased material usage and easy to use
Portable Polymerase Chain Reaction workstation	Market introduction, adopted	*Substantial cost reduction*: Approximated to be three times lower than traditional Polymerase Chain Reaction workstations *Concentration on core functionalities*: Tools necessary to conduct Polymerase Chain Reaction are provided and material usage is decreased *Optimized performance level*: Material input is minimized, and the technical quality of the innovation is sufficient to conduct Polymerase Chain Reaction accurately and efficiently
Low-cost Magnetic Resonance Imaging scanner	Proof-of-concept, continuing	*Substantial cost reduction*: Uses smaller magnets to reduce costs *Concentration on core functionalities*: Magnetic Resonance Imaging scans can be conducted *Optimized performance level*: Algorithms are developed to reduce the signal-to-noise ratio and infrastructure is being implemented for portable readouts

6.2 Product specific factors, external factors, trust, Lifestyle Compatibility, and Problem Severity affect the adoption of frugal health innovations

Drawing from framework 2.0, it was observed that several factors affecting the adoption of FHIs made a return in the interviews, being product-specific factors including Performance Expectancy, Effort Expectancy, and Price Value, external factors, i.e. Facilitating Conditions, trust in the supplier of FHIs, i.e. Trust, and the compatibility between the products' values and the consumers' preferences, i.e. Lifestyle Compatibility. Further, one additional concept was observed, being the severity of the problem, referred to as the factor Problem Severity. Interestingly, the notion of frugality comes with inherent complex problems. An overview of all relevant concepts and factors guided by interview quotes is presented in Appendix G.

6.2.1 Product-specific factors: Frugal health innovations must tackle health-related issues as intended, but can be inferior or superior compared to traditional innovations depending on the market, must be easy to use and install, and must be appropriately priced

When introducing FHIs into the market, the innovation should tackle the health-related issues as intended, as outlined by two interviewees. To that extent, Performance Expectancy, referring to the degree to which the innovation provides healthcare benefits (Table 8), seems to fit the concept. However, Performance Expectancy only deals with providing healthcare benefits, whilst the interviews introduced a nuance regarding performance inferiority and superiority of FHIs compared to traditional innovations, depending on the quality of the traditional innovations. One interviewee noted that FHIs should be superior compared to traditional innovations if the traditional innovations show poor performance or side effects, by stating:

"The current products in the market are either inefficient or toxic. […] The major problem for [people installing the traditional product] is feeling nausea and being allergic to the product. So that is an aspect we are considering while building the product."

In contrast, two interviewees noted that FHIs can be inferior compared to traditional innovations, providing that the FHI is used to obtain a first insight into the problem at hand and the traditional health innovation is subsequently used to confirm the results. One interviewee stated that:

"[The frugal innovation shows a] poorer performance compared to [the traditional innovation]. […] If you are in a remote area, and you have no access to a scanner and you have a stroke, there is something that is important, and that is time. […] It is more sensible to have a screening machine that tells you very quickly in a remote place that [a person] has a headache or a stroke as a first resource. [It does not matter] if the stroke is well defined, [it just has to be known] that [the person] has a stroke. And with that information [the person can go] to a proper place. […] So, it's more sensible, more cost-effective to have a kind of bridge process. […] You don't need a perfect quality image. You just need to discriminate a [stroke from a headache]."

Importantly, the performance of inferior FHIs still must be sufficient to address the problems, as outlined by the same two interviewees. Returning to the definition for Performance Expectancy, it has to be adjusted slightly, by including that FHIs have to perform sufficiently to address the healthcare problem, thereby encapsulating both the

underperformance and overperformance of FHIs compared to traditional innovations depending on the situation (Table 12).

For the use of FHIs, the effort required to use the innovations is of importance, as outlined by three interviewees. As Effort Expectancy refers to the degree of ease that is associated with the use of the innovation (Table 8), this observed concept seems to align with Effort Expectancy. However, besides being easy to use, the installation process of the innovations also must be easy, as outlined by two interviewees. Returning to the definition of Effort Expectancy, it therefore must be adjusted slightly by including that FHIs also have to be easy to install (Table 12).

Like the technological performance, there is also a nuance when it comes to pricing of the FHIs. Indeed, three interviewees highlighted that their FHIs are sold deliberately cheaper compared to the traditional counterparts, with one interviewee also noting that the facilitating infrastructure, installation, and maintenance must be cheaper. However, there seems to be a cognitive trade-off between the performance and perceived benefits of the innovation as outlined by one interviewee, who noted that:

"People are ready to pay a premium price if it solves a problem. So, when I ask [the customers] what sort of price range they would be happy to [pay for this innovation], they say "anything works, if [the innovation] works." […] I mean, price was a point, but it was not at the cost of [the innovations'] efficiency. […] It depends on how big the pain point that you are trying to solve is. If the pain of the problem is much higher than any other sort of factor, then definitely [the price] doesn't matter. But if there are okay-ish products […], the prices are a very big [concern]."

Thus, depending on the solution that the FHI can provide, the pricing should be adjusted accordingly, where a higher price can be maintained if the issue at hand is of large concern to the customer, and a lower price must be maintained if alternative, but properly functioning, innovations exist on the market. The construct Price Value considers such a cognitive trade-off between the perceived healthcare benefits of the application and the monetary costs of using the innovation (Table 8). As such, it is likely that this concept translates into Price Value. Yet, the definition of Price Value must be adjusted slightly to represent the costs of facilitating infrastructure, installation, and maintenance (Table 12).

Table 12. *Definitions of the product-specific factors Performance Expectancy, Effort Expectancy, and Price Value affecting the adoption of frugal health innovations.* The construct (Construct), old definition as determined via the literature review (Old definition), and adjusted definition to encompass the results from the interviews (New definition) are presented.

Construct	Old definition	New definition
Performance Expectancy	The degree to which the innovation provides healthcare benefits	The degree to which the innovation provides sufficient healthcare benefits
Effort Expectancy	"The degree of ease associated with the use of the system" (Venkatesh et al., 2003)	The degree of ease associated with the use and installation of the innovation
Price Value	"The cognitive trade-off between the perceived benefits of the applications and the monetary cost for using them" (Venkatesh et al., 2012)	The cognitive trade-off between the perceived healthcare benefits of the applications and the monetary costs of installing, using, and maintaining the innovation, and the required facilitating conditions

6.2.2 External factors: Facilitating conditions are required, but the lack thereof also provides market opportunities

When FHIs are implemented, conditions to facilitate the use of FHIs should be in place, e.g. operational infrastructure and a good supply chain for the maintenance, as outline by one interviewee. However, more than anything, the lack of, e.g., electricity or auxiliary machinery and infrastructure, provides an opportunity to market FHIs, providing that the FHIs solve the lack of such facilitating conditions. This opportunity was highlighted by three interviewees, with one interviewee purposively designing their innovation around the lack of facilitating conditions:

"The problem is that [there is a lack of] appropriate machinery and infrastructure [to test for tuberculosis]. […] So, we thought to do something about it and use a portable sample, like urine." […] There are no specific needs in order to store urine […], [and for the moveable infrastructure it would be difficult] to consistently have electricity. So, our test doesn't use electricity. […] We had lyophilized reaction molecules [which didn't require a fridge to be stored]."

Going back to the construct Facilitating Conditions, which considers that resource constraints and infrastructural constraints do not impede the use of the innovation (Table 8), the notion that some facilitating conditions are required for the FHI to properly be adopted, whilst the lack of other facilitating conditions can provide market opportunities, seems to fit with the definition of Facilitating Conditions. As such, the definition of Facilitating Conditions does not have to be adjusted.

6.2.3 Consumers must trust the frugal health innovation and developer, and the frugal health innovations must fit the aesthetic expectations of the consumer

When buying FHIs, it is important that consumers feel that the innovation is safe to buy, as noted by one interviewee. As Trust refers to the consumers' confidence in the suppliers' reliability and integrity (Table 10), the feeling of safety required by the consumer to buy the innovation likely aligns with the factor Trust. Accordingly, the definition of Trust does not have to be adjusted.

Another interviewee noted that they focussed specifically on aesthetics to ensure that their product aligned with the expectations of the customers. However, for scientific parties, this aesthetic focus resulted in a sense of doubt about the innovation, as the interviewee noted:

"And some of [the focus on aesthetics] may have worked against us. Because I know we have scientific customers, or used to anyway before we were known, who thought "Well, is this actually a real thing, or is this kind of more like a toy? Is this actually meant to me?"

The aesthetics-fit can be interpreted as a certain preference of the consumer. As Lifestyle Compatibility touches upon the compatibility between the preferences of consumer and the values offered by the product (Table 10), it is therefore likely that the observed concept aligns with the factor Lifestyle Compatibility. Accordingly, the definition of Lifestyle Compatibility does not have to be adjusted.

6.2.4 The severity of the problem also affects the adoption

Besides the factors observed in framework 2.0, i.e. Performance Expectancy, Effort Expectancy, Price Value, Facilitating Conditions, Trust, and Lifestyle Compatibility, one newly identified factor was observed. It turned out that for one interviewee, the number of cases reported per year was too low for a governmental institution to consider adopting the FHI according to their mentors, by stating:

"We have like 50 cases per year, and we have a [traditional innovation], so as a develop country we don't need [the frugal innovation]. So that's why we were redirected to a [different market]."

Thus, according to this observation, when trying to get a FHI adopted by a governmental organization, it is important to consider the severity of the problem that the FHI is tackling. As none of the factors from the conceptual framework 2.0 translated to this issue, a new construct was defined referred to as Problem Severity, which states that the magnitude of the healthcare problem should be sufficiently large (Table 13).

Table 13. *Definitions of a newly identified factor affecting the adoption of frugal health innovations.* The construct (Construct) and definition (Definition) are presented.

Construct	Definition
Problem Severity	The magnitude of the healthcare problem should be sufficiently large

6.2.5 The notion of frugal comes with inherent complex issues

Besides the identified factors affecting the adoption of FHIs, FI comes with inherent problems. One interviewee noted that the creation of something valuable using limited resources results in less perceived performance. Subsequently, this results in decreased credibility and lack of development funding, thus preventing further development:

”Definitely lack of funding. Because when we talk about lack of funding, along with that comes lack of credibility. And this again, in turn, is driven by the absence of people having trust in you because they think this [innovation] is frugal. So, when you build something frugal, […] you are using limited resources and creating something valuable. And when this comes into play, people have a problem with the word “limited”, right? And when they actually think about limited, they think that [the frugal innovation] might be less effective. And when they think [the frugal innovation] might be less effective, the [credibility of the innovation is decreased]. So, nobody is ready to fund you.”

Similarly, another interviewee noted that reduced pricing results in less perceived performance as customers use the price as a quality proxy. Consequently, FHIs should be presented as innovations tackling an issue in an ingenuous way:

”The problem with frugality is that it is about low cost, and people use money as quality proxy. […] So, the problem with frugal is that our psychology thinks “Well, that must be crap.”. So, you really need to work on creating other marketing associations that say “Yeah, we've worked super hard, it's so sophisticated, and that's why we can make it so affordable.”, and that's really hard.”

Going back to the constructs earlier identified, both observations play into Performance Expectancy. However, as noted by both interviewees, this complex interplay is inherent to the frugal characteristic of the innovations, and, as such, these effects do not seem to be decomposable into separate, isolated constructs.

6.2.6 Overlaying empirical findings with the conceptual framework: Performance Expectancy, Effort Expectancy, Price Value, Facilitating Conditions, Trust, Lifestyle Compatibility, and Problem Severity

The factors affecting the adoption of FHIs are somewhat in line with the results from the literature review (Figure 10). Notably, Performance Expectancy, Effort Expectancy, Price Value, Facilitating Conditions, Trust, and Lifestyle Compatibility affect the adoption of FHIs. Further, one newly identified factor was observed, being Problem Severity, which is of importance when selling the FHI to governmental institutions. Interestingly, social factors, i.e. Social Influence, the ability to experiment with the innovation, i.e. Trialability, and the degree of knowledge required to use the innovation, i.e. Consumer Literacy, were not identified through the interviews. Additionally, the interviews clearly show a straightforward interaction between isolated factors and the adoption of FHIs, whilst the literature shows that more complex interplay between several antecedents exist. It is important to note, however, that the interviews discussed the notion of adoption, and not Behavioural Intention to adopt, as FHI developers were interviewed and not the FHI-consumers themselves.

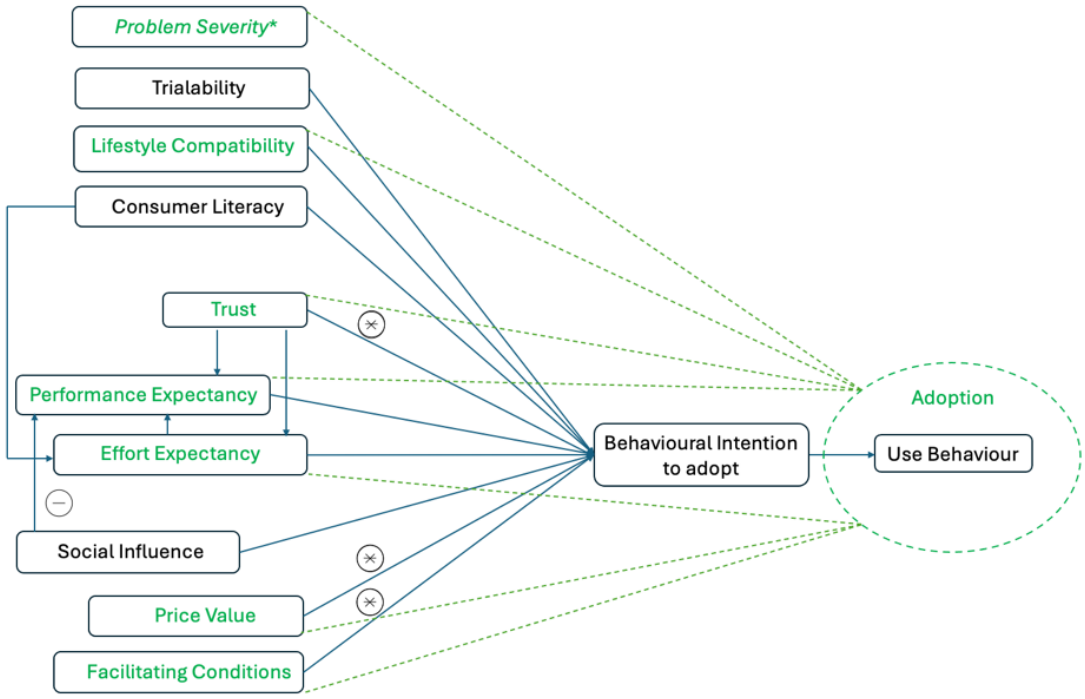

Figure 10. *Empirical findings on factors affecting the adoption of frugal health innovations aligned with the synthesized conceptual framework from the literature.* The synthesized framework from the literature is shown, with relationships between variables depicted by blue arrows. Negative correlations are represented by the minus sign, and the cross sign represents a positive and negative correlation simultaneously. Green-highlighted factors were observed in the interviews to affect the adoption of frugal health innovations, as depicted by the dotted green lines. The italicized Problem Severity was not previously observed in the literature. *: Problem Severity is only relevant in case frugal health innovations are sold to governmental institutions.

7 Discussion

The goal of this research study was to determine the factors affecting the adoption of FHIs. To achieve this, a literature review was conducted to retrieve a theoretical perspective that is the most appropriate to study the adoption of FHIs, which was subsequently enhanced with empirical evidence from the literature to synthesize a conceptual framework to guide the study of FHI adoption. Ultimately, the conceptual framework was validated through semi-structured interviews, providing an insight in the factors affecting the adoption of FHIs.

7.1 The synthesized framework aggregates evidence from the literature

7.1.1 Product-specific factors affect the adoption of frugal innovations

FIs are adopted if the performance is sufficient, i.e. if Performance Expectancy is sufficed. Indeed, FIs must be useful in the sense that they tackle the issue at hand adequately (Albert, 2019). This requirement also translates back to the definition of FIs by Weyrauch, and Herstatt (2016), who found that FIs must be functional and should only reduce non-essential features. Further, Effort Expectancy affects the adoption of FIs, where innovations are more readily adopted if they are easy to use. Indeed, the ease-of-use is particularly important for FIs considering the lack of literacy in developing countries (Leonard et al., 2020). Again, this translates to the definition of FIs by Weyrauch, and Herstatt (2016), who found that FIs are user friendly and easy to use. This also explains the fact that Consumer Literacy affects Effort Expectancy, where the higher the literacy levels, the more the innovation is perceived as easy to use. Interestingly, Effort Expectancy was not observed to affect the adoption of FIs by Joshi (2024), which is likely due to the fact that Joshi (2024) surveyed participants already using the innovation, whilst Costa et al. (2021), and Purohit, and Arora (2023), who observed that Effort Expectancy does affect the adoption, considered participants irrespective of their experience. To that extent, it is likely that prior experience with the FI removes the need for ease-of-use.

Besides Performance Expectancy and Effort Expectancy, Price Value also affects the adoption of FIs. Indeed, considering the resource constraint-settings, FIs are often sold at a lower price, translating again to the FI definition of Weyrauch, and Herstatt (2016) who found that FIs show substantial cost reduction compared to traditional innovations. Interestingly, there was a discrepancy where Price Value was observed to be a facilitator in Joshi (2024) but a barrier in Ashoer et al. (2024). This discrepancy is explainable when considering the difference in measurement items between both studies, where Joshi (2024) measured Price Value in terms of affordability, whilst Ashoer et al. (2024) measured Price Value in terms of expensiveness. Thus, clearly showing that Price Value can act both as a facilitator and a barrier, depending on its' positive or negative connotation, respectively.

7.1.2 External factors and social factors affect the adoption of frugal innovations

Besides product-specific factors, Facilitating Conditions and Social Influence also affect the adoption of FIs. Indeed, FIs are specifically developed under infrastructural constraints (Sarkar, & Mateus, 2022), and, as such, it is important that facilitating conditions do not impede the use of the innovation. Interestingly, a discrepancy was observed where Facilitating Conditions was a facilitator in Costa et al. (2021) and Joshi (2024), and a barrier in Purohit, and Arora (2023). Again, this discrepancy is due to the difference in questionnaire items, where Costa et al. (2021) and Joshi (2024) measured Facilitating Conditions in terms of their presence, whereas Purohit, and Arora (2023) measured Facilitating Conditions in terms of the lack thereof. This difference clearly shows that Facilitating Conditions can act both as a facilitator and a barrier, depending on their presence or absence, respectively.

Further, Social Influence also affects the adoption of FIs, where Social Influence acts as a facilitator, except for Costa et al. (2021) who observed Social Influence to not affect the adoption of FIs. This discrepancy likely relates back to the economic setting that Costa et al. (2021) studied, which was a developed country. Hussain et al. (2019) and Purohit, and Arora (2023), who observed that Social Influence does affect the adoption of FIs, studied the adoption in

a developing country. In developing countries, a collectivistic culture is often more present, where social influence plays a more important role than in a developed country, which are more individualistic in nature (Faqih, 2020; Hasan et al., 2020; Santos, Varnum, & Grossmann, 2017). Further, Social Influence negatively affects Performance Expectancy as observed by Purohit, and Arora (2023). In essence, Purohit, and Arora (2023) interpreted this result in terms of the social opinion about the usefulness of the FI being negative, yet, this relationship indicates that the more socially relevant people encourage the adoption of the FI, the less the perceived usefulness of the FI becomes. However, other studies have shown that Social Influence affects the usefulness of the innovation positively (Haverila, McLaughlin, & Haverila, 2023). Interestingly, this contradiction begs the question what the actual relationship between Social Influence and Performance Expectancy is. Another interpretation may be that the stronger the Social Influence, the less important the Performance Expectancy becomes for the adoption of FIs, as a trusted social group suggests using the innovation. Such a phenomenon could be well studied by considering Performance Expectancy as a mediating variable, instead of the independent variable, but unfortunately this was not done by Purohit, and Arora (2023).

7.1.3 Personal factors do not affect the adoption of frugal innovations

For personal factors, it was observed that Hedonic Motivation does not affect the adoption of FIs. Although enjoyment is a relevant concept that influences the adoption of traditional innovations (Venkatesh et al., 2012), it is possible that the development environment of FIs, where they are developed to tackle needs (Basu, Banerjee, & Sweeny, 2013; Simula, Hossain, & Halme, 2015), rather than to provide enjoyment, results in a sense of urgency to obtain the innovation, thereby diminishing the need for enjoyment of the innovation. Further, Habit affects the adoption of FIs according to Hussain et al. (2019), whilst it does not affect the adoption according to Joshi (2024). Consequently, Habit was removed because it is likely a situational factor. However, it should be noted that Joshi (2024) considered participants in their study that were already experienced users of the studied innovation, whilst this was not the case for Hussain et al. (2019). As such, it could be argued that previous experience with the innovation may make consumers more conscious about their actions, thereby diminishing the reliance on habits.

7.1.4 Trialability, Lifestyle Compatibility, Consumer Literacy, and Trust also affect the adoption of frugal innovations

Trialability, Lifestyle Compatibility, Consumer Literacy, and Trust also affect the adoption of FIs. The importance of Trialability could be explained by considering that there is a barrier to the adoption if the performance of the innovation is not seen in practice. This is especially likely considering that funding is stringent in developing countries, resulting in some kind of preventative pressure to acquire wrongful innovations. Another explanation may be that experiencing with FIs overcomes barriers associated with the ease-of-use and complexity of the FIs (Hasan et al., 2020). Further, Lifestyle Compatibility likely affects the adoption because for consumers in developing countries such alignment can provide a sense of inclusion (Arshad, 2021; Mills, 2014; Sarkar, & Mateus, 2022; Zanello et al., 2016).

Consumer Literacy is interesting, as this relates directly to Effort Expectancy. Indeed, Consumer Literacy is an antecedent of Effort Expectancy, where the innovation is perceived as easier to use if the consumer has the required literacy to use the innovation (Ashoer et al., 2024; Purohit, & Arora, 2023). Yet, Consumer Literacy was also observed to directly influence the Behavioural Intention to adopt by Joshi (2024). As seen before, the lack of required literacy remains a problem in developing countries (Leonard et al., 2020). Important to note is that possible moderation of the relationship between Consumer Literacy and Behavioural Intention to adopt by Effort Expectancy in Joshi (2024) was not measured explicitly, and, as such, it is possible that Joshi (2024) measured such a moderating relationship instead of a direct relationship.

Trust was observed to affect the Behavioural intention to adopt in all studies, except for Sodhay et al. (2024). Besides, Trust also was observed to affect Performance Expectancy and Effort Expectancy. Indeed, the degree of consumer confidentiality towards a suppliers' reliability and integrity plays an important role in marginalized communities (Schmidt-Sane et al., 2023). Interestingly, Pipitwanichakarn, and Wongtada (2019) observed Trust to be a facilitator, whereas Joshi (2024) and Purohit, and Arora (2023) observed Trust to be a barrier. Again, this

discrepancy is likely due to the differences in questionnaire items, where Pipitwanichakarn, and Wongtada (2019) measured Trust in terms of the presence of trust and absence of risks, whereas Joshi (2024) and Purohit, and Arora (2023) measured Trust in terms of the presence of certain risks. This difference clearly shows that Trust can act both as a facilitator and a barrier, depending on the presence or absence of trust and perceived risk.

7.2 The synthesized framework can be used to study the adoption of frugal health innovations

7.2.1 Empirical validation of the synthesized framework confirmed its' usefulness in the context of frugal health innovations

The conceptual framework was synthesized using empirical evidence, with the argument that empirical evidence on FI adoption would translate to the context of FHI adoption. This was done because of ample empirical evidence in the literature on FI adoption, and the lack thereof for FHI adoption. Having made this assumption in this research study, it was therefore necessary to empirically validate the conceptual framework through interviews with FHI developers. Of the nine factors affecting the adoption of FIs, six were validated through the interviews, being Performance Expectancy, Effort Expectancy, Price Value, Facilitating Conditions, Trust, and Lifestyle Compatibility. Interestingly, Problem Severity, a factor not previously observed in the literature, was also found to affect the adoption of FHIs. As FHIs are FIs developed to tackle healthcare issues, the relevance of the observed factors follows the same explanation as stated above for the adoption of FIs. However, in terms of observations from the interviews, there were some nuances between the conceptual framework and the interview data.

Although Performance Expectancy affects the adoption of FHIs, the performance of the innovation does not necessarily always have to be better than the traditional innovation. The most important observation here, is that the performance of FHIs is context-dependent, and should be tailored to the gap that the innovation addresses in healthcare. Simply providing a better solution does not guarantee automatic adoption of the FHI. Interestingly, this translates again to the definition of FI by Weyrauch, and Herstatt (2016), who state that the performance does not necessarily have to be better than that of the traditional innovation, but rather optimized to the context at hand.

For Price Value, a similar nuance was observed, where the FHIs do not necessarily have to be cheaper than already existing innovations, even though this is often the entry point for development. Interestingly, this contrasts with the proposal of Weyrauch, and Herstatt (2016), who assume a cost reduction of at least one third for FIs. Similarly, Rao (2013) found that FIs are 58 % to 97 % cheaper than traditional innovations. Perhaps, consumers are willing to spend more if the FHI shows a better performance than the traditional innovation, considering that healthcare-related innovations are essential innovations.

Another nuance was observed for the factor Facilitating Conditions. In the literature studies, Facilitating Conditions were defined according to the definition of Venkatesh et al. (2003) and Venkatesh et al. (2012), who state that supporting infrastructure should be present. The results of the interview clearly show that this should not always be the case and make an argument for the capitulation of resource- and infrastructural limitations by FHIs, as such limitations actually can serve as a market opportunity.

Problem Severity was a newly identified factor, not yet observed in the literature. Apparently, the problem must be severe enough to ensure adoption of FHIs by governmental institutions. This is likely because governmental organizations must carefully consider their available resources. This is further acknowledged by the fact that governmental institutions prioritize health-issues according to their policy (Greenhalgh et al., 2017; Leonard et al., 2020; Mills, 2014). As such, Problem Severity is important to consider when the FHI is to be adopted by governmental institutions.

7.2.2 *The discrepancy between interview results and the literature is likely due to the developers' perspective*

Compared to the synthesized conceptual framework, interview results showed no proof of the importance of Trialability, Consumer Literacy, Social Influence. It is important to note that developers of FHIs were interviewed, thereby lacking the perspective of FHI consumers. This becomes evident when considering that mostly product-specific and external factors, i.e. Performance Expectancy, Effort Expectancy, Price Value, and Facilitating Conditions, were observed from the interviews. Therefore, it is likely that developers responded from a developing point-of-view, i.e. taking the product specific factors and facilitating conditions into account. It should be noted that the absence of proof from the interviews does not mean proof of absence. Especially considering that open questions were asked, and not questions related directly to the factors from the synthesized framework. Therefore, it is important to still consider the possibility that the non-identified factors from framework 2.0 affect the adoption of FHIs.

Another discrepancy between the conceptual framework and the results from the interview that should be addressed, is the notion of Behavioural Intention to adopt. The goal of this research study was to study the factors affecting the adoption, thereby taking adoption as a central notion. Yet, the conceptual framework takes the Behavioural Intention to adopt as a central notion, which essentially says something about the willingness to adopt an innovation rather than the actual adoption (Venkatesh et al., 2012). Importantly, this is due to an inherit limitation of the literature studies, as they did not study the use of the innovations longitudinal. Further, as the Behavioural Intention to adopt says something about the willingness to adopt the innovation, it automatically becomes a consumer-centric concept. As interviews were conducted with FHI developers in this research study, such a consumer-centric approach was not possible. However, Ashoer et al. (2024) showed that the Behavioural Intention to adopt FIs results in the actual adoption. Therefore, it can be assumed that factors affecting the Behavioural Intention to adopt observed from the literature also affect the actual adoption. This assumption is essential as it helps to draw similarities between the interview data and the conceptual framework. Yet, this relationship between the Behavioural Intention to adopt and actual adoption must be further explored in the context of FHIs, as there is no empirical evidence that this relationship exists in the healthcare sector.

7.2.3 *Addressing the identified factors does not automatically guarantee adoption*

Although the interview data provides a first insight into the relevance of Performance Expectancy, Effort Expectancy, Price Value, Facilitating Conditions, Trust, Lifestyle Compatibility, and Problem Severity for FHI adoption, it cannot be stated that the addressing a single factor results in adoption. For instance, increasing the products' fit with the lifestyle of consumers, thereby addressing Lifestyle Compatibility, may still require the innovation to be sufficiently easy to use, and as such Effort Expectancy also must be addressed. Further, as stated earlier, the absence of proof from the interviews is not proof of absence. For instance, there was no indication on the effects that policy alignment can have on the adoption of FHIs, yet there is still an argument that this can contribute to the adoption of FHIs. Notably, during this research study, the adoption of FHIs in complex health organizational structures was not considered. As FHIs still must be adopted by, e.g., hospitals, it is likely that policy alignment affects the adoption of FHIs, especially considering that healthcare innovations can benefit from such policy alignment (Greenhalgh et al., 2017; Leonard et al., 2020; Mills, 2014; Sarkar, & Matetus, 2022; Zanello et al., 2016). For example, although policy makers have yet to introduce stimuli for FHI development and adoption, two FHIs that have been developed at the policymaking level have shown to be successful (Bhatti et al., 2017). Therefore, it is still paramount to better understand the effects of such missing concepts on the adoption of FHIs, as introduced in the Limitation section. What can be said, however, is that the observed factors in this research study do affect the adoption of FHIs, and addressing them likely increases the probability of adoption.

To add to this problem, interview data clearly showed a complex issue with the notion of frugality. Basically, the concept of innovation development under resource limitation and reduced pricing comes with beliefs of diminished technical performance of the innovation, either resulting less funding and thus further development of the FHI as stated by one interviewee, or in a mismatch between product and consumer values as stated by another interviewee. It should be noted, however, that more funding would not necessarily ensure adoption, as the identified factors in this research study still play a role in the adoption process. What can be taken away from these observations, however, is that there

exists a complex issue with the phenomenon of FHI, where the FHI is branded as a certain concept to solve an issue, i.e. being developed under resource constraints, yet that concept results in a decreased perceived technical effectiveness, a factor that has been shown to affect adoption. As such, it is necessary to work on creating other marketable associations, where the FHIs are presented as having tackled an issue in an ingenuous way rather than simply stripping off functionalities.

7.3 Studying frugal health innovation adoption can be guided by the conceptual framework

This research study provides a conceptual framework describing the factors affecting the adoption of FHIs, verified through interviews. Notably, to the best of the authors' knowledge, this research study is the first study to synthesize empirical evidence in the literature on FI adoption and applying this to the context of FHIs. Doing so, helped to identify the factors that affect the adoption of FHIs as outlined in the conceptual framework.

As shown in the Introduction section, empirical evidence on the factors that affect the adoption of FHIs is limited. Going back to the evidence that does exists, the conceptual framework developed in this study seems to describe the existing evidence in the literature, yet the observed nuances seem to be new. For example, Nanath (2011) found that the cheap operation of LifeSpring Hospitals is key to their success, which aligns with Price Value in the conceptual framework, yet does not align with the fact that pricing must be appropriate and not necessarily cheaper. Further, the importance of technical performance of the innovation adequately addressing healthcare needs was also found to be of importance, as shown by Performance Expectancy, which is in line with the observations by Nanath (2011), the findings on the success of gas insufflation-less laparoscopic surgery equipment as found by Webb et al. (2022), and the propositions of Lundin, and Dumont (2017). Yet, this research study provides new insights in the superiority and inferiority of FHIs compared to traditional innovations. Additionally, it was observed that infrastructural constraints should not impede the use of FHIs, as outlined by Facilitating Conditions, which is in line by the observations of Webb et al. (2022) and Auma et al. (2023) and the propositions of Lundin, and Dumont (2017). However, the fact that the absence of infrastructure can provide an opportunity for FHIs seems to be a new observation. Further, the fact that FHIs should be easy to use and maintain, as outlined by Effort Expectancy, aligns with the propositions of Lundin, and Dumont (2017) and the observation of Miesler et al. (2020). Similarly, the fact that the trust of the consumer should be considered, as shown by Trust, aligns with the observations of Miesler et al. (2020). In contrast, however, findings of this research study do not address the importance of stakeholder involvement, which has been shown to be of importance by Auma et al. (2023) and Lundin, and Dumont (2017). Likewise, the relevance of the severity of the problem, as shown by Problem Severity, has not yet been addressed in the literature.

Telemedicine is a form of providing healthcare in a remote manner. As argued before, telemedicine innovations are considered FHIs, as they increase accessibility to healthcare and decrease costs due to a reduction in overhead and expensive apparatus (Mishra, & Sharma, 2022). Alazzam, Al-Sharo, and Al-Azzam (2018) and Semiz, and Semiz (2021) studied the adoption of telemedicine using the UTAUT 2, and found that Performance Expectancy, Effort Expectancy, Social Influence, Trust, Habit, and Hedonic Motivation affect its' adoption, whereas Semiz, and Semiz (2021) also observed that Facilitating Conditions affect the adoption of telemedicine. The findings by Alazzam et al. (2018) and Semiz, and Semiz (2021) align with the observations in this research study regarding product-specific factors, i.e. Performance Expectancy and Effort Expectancy, as well as the importance of Trust and Facilitating Conditions. Interestingly, Price Value was not studied by Alazzam et al. (2018) and Semiz, and Semiz (2021), and hence nothing on the presence of this factor for telemedicine can be said. As argued for Social Influence, the absence of its' importance in this research study is likely due to the perspective of the developers in this research study. The same could be argued for Hedonic Motivation and Habit, as these are concepts that are consumer-centric.

7.4 Research limitations

To ensure that F(H)Is were studied, the innovations were tested to the FI definitions of Weyrauch, and Herstatt (2016). Clearly, this approach helped to filter out innovations, as became evident from the removal of different literature studies and innovations considered for the interviews. However, there are several issues with this approach. First, the definition of FIs was obtained from German interviewees (Weyrauch, & Herstatt, 2016), thus lacking the perspective of underdeveloped countries and thus lacking generalizability toward developing countries. This is especially important considering that FIs are defined differently in developing and underdeveloped countries (Knorringa et al., 2016) and mostly rolled out in developing countries (Sarkar, & Mateus, 2022). Second, this approach requires the comparison of the F(H)I to traditional innovations. To do so, in-depth market knowledge and the perspective of customers is required to understand whether the innovation shows substantial cost reduction, focus on core essentials, and optimized performance levels. The required information is often inaccessible or contributes significantly to the workload, and hence this was not done in this research study. This is, however, important, as it helps to scrutinize whether the innovation is an F(H)I or not.

Although an effort was made to synthesize a conceptual framework describing the factors affecting the adoption of FHIs, there are several limitations to consider. First, the literature review focussed on FIs, and not on healthcare innovations. This choice was deliberate to limit the workload, and because it was argued that evidence on FIs translate to FHIs as FHIs are FIs providing solutions in the healthcare sector. In essence, however, FHIs are comprised of two sub-innovations, being FIs, and health innovations. Therefore, the lack of inclusion of factors affecting the adoption of health-related innovations resulted in a focus only on factors important for FIs. This, indeed, showed, as all articles in the literature review discussed the adoption of mobile FIs or frugal cars. This limitation is especially important to consider as factors that affect the adoption of health innovations remain likely relevant for the adoption of FHIs as argued before for, e.g., policy alignment. Second, Hedonic Motivation and Habit were removed in the conceptual framework due contrasting and lacking evidence. It is important to note, however, that the absence of proof does not mean proof of absence. Therefore, it remains possible that these relationships matter for FHIs, as observed by studies on the adoption of telemedicine (Alazzam et al., 2018; Semiz, & Semiz, 2021). Third, no discriminant validity tests for the merging of constructs were conducted. The argumentation for merging constructs was based on a qualitative analysis that considered the definition of the different constructs. Although the questionnaire items of individual constructs in the literature studies did touch upon the same concepts for merged constructs, it was not tested whether these merged constructs measure a similar concept or a different one. As such, it is well possible that this merger of constructs represents an oversimplification, albeit necessary due to the scope of this research. To add to this, empirically validated relationships may be different. For example, Perceived Usefulness in the TAM also affects adoption directly (Davis, 1989), whilst, according to the synthesis conducted in this research study, Performance Expectancy encapsulating Perceived Usefulness, does not affect adoption. Therefore, it is imperative to acknowledge the lack of discriminant validity in the analysis conducted in this research study that may have resulted in an oversimplification.

The results of the interviews provide a first insight into the factors affecting the adoption of FHIs. Yet, there are several limitations that should be considered. First, one developer of the FHIs was transitioning from the design phase to the proof-of-principle phase. Although efforts were made to retrieve practical evidence, there is a high degree of uncertainty in terms of clarity whether discussed concepts were considered in practice. Second, during the coding of the interviews it became clear the not all questions were asked according to the interview protocol. Some questions were stated slightly different, whilst other questions were asked in a suggestive manner by introducing previously observed factors from the interviews. Although a mock interview session was conducted, aiming to prevent these issues, these biases were unfortunately re-introduced during some of the interviews. Third, it became evident from the interviews that at times respondents forgot the importance of certain concepts, as some interviewees responded to be reminded of a topic upon introducing a clarifying question. This highlights the possibility of certain concepts not being considered during the interviews. Fourth, question 14 of the interviews considered concepts observed earlier in the literature. This question was deliberately asked at the end of the interview to prevent leading questions early in the interview and achieve rich data. However, the major problem with question 14 was the fact that this question required

the analysis of the interview data in tandem with conducting the interview, which was not always possible. Indeed, for two out of the four interviews, question 14 was not asked due to a lack of time. This issue was not observed during the mock interview, likely because the author of this research study already knew the outcome of certain questions beforehand and could therefore anticipate on the inclusion of factors for question 14. Fifth, and most importantly, only four interviews with FHI developers were conducted. Although the study on different types of FHIs contributed to the generalizability of the results, the absence of a consumer perspective diminishes the generalizability of the results toward the adoption of FHIs.

7.5 Future recommendations

During this study, the factors affecting the adoption of FHIs have been identified, by synthesizing a framework from empirical evidence in the literature and verifying the results through interviews. Although this research study is the first study to aggregate empirical evidence from the literature and present a conceptual framework on the factors affecting the adoption of FHIs, there are several opportunities for future studies in the field of FHI adoption.

First, empirically determined factors affecting the adoption of health innovations should be included in the synthesis of the conceptual framework. FHIs consist of two sub-type innovations, being FIs and health innovations. Although the literature review touched up on factors affecting the adoption of FIs, it did not consider factors affecting the adoption of health innovations. Therefore, to optimize the framework, an additional literature review should be conducted taking health innovations into account as done by Arshad (2021) for the diffusion of FHIs.

Second, the consumers' perspective should be studied. Although the interviews were used to validate the conceptual framework, the consumers' perspective can provide more insight into the adoption of FHIs, as outlined by the missing consumer-centric factors. To add to this, the framework should be verified quantitatively with a larger sample, e.g. through means of questionnaires. This would help to further validate the framework by deriving the statistical significance on barriers and enablers and obtain, e.g., correlation coefficients to understand the most important factors.

Third, without losing parsimony, moderating variables can be considered. It is imperative to note that FHIs can be adopted in both developing countries and developed countries (Sarkar, & Mateus, 2022), yet the many socioeconomic differences between developed and developing countries may affect the importance of certain factors. This phenomenon was already observed previously in the literature, where Social Influence does not affect the adoption of FIs in developed countries (Costa et al., 2021), yet does so in developing countries (Hussain et al., 2019; Joshi, 2024; Sodhay et al., 2024). Providing insight into moderating variables would help to further generalize the results independent of the economic context.

7.6 Study implications

Understanding the factors that affect the adoption of FHIs from a theoretical perspective is paramount as it helps to identify underlying principles and provide a conceptual framework to study the adoption of FHIs. Such efforts help to guide FHI developers and emphasize the importance of certain components for developing, contributing to an increased adoption probability, thereby helping to combat resource constraints in the healthcare sector. This research study provides a conceptual framework to study the adoption of FHIs, validated through interviews.

Practically, this research provides an insight for FHI developers what the important components for adoption are. The conceptual framework emphasizes that the context of the healthcare problem is paramount to understand, as the performance of the FHI can be either inferior or superior to traditional health innovations, depending on the problem it solves, and in the case of the involvement of governmental institutions the FHI must address a severe problem. To add to this, an understanding of the context of the healthcare problem also helps to identify whether the FHI must overcome the lack of facilitating conditions or whether the lack thereof provides an opportunity for the FHI. Further, the conceptual framework shows that the FHIs also must address the customers' requirements and context, as alignment with their values in terms of aesthetics, price expectations, and effort expectancy is paramount for the

adoption of FHIs. Besides all, trust must be established between the consumer and the developer, so that the consumer feels safe and secure to use the innovation.

Theoretically, this research study shows that the UTAUT 2 is the most suitable framework to study the adoption of FHIs, confirming its' unified character. Further, this research study shows that the synthesized conceptual framework can be used to study the adoption of FHIs, thereby providing a guidance for future studies on FHIs adoption. Future research must focus on the health innovation-related aspects to further scrutinize the conceptual framework, validate the framework from a consumer perspective, and verify the conceptual framework quantitatively. Further, a parallel can be drawn between the definition of F(H)Is and the factors that affect its' adoption, where the defining criteria of concentration on core functionalities and an optimized performance are in line with this research study. The notion of substantial cost reduction, however, does not seem to apply to all FHIs, as pricing must be appropriate rather than necessarily lower compared to traditional innovations.

8 Conclusion

The goal of this research was to determine the factors affecting the adoption of FHIs. To achieve this, the main research question "What factors affect the adoption of frugal health innovations?" was asked. A literature review was conducted to synthesize a conceptual framework which was subsequently validated through interviews with FHIs developers. The literature review showed that nine different theories, models, and frameworks have been applied to study the adoption of FIs, yet most fail to scale to FHIs. However, the UTAUT 2 covers sociological factors and socio-economic inequalities, and was therefore identified to be the most appropriate framework to study the adoption of FHIs. Further, the literature review revealed that Performance Expectancy, Effort Expectancy, Social Influence, Price Value, and Facilitating Conditions, from the UTAUT 2 are likely facilitators to the adoption of FHIs, where Price Value and Facilitating Conditions act simultaneously as a barrier and facilitator depending on their presence or absence, respectively. Additional factors were also identified, being Trialability, Lifestyle Compatibility, Consumer Literacy, and Trust, which are facilitators except for Trust, which is a simultaneous facilitator and barrier depending on its's presence or absence, respectively. Notably, Habit and Hedonic Motivation do not seem to affect the adoption of FHIs. Through interviews, the importance of Performance Expectancy, Effort Expectancy, Price Value, Facilitating Conditions, Trust, and Lifestyle Compatibility was confirmed for the adoption of FHIs. Further, in case FHIs are sold to governmental organizations, Problem Severity is of importance. Interview results showed a clear discrepancy, however, between the presence of developer-centric factors and consumer-centric factors, as evidenced by the lack of Social Influence, Trialability, and Consumer Literacy, likely because interviews were not conducted with FHI consumers (Figure 11).

To increase the probability of adoption, FHIs developers are urged to understand the context of the healthcare problem, as the performance of the FHI can be either inferior or superior to traditional health innovations, depending on the problem it solves, and in the case of the involvement of governmental institutions the FHI must address a severe problem. Further, an understanding of the context of the healthcare problem also helps to identify whether the lack of facilitating conditions is an opportunity for the FHI or whether the FHI must overcome the lack thereof. Moreover, the FHI developers are urged to understand the customers' requirements and context, as alignment with their values in terms of aesthetics, price expectations, and literacy also affects the adoption. Besides all, trust must be established between the consumer and the developer, so that the consumer feels safe and secure to use the innovation. All in all, this exploratory research provides a first insight in the factors affecting the adoption of FHIs through the synthesized conceptual framework, thereby contributing to the embryonic literature on FHI adoption. Future endeavours must focus on the inclusion of health innovation-related aspects, to further scrutinize the conceptual framework. Besides, the consumers' perspective must be studied to better understand the role of consumer-centric factors, and further quantitative validation of the framework is also paramount as it helps to identify the factors that affect the adoption of FHIs the most.

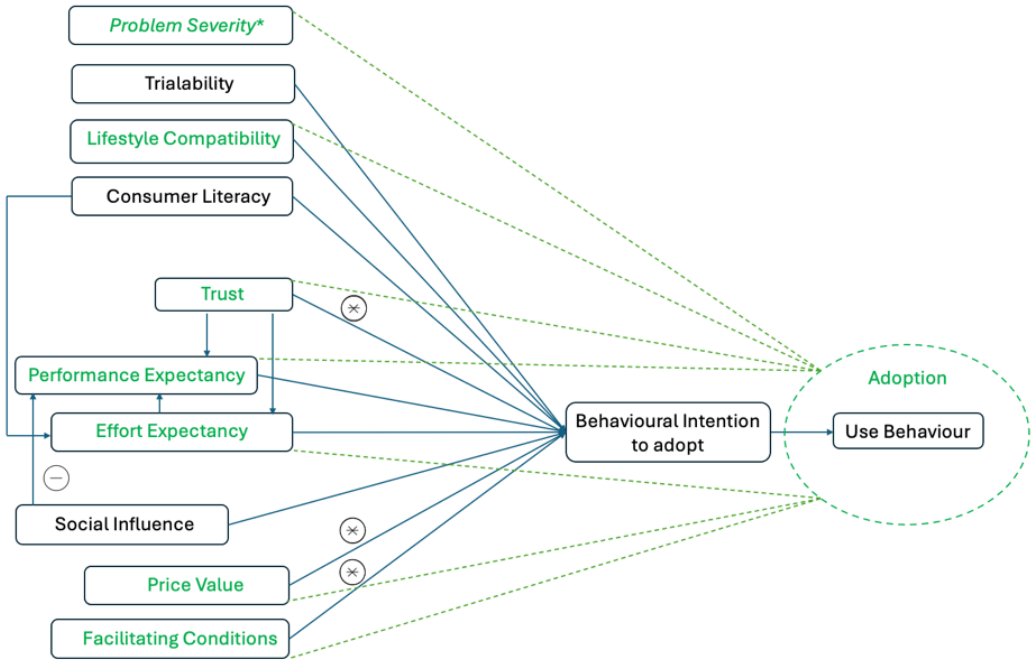

Figure 11. *Factors affecting the adoption of frugal health innovations aligned with the synthesized conceptual framework from the literature.* The synthesized framework from the literature is shown, with relationships between variables depicted by blue arrows. Negative correlations are represented by the minus sign, and the cross sign represents a positive and negative correlation simultaneously. Green-highlighted factors were observed in the interviews to affect the adoption of frugal health innovations, as depicted by the dotted green lines. The italicized Problem Severity was not previously observed in the literature. *: Problem Severity is only relevant in case frugal health innovations are sold to governmental institutions.

References

Abejirinde, I. O. O., Ilozumba, O., Marchal, B., Zweekhorst, M., & Dieleman, M. (2018). Mobile health and the performance of maternal health care workers in low-and middle-income countries: A realist review. *International Journal of Care Coordination*, **21**(3):73-86.

Adelakun, O., Kallio, P., Garcia, R., & Fleischer, A. (2016). *Telemedicine adoption and sustainability in extreme resource poor countries* [Conference Article]. Twenty-second Americas Conference on Information Systems: San Diego, California, United States of America.

Adlung, C., Hinrichs-Krapels, S., Diehl, J. C., & Van der Kooij, N. (n.d.). *Existing and emerging frameworks for adopting and diffusing medical device equipment in low-resource settings: A scoping review* [Manuscript submitted for publication]. Faculty of Technology, Policy, and Management, Delft University of Technology, Delft, The Netherlands.

Agarwal, N., Grottke, M., Mishra, S., & Brem, A. (2016). A systematic literature review of constraint-based innovations: State of the art and future perspectives. *IEEE Transactions on Engineering Management*, **64**(1):3-15.

Agarwal, N., & Brem, A. (2017). Frugal innovation – Past, present, and future. *IEEE Engineering Management Review*, **45**(3):37-41.

Ajzen, I. (1991). The Theory of Planned Behaviour. *Organizational Behaviour and Human Decision Processes*, **50**(2):179-211.

Alami, H., Rivard, L., Lehoux, P., Hoffman, S. J., Cadeddu, S. B. M., Savoldelli, M., Samri, M. A., Ahmed, M. A. A., Vloot, R., & Fortin, J. P. (2020). Artificial intelligence in health care: Laying the foundation for responsible, sustainable, and inclusive innovation in low-and middle-income countries. *Globalization and Health*, **16**:1-6.

Alazzam, M. B., Al-Sharo, Y. M., & Al-Azzam, M. K. (2018). Developing (UTAUT 2) model of adoption mobile health application in Jordan E-government. *Journal of Theoretical & Applied Information Technology*, **96**(12).

Albert, M. (2019). Sustainable frugal innovation – The connection between frugal innovation and sustainability. *Journal of Cleaner Production*, **237**:117747.

Arbutus Medical (n.d.). *TrakPak®.* Adapted from https://arbutusmedical.com/our-devices/ on 05-09-2024.

Archer, N., Lokker, C., Ghasemaghaei, M., & DiLiberto, D. (2021). eHealth implementation issues in low-resource countries: Model, survey, and analysis of user experience. *Journal of Medical Internet Research*, **23**(6):e23715.

Arinloye, D. D. A., Linnemann, A. R., Hagelaar, G., Coulibaly, O., & Omta, O. S. (2015). Taking profit from the growing use of mobile phone in Benin: A contingent valuation approach for market and quality information access. *Information Technology for Development*, **21**(1):44-66.

Arshad, H. (2021). *Frugal innovation in healthcare: Aligning systematic review, patterns, and factors for diffusion in developing economies* [Doctoral dissertation]. University of Leipzig, Leipzig, Germany. Adapted from https://ul.qucosa.de/api/qucosa%3A74099/attachment/ATT-0/ on 25-08-2024.

Ashoer, M., Jebarajakirthy, C., Lim, X. J., Mas'ud, M., & Sahabuddin, Z. A. (2024). Mobile fintech, digital financial inclusion, and gender gap at the bottom of the pyramid: An extension of Mobile Technology Acceptance model. *Procedia Computer Science*, **234**:1253-1260.

Auma, J., Ndawula, A., Ackers-Johnson, J., Horder, C., Seekles, M., Kaul, V., & Ackers, L. (2023). Task-shifting for point-of-care cervical cancer prevention in low-and middle-income countries: A case study from Uganda. *Frontiers in Public Health*, **11**:1105559.

Baishya, K., & Samalia, H. V. (2020). Extending Unified Theory of Acceptance and Use of Technology with perceived monetary value for smartphone adoption at the Bottom of the Pyramid. *International Journal of Information Management*, **51**:102036.

Basu, R. R., Banerjee, P. M., & Sweeny, E. G. (2013). Frugal innovation: Core competencies to address global sustainability. *Journal of Management for Global sustainability*, **1**(2):5.

Bhatti, Y. A., Prime, M., Harris, M., Wadge, H., McQueen, J., Patel, H., Carter, A. W., Partson, G., & Darzi, A. (2017). The search for the holy grail: Frugal innovation in healthcare from low-income or middle-income countries for reverse innovation to developed countries. *BMJ Innovations*, **3**:212-220.

Bianchi, C., Bianco, M., Ardanche, M., & Schenck, M. (2017). Healthcare frugal innovation: A solving problem rationale under scarcity conditions. *Technology in Society*, **51**:74-80.

Bolton, W. S., Aruparayil, N., Quyn, A., Scott, J., Wood, A., Bundu, I., Gnanaraj, J., Brown, J. M., & Jayne, D. G. (2019). Disseminating technology in global surgery. *Journal of British Surgery*, **106**(2):e34-e43.

Bonato, S. (2016). Google Scholar and Scopus. *Journal of the Medical Library Association*, **104**(3):252-254.

Brown, D. W., Shulman, A., Hudson, A., Smith, W., Fisher, B., Hollon, J., Pipman, Y., Van Dyk, J., & Einck, J. (2014). A framework for the implementation of new radiation therapy technologies and treatment techniques in low-income countries. *Physica Medica*, **30**(7):791-798.

Businesswire (2023). *eEmporia, the Austrian innovator, has already sold 16 million smartphones and button cell phones for older people*. Adapted from https://www.businesswire.com/news/home/20230220005131/en/emporia-the-Austrian-innovator-has-already-sold-16-million-smartphones-and-button-cell-phones-for-older-people on 25-08-2024.

Costa, L., Teixeira, A., & Brochado, A. (2021). Determinants of consumers' frugal innovation acceptance in a developed country. *Young Consumers*, **22**(2):185-201.

Dabić, M., Obradović, T., Vlačić, B., Sahasranamam, S., & Paul, J. (2022). Frugal innovations: A multidisciplinary review & agenda for future research. *Journal of Business Research*, **142**:914-929.

David-West, O., Iheanachor, N., & Umukoro, I. O. (2019). Mobile money as a frugal innovation for the bottom of the pyramid – Cases of selected African countries. *Africa Journal of Management*, **5**(3):274-302.

Davis, F. D. (1989). Perceived usefulness, perceived ease of use, and user acceptance of information technology. *MIS Quarterly*, **13**(2):319-340.

De Meijer, C., Wouterse, B., Polder, J., & Koopmanschap, M. (2013). The effect of population aging on health expenditure growth: A critical review. *European Journal of Ageing*, **10**:353-361.

De Vries, H., Tummers, L., & Bekkers, V. (2018). The diffusion and adoption of public sector innovations: A meta-synthesis of the literature. *Perspectives on Public Management and Governance*, **1**(3):159-176.

Delft University of Technology (n.d.). *Graduation portal.* Adapted from https://www.tudelft.nl/studenten/faculteiten/tbm-studentenportal/onderwijs/master/graduation-portal on 19-09-2024.

DePasse, J. W., & Lee, P. T. (2013). A model for 'reverse innovation' in health care. *Globalization and Health*, **9**:1-7.

Durlak, J. A., & DuPre, E. P. (2008). Implementation matters: A review of research on the influence of implementation on program outcomes and the factors affecting implementation. *American Journal of Community Psychology*, **41**:327-350.

Ekie, J., & Ekie, T. (2022). Delivering together: A framework for sustainable ownership of early warning and health emergency surveillance technologies in low-and middle-income countries. *Journal of Public Health in Africa*, **13**(1).

Enraf Nonius (n.d.). *GE Vscan Air*. Adapted from https://www.enraf-nonius.nl/producten/draagbare-echo-apparaten/ge-vscan-air/?gad_source=1&gbraid=0AAAADbbAMzPxNA5Ua8lVuwyVzGLdy2vg&gclid=EAIaIQobChMI5rvnmNKriAMVh6doCR29QwtPEAAYASAAEgI9c_D_BwE on 05-09-2024.

Eriksson, N., Gökhan, A., & Stenius, M. (2021). A qualitative study of consumer resistance to mobile payments for in-store purchases. *Procedia Computer Science*, **181**:634-641.

Faqih, K. M. (2020). The influence of perceived usefulness, social influence, internet self-efficacy and compatibility on users' intentions to adopt e-learning: Investigating the moderating effects if culture. *International E-Journal of Advances in Education*, **5**(15):300-320.

Fishbein, M. A., & Ajzen, I. (1975). *Belief, Attitude, Intention, and Behaviour: An introduction to theory and research*. Addison-Wesley: Boston, Massachusetts, United States of America.

Fong, K. K. K., & Wong, S. K. S. (2015). Hong Kong Wi-Fi adoption and security survey 2014. *Computer and Information Science*, **8**(1):74.

Fradin, M. S. (1998). Mosquitoes and mosquito repellents: A clinician's guide. *Annals of Internal Medicine*, **128**(11):931-940.

Government of the United Kingdom (n.d.). *Shakerscope LTD.* Adapted from https://find-and-update.company-information.service.gov.uk/company/05592943 on 29-01-2025.

Greenhalgh, T., Wherton, J., Papoutsi, C., Lynch, J., Hughes, G., Hinder, S., Fahy, N., Procter, R., & Shaw, S. (2017). Beyond adoption: A new framework for theorizing and evaluating nonadoption, abandonment, and challenges to the scale-up, spread, and sustainability of health and care technologies. *Journal of Medical Internet Research*, **19**(11):e8775.

Hardon, S. F., Schilder, F., Bonjer, J., Dankelman, J., & Horeman, T. (2019). A new modular mechanism that allows full detachability and cleaning of steerable laparoscopic instruments. *Surgical Endoscopy*, **33**:3484-3493.

Hardy, V., Thompson, M., Alto, W., Keppel, G. A., Hornecker, J., Linares, A., Robitaille, B., & Baldwin, L. M. (2016). Exploring the barriers and facilitators to use of point of care tests in family medicine clinics in the United States. *BMC Family Practice*, **17**:1-8.

Hasan, R., Lowe, B., & Petrovici, D. (2020). Consumer adoption of pro-poor service innovations in subsistence marketplaces. *Journal of Business Research*, **121**:461-475.

Haverila, M. J., McLaughlin, C., & Haverila, K. (2023). The impact of social influence on perceived usefulness and behavioral intentions in the usage of non-pharmaceutical interventions (NPIs). *International Journal of Healthcare Management*, **16**(1):145-156.

Hindocha, C. N., Antonacci, G., Barlow, J., & Harris, M. (2021). Defining frugal innovation: A critical review. *BMJ Innovations*, **7**(4).

Hong, Q.N., Pluy, P., Fàbregues, S., Bertlett, G., Boardman, F., Cargo, M., Dagenais, P., Gagnon, M. P., Griffiths, F., Nicolau, B., O'Cathain, A., Rousseau, M. C., & Vedel, I. (2018). *Mixed Methods Appraisal Tool (MMAT) Vesion 2018*. Adapted from http://mixedmethodsappraisaltoolpublic.pbworks.com/w/file/fetch/127916259/MMAT_2018_criteria-manual_2018-08-01_ENG.pdf on 11-12-2024.

Hossain, M. (2017). Mapping the frugal innovation phenomenon. *Technology in Society*, **51**:199-208.

Hossain, M. (2018). Frugal innovation: A review and research agenda. *Journal of Cleaner Production*, **182**:926-936.

Hossain, M. (2020). Frugal innovation: Conception, development, diffusion, and outcome. *Journal of Cleaner Production*, **262**:121456.

Hossain, M., Agarwal, N., Bhatti, Y., & Levänen, J. (2022). Frugal innovation: Antecedents, mediators, and consequences. *Creativity and Innovation Management*, **31**(3):521-540.

Hussain, M., Mollik, A. T., Johns, R., & Rahman, M. S. (2019). M-payment adoption for Bottom of Pyramid segment: An empirical investigation. *International Journal of Bank Marketing*, **37**(1):362-381.

Israel-Ballard, K. A., Maternowska, M. C., Abrams, B. F., Morrison, P., Chitibura, L., Chipato, T., Chirenje, Z. M., Padian, N. S., & Chantry, C. J. (2006). Acceptability of heat treating breast milk to prevent mother-to-child transmission of human immunodeficiency virus in Zimbabwe: A qualitative study. *Journal of Human Lactation*, **22**(1):48-60.

Ituna-Yudonago, J. F., Galindo-Luna, Y. R., Garcia-Valladares, O., Brown, R. B., Shankar, R., & Ibarra-Bahena, J. (2021). Review of solar-thermal collectors powered autoclave for the sterilization of medical equipment. *Alexandria Engineering Journal*, **60**(6):5401-5417.

Joshi, R. (2024). A mixed methods UTAUT2-based approach to understanding unified payments interface adoption in BOP users. *International Journal of Electronic Banking*, **4**(3):235-258.

Kabongo, E. M., Mukumbang, F. C., Delobelle, P., & Nicol, E. (2021). Explaining the impact of mHealth on maternal and child health care in low-and middle-income countries: A realist synthesis. *BMC Pregnancy and Childbirth*, **21**:1-13.

Katz, E., Blumler, J. G., & Gurevitch, M. (1973). Uses and gratifications research. *The Public Opinion Quarterly*, **37**(4):509-523.

Kee, K. F. (2017). Adoption and diffusion. In C. R. Scott, J. R. Barker, T. Kuhn, J. Keyton, P. K. Turner, & L. K. Lewis (Eds.), *International Encyclopedia of Organizational Communication*. Wiley-Blackwell: Hoboken, New Jersey, United States of America.

Khan, R., & Melkas, H. (2020). The social dimension of frugal innovation. *International Journal of Technology Management*, **83**(1-3):160-179.

Khanna, T., Rangan, V. K., & Manocaran, M. (2005). Narayana Hrudayalaya heart hospital: Cardiac care for the poor. *Harvard Business Review*, **9**:505-078.

Khatun, F., Heywood, A. E., Ray, P. K., Bhuiya, A., & Liaw, S. T. (2016). Community readiness for adopting mHealth in rural Bangladesh: A qualitative exploration. *International Journal of Medical Informatics*, **93**:49-56.

Kim, H. W., Chan, H. C., & Gupta, S. (2007). Value-based adoption of mobile internet: An empirical investigation. *Decision Support Systems*, **43**(1):111-126.

Kiwanuka, A. (2015). Acceptance process: The missing link between UTAUT and diffusion of innovation theory. *American Journal of Information Systems*, **3**(2):40-44.

Knorringa, P., Peša, I., Leliveld, A., & Van Beers, C. (2016). Frugal innovation and development: Aides or adversaries? *The European Journal of Development Research*, **28**:143-153.

Koksal, M. H. (2016). The intentions of Lebanese consumers to adopt mobile banking. *International Journal of Bank Marketing*, **34**(3):327-346.

Kulviwat, S., Bruner, G. C., Kumar, A., Nasco, S. A., & Clark, T. (2007). Toward a unified theory of consumer acceptance technology. *Psychology & Marketing*, **24**(12):1059-1084.

Kumra, R., Khalek, S. A., & Samanta, T. (2021). Factors affecting BoP producer intention to use P2P lending platforms in India. *Journal of Global Marketing*, **34**(4):328-352.

Lee, M. C. (2009). Factors influencing the adoption of internet banking: An integration of TAM and TPB with Perceived Risk and Perceived Benefit. *Electronic Commerce Research and Applications*, **8**(3):130-141.

Lee, J. H., & Song, C. H. (2013). Effects of trust and perceived risk on user acceptance of a new technology service. *Social Behavior and Personality: An International Journal*, **41**(4):587-597.

Leliveld, A., & Knorringa, P. (2018). Frugal innovation and development research. *The European Journal of Development Research*, **30**:1-16.

Leonard, E., De Kock, I. H., & Bam, W. G. (2019). *Investigating the relationships between health and innovation systems to guide innovation adoption* [Conference Article]. IEEE International Conference on Engineering, Technology and Innovation: Valbonne Sophia-Antipolis, France.

Leonard, E., De Kock, I. H., & Bam, W. (2020). Barriers and facilitators to implementing evidence-based health innovations in low-and middle-income countries: A systematic literature review. *Evaluation and Program Planning*, **82**:101832.

Lin, H. F. (2011). An empirical investigation of mobile banking adoption: The effect of innovation attributes and knowledge-based trust. *International Journal of Information Management*, **31**(3):252-260.

Lumpkin, G. T., & Dess, G. G. (1996). Clarifying the entrepreneurial orientation construct and linking it to performance. *Academy of Management Review*, **21**(1):135-172.

Lundin, J., & Dumont, G. (2017). Medical mobile technologies – What is needed for a sustainable and scalable implementation on a global scale? *Global Health Action*, **10**(3):1344046.

Mandal, S. (2014). Frugal innovations for global health – Perspectives for students. *IEEE Pulse*, **5**(1):11-13.

Marcelo, A., Adejumo, A., & Luna, D. (2011). Health informatics for development: A three-pronged strategy of partnerships, standards, and mobile Health. *Yearbook of Medical Informatics*, **20**(1):96-101.

Marinakis, Y., Walsh, S. T., & Harms, R. (2016). C*atalyzing new product adoption at the Base of the Pyramid* [Conference Article]. International Conference on Management of Technology, IAMOT: Technology-Future Thinking. Orlando, Florida, United States of America.

Mass Design Group (n.d.). *Future health systems*. Adapted from https://cargocollective.com/futurehealth/Embrace-Infant-Warmer on 05-09-2024.

McGrath, C., Palmgren, P. J., & Liljedahl, M. (2019). Twelve tips for conducting qualitative research interviews. *Medical Teacher*, **41**(9):1002-1006.

Miesler, T., Wimschneider, C., Brem, A., & Meinel, L. (2020). Frugal innovation for point-of-care diagnostics controlling outbreaks and epidemics. *ACS Biomaterials Science & Engineering*, **6**(5):2709-2725.

Mills, A. (2014). Health care systems in low-and middle-income countries. *New England Journal of Medicine*, **370**(6):552-557.

Mishra, V., & Sharma, M. G. (2022). Telemedicine as frugal intervention to health care: A case of diabetes management. *International Journal of Healthcare Management*, **15**(2):165-170.

Molina-Maturano, J., Speelman, S., & De Steur, H. (2020). Constraint-based innovations in agriculture and sustainable development: A scoping review. *Journal of Cleaner Production*, **246**:119001.

Morgan, R. M., & Hunt, S. D. (1994). The commitment-trust theory of relationship marketing. *Journal of Marketing*, **58**:20-38.

Nanath, K. (2011). LifeSpring Hospitals: A social innovation in Indian healthcare. *Emerald Emerging Markets Case Studies*, **1**(1):1-14.

Nandakumar, A. K., Beswick, J., Thomas, C. P., Wallack, S. S., & Kress, D. (2009). Pathways of health technology diffusion: The United States and low-income countries. *Health Affairs*, **28**(4):986-995.

Nilsen, P. (2015). Making sense of implementation theories, models and frameworks. *Implementation Science* **10**(53):1-13.

Niroumand, M., Shahin, A., Naghsh, A., & Peikari, H. R. (2020). Frugal innovation enablers: A comprehensive framework. *International Journal of Innovation Science*, **12**(1):1-20.

Niroumand, M., Shahin, A., Naghsh, A., & Peikari, H. R. (2021). Frugal innovation enablers, critical success factors and barriers: A systematic review. *Creativity and Innovation Management*, **30**(2):348-367.

O'Donnell, A., Kaner, E., Shaw, C., & Haighton, C. (2018). Primary care physicians' attitudes to the adoption of electronic medical records: A systematic review and evidence synthesis using the clinical adoption framework. *BMC Medical Informatics and Decision Making*, **18**:1-16.

Oosting, R. M., Dankelman, J., Wauben, L. S. G. L., Madete, J., & Groen, R. S. (2018). *Roadmap for design of surgical equipment for safe surgery worldwide* [Conference Article]. IEEE Global Humanitarian Technology Conference: San Jose, California, United States of America.

Osakwe, C. N., & Okeke, T. C. (2016). Facilitating mCommerce growth in Nigeria through mMoney usage: A preliminary analysis. *Interdisciplinary Journal of Information, Knowledge, and Management*, **11**:115-139.

Pal, D., Vanijja, V., & Papasratorn, B. (2015). An empirical analysis towards the adoption of NFC mobile payment system by the end user. *Procedia Computer Science*, **69**:13-25.

Pipitwanichakarn, T., & Wongtada, N. (2019). Mobile commerce adoption among the Bottom of the Pyramid: A case of street vendors in Thailand. *Journal of Science and Technology Policy Management*, **10**(1):193-213.

Pisoni, A., Michelini, L., & Martignoni, G. (2018). Frugal approach to innovation: State of the art and future perspectives. *Journal of Cleaner Production*, **171**:107–126.

Prabhu, J. (2017). Frugal innovation: Doing more with less for more. *Philosophical Transactions of the Royal Society A: Mathematical, Physical and Engineering Sciences*, **375**(2095):20160372.

Preferred Reporting Items for Systematic reviews and Meta-Analyses (2024). *PRISMA statement*. Adapted from https://www.prisma-statement.org on 13-08-2024.

Prime Minister's Office Bangladesh (2022). *Union Digital Centres*. Adapted from https://a2i.gov.bd/wp-content/uploads/2022/09/Union-Digital-Centres-Innovation-brief.pdf on 13-11-2024.

Purohit, S., & Arora, R. (2023). Adoption of mobile banking at the Bottom of the Pyramid: An emerging market perspective. *International Journal of Emerging Markets*, **18**(1):200-222.

Rahman, A. E., Ameen, S., Hossain, A. T., Perkins, J., Jabeen, S., Majid, T., Uddin, A., Shaikh, Z. H., Islam, M. S., Islam, J. Ashrafee, S., Alam, H. S., Saberin, A., Ahmed, S., Banik, G., Kabir, E., Ahmed, A., Chisti, M. J., Cunningham, S., Dockrell, D. H., Nair, H., El Arifeen, S., & Campbell, H. (2022). Introducing pulse oximetry for outpatient management of childhood pneumonia: An implementation research adopting a district implementation model in selected rural facilities in Bangladesh. *EClinicalMedicine*, **50**:101511.

Rao, B. C. (2013). How disruptive is frugal? *Technology in Society*, **35**(1):65-73.

Ratcliff, R., & Doshi, K. (2016). Using the Bass Model to analyze the diffusion of innovations at the Base of the Pyramid. *Business & Society*, **55**(2):271-298.

Ray, S., & Ray, P. K. (2011). Product innovation for the people's car in an emerging economy. *Technovation*, **31**(5-6):216-227.

Rejikumar, G. (2013). A pre-launch exploration of customer acceptance of usage based vehicle insurance policy. *IIMB Management Review*, **25**(1):19-27.

Renaud, K., & Van Biljon, J. (2008). Predicting technology acceptance and adoption by the elderly: A qualitative study. In *Proceedings of the 2008 Annual Research Conference of the South African Institute of Computer Scientists and Information Technologists on IT Research in Developing Countries: Riding the Wave of Technology* (pp. 210 – 219). Association for Computing Machinery: New York City, New York, United States of America.

Rogers, E. M. (1983). *Diffusion of Innovations* (3rd e.d., pp. 163 – 238). The Free Press: New York City, New York, United States of America.

Rossetto, D. E., Borini, F. M., Bernardes, R. C., & Frankwick, G. L. (2017). A new scale for measuring frugal innovation: The first stage of development of a measurement tool. *VI SINGEP – International Symposium on Project Management, Innovation, and Sustainability*, **6**:1-16.

Rossetto, D. E., Borini, F. M., Bernardes, R. C., & Frankwick, G. L. (2023). Measuring frugal innovation capabilities: An initial scale proposition. *Technovation*, **121**:102674.

Sachdeva, K., & Shrivastava, T. (2018). CBNAAT: A boon for early diagnosis of tuberculosis-head and neck. *Indian Journal of Otolaryngology and Head & Neck Surgery*, **70**:572-577.

Santos, H. C., Varnum, M. E., & Grossmann, I. (2017). Global increases in individualism. *Psychological Science*, **28**(9):1228-1239

Sarkar, S., & Mateus, S. (2022). Doing more with less: How frugal innovations can contribute to improving healthcare systems. *Social Science & Medicine*, **306**:115127.

Schmidt-Sane, M., Storer, E., Ripoll, S., & Hrynick, T. (2023). Exploring medical mistrust: From clinic to community. *Journal of the British Academy*, **11**(6):1-12.

Sciaudone, M., Carpena, R., Calderón, M., Sheen, P., Zimic, M., Coronel, J., Gilman, R. H., & Bowman, N. M. (2023). Rapid detection of Mycobacterium tuberculosis using recombinase polymerase amplification: A pilot study. *PLoS One*, **18**(12):e0295610.

Semiz, B. B., & Semiz, T. (2021). Examining consumer use of mobile health applications by the extended UTAUT model. *Business & Management Studies: An International Journal*, **9**(1):267-281.

Shanko, G., Negash, S., & Bandyopadhyay, T. (2016). Mobile healthcare services adoption. *International Journal of Networking and Virtual Organisations*, **16**(2):143-156.

Sheth, J. N. (2011). Impact of emerging markets on marketing: Rethinking existing perspectives and practices. *Journal of Marketing*, **75**(4):166-182.

Sigma Aldirch (n.d.). *Eppendorf® ThermoMixer® F2.0.* Adapted from https://www.sigmaaldrich.com/NL/en/product/sigma/ep5387000013?utm_source=google%2Cgoogle&utm_medium=organicshopping%2Ccpc&utm_campaign=21684405540&utm_content=172562433292&gad_source=1&gbraid=0AAAAAD8kLQTod5jZu0c6UOYMLTAjj6esh&gclid=Cj0KCQiAvbm7BhC5ARIsAFjwNHsPmrSVd_fUOK6q7H5TXA4zMdhr7aW6xDYFvw67bl65Ej46yPcDuXgaAjTtEALw_wcB on 27-12-2024.

Simula, H., Hossain, M., & Halme, M. (2015). Frugal and reverse innovations – Quo Vadis? *Current Science*, **109**(9):1567-1572.

Singh, V. K., Singh, P., Karmakar, M., Leta, J., & Mayr, P. (2021). The journal coverage of Web of Science, Scopus and Dimensions: A comparative analysis. *Scientometrics*, **126**:5113-5142.

Skjott Linneberg, M., & Korsgaard, S. (2019). Coding qualitative data: A synthesis guiding the novice. *Qualitative Research Journal*, **19**(3):259-270.

Smithsonian Institution (n.d.). *Jaipur foot and below knee prosthesis*. Adapted from https://www.si.edu/object/chndm_DO90.003 on 05-09-2024.

Sodhay, S., Kathuria, L. M., Kaur, T., & Kaur, G. (2024). Behavioural intention to adopt mobile wallets at the Bottom of the Pyramid: A developing economy perspective. *International Journal of Quality and Service Sciences*, **16**(3):345-371.

Spicer, N., Hamza, Y. A., Berhanu, D., Gautham, M., Schellenberg, J., Tadesse, F., Umar, N., & Wickremasinghe, D. (2018). 'The development sector is a graveyard of pilot projects!' Six critical actions for externally funded implementers to foster scale-up of maternal and newborn health innovations in low and middle-income countries. *Globalization and Health*, **14**:1-13.

Subramanian, S., Sankaranarayanan, R., Esmy, P. O., Thulaseedharan, J. V., Swaminathan, R., & Thomas, S. (2016). Clinical trial to implementation: Cost and effectiveness considerations for scaling up cervical cancer screening in low- and middle-income countries. *Journal of Cancer Policy*, **7**:4-11.

Sung, M., He, J., Zhou, Q., Chen, Y., Ji, J. S., Chen, H., & Li, Z. (2022). Using an integrated framework to investigate the facilitators and barriers of health information technology implementation in noncommunicable disease management: Systematic review. *Journal of Medical Internet Research*, **24**(7):e37338.

Taherdoost, H. (2018). A review of technology acceptance and adoption models and theories. *Procedia Manufacturing*, **22**:960-967.

Tamvada, J. P., Narula, S., Audretsch, D., Puppala, H., & Kumar, A. (2022). Adopting new technology is a distant dream? The risks of implementing Industry 4.0 in emerging economy SMEs. *Technological Forecasting and Social Change*, **185**:122088.

Teriö, M., Eriksson, G., Kamwesiga, J. T., & Guidetti, S. (2019). What's in it for me? A process evaluation of the implementation of a mobile phone-supported intervention after stroke in Uganda. *BMC Public Health*, **19**:1-13.

Tkadlec, J., Peckova, M., Sramkova, L., Rohn, V., Jahoda, D., Raszka, D., Berousek, J., Mosna, F., Vymazal, T., Kvapil, N., & Drevinek, P. (2019). The use of broad-range bacterial PCR in the diagnosis of infectious diseases: A prospective cohort study. *Clinical Microbiology and Infection*, **25**(6):747-752.

United Nations (2020). *The sustainable development goals report*. Adapted from https://unstats.un.org/sdgs/report/2020/The-Sustainable-Development-Goals-Report-2020.pdf on 19-06-2020.

Venkatesh, V., Morris, M. G., Davis, G. B., & Davis, F. D. (2003). User acceptance of information technology: Toward a unified view. *MIS quarterly*, **27**(3):425-478.

Venkatesh, V., Thong, J. Y., & Xu, X. (2012). Consumer acceptance and use of information technology: Extending the Unified Theory of Acceptance and Use of Technology. *MIS quarterly*, **36**(1):157-178.

Verma, P. (2024). Generating customer wealth by mobile-based agricultural extension services: BOP farmers in the emerging markets. *Journal of Science and Technology Policy Management*. Advanced online publication.

Waknis, P. P., Prasad, G. S. V., & Wadje, S. (2013). A simple method to control bleeding by stationary paper clips as an alternate to Raney clips during coronal incisions. *Journal of Maxillofacial and Oral Surgery*, **12**:117-119.

Wald, L. L., McDaniel, P. C., Witzel, T., Stockmann, J. P., & Cooley, C. Z. (2020). Low-cost and portable MRI. *Journal of Magnetic Resonance Imaging*, **52**(3):686-696.

Webb, M. M., Bridges, P., Aruparayil, N., Chugh, C., Beacon, T., Singh, T., Sawhney, S. S., Bains, L., Hall, R., Jayne, D., Gnanaraj, J., Mishra, A., & Culmer, P. R. (2022). The RAIS device for global surgery: Using a participatory design approach to navigate the translational pathway to clinical use. *IEEE Journal of Translational Engineering in Health and Medicine*, **10**:1-12.

Wentzel, J. P., Diatha, K. S., & Yadavalli, V. S. S. (2013). An application of the extended Technology Acceptance Model in understanding technology-enabled financial service adoption in South Africa. *Development Southern Africa*, **30**(4-5):659-673.

Weyrauch, T., & Herstatt, C. (2016). What is frugal innovation? Three defining criteria. *Journal of Frugal Innovation*, **2**:1-17.

Wisdom, J. P., Chor, K. H. B., Hoagwood, K. E., & Horwitz, S. M. (2014). Innovation adoption: A review of theories and constructs. *Administration and Policy in Mental Health and Mental Health Services Research*, **41**:480-502.

Wood, W., & Neal, D. T. (2007). A new look at habits and the habit-goal interface. *Psychological Review*, **114**(4):843.

Yagnick, N. S., Singh, R., Tripathi, M., Mohindra, S., Deora, H., Suri, A., & Gupta, S. K. (2019). Need for grass root innovation in developing countries: Case for stationary binder clips in scalp hemostasis. *World Neurosurgery*, **121**:222-226.

Yakubu, A., Paloji, F., Bonnet, J. P. G., & Wetter, T. (2021). Development of an instrument for assessing the maturity of citizens for consumer health informatics in developing countries: The case of Chile, Ghana, and Kosovo. *Methods of Information in Medicine*, **60**(1-2):062-070.

Yang, Q., Pang, C., Liu, L., Yen, D. C., & Tarn, J. M. (2015). Exploring consumer perceived risk and trust for online payments: An empirical study in China's younger generation. *Computers in Human Behavior*, **50**:9-24.

Zanello, G., Fu, X., Mohnen, P., & Ventresca, M. (2016). The creation and diffusion of innovation in developing countries: A systematic literature review. *Journal of Economic Surveys*, **30**(5):884-912.

Zhang, X. (2018). Frugal innovation and the digital divide: Developing an extended model of the diffusion of innovations. *International Journal of Innovation Studies*, **2**(2):53-64.

Use of artificial intelligence tools

During this thesis, the artificial intelligence tool ChatGPT has been used for two purposes, but all output was neglected. In essence, ChatGPT was used as a search tool to find relevant academic material. First, ChatGPT was used to get an indication what frameworks have been used to study the adoption of frugal health innovations. After observing a response without valid references, the output was discarded and not used for this research study. Second, ChatGPT was used to see if there were any research studies available that studied the adoption of frugal (health) innovations to find more empirical work. However, after observing a response with unscientific references, the output was discarded. To that extent, ChatGPT has only been used as a search tool, but the output has not been used in this research study to ensure academic integrity. The work presented in this research study is therefore created by the researcher.

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Appendices

Appendix A: Literature review knowledge gap

To determine whether the factors affecting the adoption of FHIs have been studied from a theoretical perspective, a literature review was conducted in line with the Preferred Reporting Items for Systematic reviews and Meta-Analyses statement (Preferred Reporting Items for Systematic Reviews and Meta-Analyses, 2024). Literature studies were retrieved from Scopus, referred to as "search entry", or via alternative routes, e.g., via in-text references, referred to as "others" (Figure A1). Scopus was used as the database as it contains a more exhaustive list of indexed journals than Webb of Science (Singh et al., 2021) and, in contrast to Google Scholar, only contains peer-reviewed articles (Bonato, 2016). A combination of FI, adoption, and theory, including overlapping concepts of FI (Table 1), adoption (Table 2), and theoretical perspective (Table 3), and healthcare was used as the search entry in Scopus (Table A1). Besides the overlapping concepts of adoption, acquisition, roll-out, scaling up, absorptive capacity, and market introduction were considered as these terms may describe technology adoption from a market perspective, and failure, non-successful, and abandoned were included to consider studies on non-adopted innovations. Further, besides the overlapping concepts of a theoretical perspective, guidelines were considered due to their relevance to the healthcare sector (Adlung, n.d.), and enabler, barrier (Niroumand et al., 2021), attribute, and concept were considered to search specifically for factors. Healthcare was specified by searching for a combination of diagnostics and medical- and health devices, equipment, technology, or innovations to consider multiple descriptions of healthcare innovations. After retrieval of the literature studies, articles published during or after 2010 were included. Subsequently, articles were included if they covered FHIs, or a similar health innovation concept, and, if not, articles were discarded. Hereafter, articles were included if they also covered adoption, or a similar technology use concept, and, if not, articles were discarded. Ultimately, articles that were not written in English, or articles that were not accessible, were excluded.

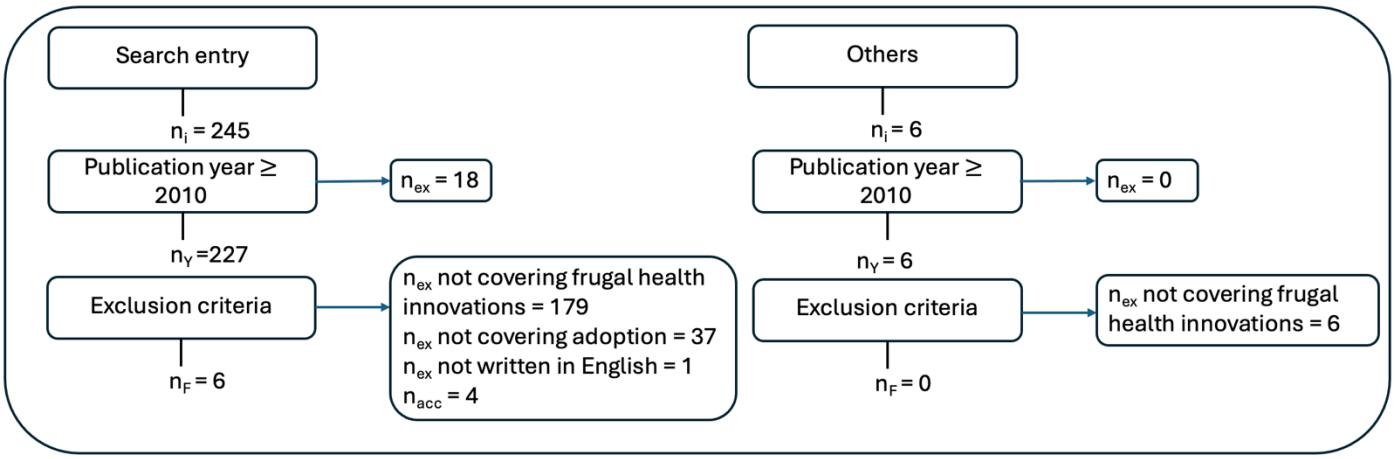

Figure A1. *Preferred Reporting Items for Systematic reviews and Meta-Analyses statement for the knowledge gap.* Literature studies were retrieved through Scopus using the search entry (Search entry) or through other sources, e.g. via in-text references (Others). The initial number of articles (n_i), number of articles retained after filtering on publication date (n_Y), and the final number of articles retained after filtering on the exclusion criteria (n_F) are indicated. The number of excluded articles (n_{ex}) is included with an explanation on the exclusion criteria, being exclusion because the article was not about frugal health innovations, or a related health innovation concept, not about adoption, or a related technology use concept, or not written in English. Furthermore, the number of articles removed due to inaccessibility (n_{acc}) are also indicated.

Table A1. *Search entry used to identify articles to derive the knowledge gap*. The search entry used to retrieve literature studies as used in Scopus (Search entry) and the number of initial articles retrieved (n_i) are indicated. The search field used was the title, abstract, and keywords (TITLE-ABS-KEY). Boolean operators (AND and OR) were used to include both sets of strings or a combination of strings, quotation marks (“”) were used to include the exact strings, and wildcards (*) were used to include any other string following that set of strings. For clarity, brackets are colour coded, with the highest order being blue, followed by orange and then by red.

Search entry	n_i
TITLE-ABS-KEY:("frugal innovat*" OR "frugal engineer*" OR "constrain*-based innovat*" OR "constrain* based innovat*" OR "bottom-of-the-pyramid" OR "bottom of the pyramid" OR "BoP" OR "Jugaad innovat*" OR "grassroot innovat*" OR "social* driven innovat*" OR "social-driven innovat*") **AND** TITLE-ABS-KEY:("adopt*" OR "diffus*" OR “user-accept*” OR “user accept*” OR "implement*" OR "fail*" OR "non-successful" OR "no success" OR "abandon*" OR "absor* capacit*" OR "use" OR "using" OR "acquisition" OR "acquire" OR "roll-out" OR "roll out" OR "market introduction" OR “scale-up” OR “scaling-up” OR “scale up” OR “scaling up”) **AND** TITLE-ABS-KEY:(“framework” OR “theor*” OR “model” OR “guideline*” OR “enabl*” OR “barrier” OR “attribute” OR “concept”) **AND** TITLE-ABS-KEY:("diagnostic*" OR ("med*" AND ("device*" OR “equipment” OR "technol*" OR “innovation*")) OR ("health*" AND ("device*" OR “equipment” OR "technol*" OR “innovation*")))	245

The subject, methodology, and relevance score of the retrieved articles are shown in Table A2. The case-studies by Auma et al. (2023), Nanath (2011), and Webb et al. (2022) were considered of low relevance, considering that case studies did not study FHI adoption from a theoretical perspective, and also lack generalizability. The studies by Lundin, and Dumont (2017) and Miesler et al. (2020) were considered of medium relevance because, even though they did not study FHI adoption from a theoretical perspective, these studies did propose a list of factors affecting the adoption of FHIs derived from multiple sources, in contrast to the case studies, therefore contributing to the generalizability of the results. The study of Arshad (2021) was considered of high relevance, because Arshad (2021) did derive factors affecting the diffusion, yet not adoption, of FHIs by applying a theoretical framework.

Table A2. *Subject, methodologies, and relevance score of the articles discussed in the knowledge gap.* The study (Study), subject and methodologies (Subject and methodologies), and relevance score (Relevance) are indicated. Articles are sorted by relevance score.

Article	Subject and methodologies	Relevance
Auma et al. (2023)	**Subject:** Integration of a task-shifted, point-of-care, prevention program in a community-based public health facility in Uganda **Methodology:** Case-study	Low
Nanath (2011)	**Subject:** Scaling of a social-innovation-based hospital at the Indian Bottom-of-the-Pyramid market **Methodology:** Case-study	
Webb et al. (2022)	**Subject:** Adoption of a frugal surgery device in Indian Bottom-of-the-Pyramid markets **Methodology:** Case-study	
Lundin, & Dumont (2017)	**Subject:** Factors affecting the scalability and sustainability of frugal mobile image- and sensor-based diagnostics **Methodology:** Examples from the literature, anecdotal evidence	Medium
Miesler et al. (2020)	**Subject:** Analysis of technological complexity, usability, current advantages, and shortcomings of point-of-care diagnostics **Methodology:** Examples from the literature	
Arshad (2021)	**Subject:** Factors affecting the diffusion of frugal health innovations in developing and emerging economies **Methodology:** Systematic literature review, interviews	High

Appendix B: Adoption, diffusion, user-acceptance and implementation theories, models, and frameworks

To determine which theories, models, and frameworks exist that enable the analysis of technology adoption, diffusion, implementation, and user-acceptance of technology, review articles describing theories, models, and frameworks used to analyse technology adoption and user-acceptance of technology (Taherdoost, 2018), medical device adoption and diffusion in low- and middle income countries (Adlung, n.d.), and technology implementation in the healthcare sector (Nilsen, 2015) were consulted. Individual theories, models, and frameworks are presented in Table A3 and emerging models, and frameworks are presented in Table A4.

Table A3. *Individual theories, models, and frameworks used to describe technology adoption and user-acceptance of technology, the adoption and diffusion of medical devices in low- and middle-income countries, and technology implementation in the healthcare sector.* An overview of the theories, models, frameworks (Theories, models, frameworks) is given. a: Adapted from Nilsen (2015); b: Adapted from Adlung (n.d.); c: Adapted from Taherdoost (2018).

Theories, models, frameworks
Absorptive Capacity Theory [a]
Active Implementation Framework [a]
Capability, Opportunity, Motivation, and Behaviour [a]
Capacity-Opportunities-Motivation-Behaviour Theory [a]
Cognitive Continuum Theory [a]
Cognitive-Experiential Self-Theory [a]
Compatibility Beliefs Theorization from Technology Acceptance Research [b]
Compatibility Unified Theory of Acceptance and Use of Technology [c]
Conceptual Model for Considering the Determinants of Diffusion, Dissemination, and Implementation of Innovations in Health Service Delivery and Organization [a]
Consolidated Framework for Implementation Research [a]
Diffusion of Innovations Theory [a, b, c]
Dynamic Sustainability Framework [b]
Igbaria's Model [c]
Implementation Climate [a]
Institutional Theory [a]
Knowledge Translation Theory [a]
Leavitt's Concept of Organizational Forces in Equilibrium [b]
Medical Research Council Framework [b]
Model of PC Utilization [c]
Motivational Model [c]
Network Theory [a]
Normalization Process Theory [a]
Novice-Expert Theory [a]
Organizational Readiness Theory [a]
Perceived Characteristics of Innovating Theory [c]
Promoting Action on Research Implementation in Health Services Framework [a]
Reach, Effectiveness, Adoption, Implementation, and Maintenance Framework [b]
Situated Change Theory [a]
Social Cognitive Theory [c, a]
Strengths, Weaknesses, Opportunities, and Threats Analysis [b]
Technology Acceptance Model [c, b]
Theoretical Domains Framework [a]
Theory of Interpersonal Behaviour [a, c]
Theory of Planned Behaviour [a, c]

Continuation of Table A3
Theory of Reasoned Action [a, c]
Theory of Structural Holes [a]
Understanding-User-Context Framework [a]
Unified Theory of Acceptance and Use of Technology [b, c]
Unified Theory of Acceptance and Use of Technology 2 [c]
Uses and Gratification Theory [c]
Framework by Durlak, & DuPre (2008) [a]
Framework by Alami et al. (2020) [b]
Framework by Nandakumar et al. (2009) [b]
Framework by Marcelo, Adejumo, & Luna (2011) [b]
Framework by Spicer et al. (2018) [b]
Framework by Ekie, & Ekie (2022) [b]
Framework by O'Donnell et al. (2018) [b]
Framework by Subramanian et al. (2016) [b]

Table A4. *Emerging models and frameworks developed to describe the adoption and diffusion of medical devices in low- and middle-income countries.* The underpinning (Underpinning) and the resulting emerging (Emerging) models and frameworks are presented. All information was adapted from Adlung (n.d.).

Underpinning	Emerging
Underpinning: Fit between Individuals, Task, and Technology Framework, Self-efficacy Theory, Technology-to-Performance Chain Model, Political, Economic, Social, Technological, Environmental, Legal, and Infrastructural Toplogy, Technology Acceptance Model	Framework by Abejirinde et al. (2018)
Underpinning: Reverse Innovation Theory, Diffusion of Innovations Theory, Gladwells' Innovation Adoption Tipping Point, Berwick's seven rules to nurture innovation, Govindarajan & Trimble five innovation gaps	Model by DePasse, & Lee (2013)
Underpinning: Unified Theory of Acceptance and Use of Technology, Diffusion of Innovations Theory, Technology Acceptance Model, Modified Theory of Planned Behavior, Theory of Interpersonal Behavior, Kifle's Adoption Model	Model by Adelakun et al. (2016)
Underpinning: Promoting Action on Research Implementation in Health Services Framework, Medical Research Council Guidance	Framework by Teriö et al. (2019)
Underpinning: WHO's Managing the Mismatch Guidelines, WHO's Manual for Surgical Care, WHO's Medical Device Regulation Guidelines, European Safety Regulations	Framework by Oosting et al. (2018)
Underpinning: mHealth Readiness Conceptual Framework	Framework by Khatun et al. (2016)
Underpinning: WHO's Implementation Research Framework	Model by Rahman et al. (2022)
Underpinning: Training Programs in Radiation Therapy, ESTRO's Core Curricula, AAPM's Report on Education and Training for Medical Physicists, IAEA documents describing training for Medical Physicist	Framework by Brown et al. (2014)
Underpinning: Context-Mechanism-Outcome Framework	Model by Kabongo et al. (2021)
Underpinning: Idea, Development, Exploration, Assessment, Long-term Follow-up Framework, Global Competency Framework for Clinical Research, WHO Medical Device Technical Series, WHO Health Technology Assessment of Medical Devices Guidelines	Model by Bolton et al. (2019)
Underpinning: Consolidated Framework for Implementation Research, Levels of Change Framework, Reach Effectiveness Adoption Implementation Maintenance, McLeroy's Socioecological Model	Framework by Sung et al. (2022)
Underpinning: National Innovation System approach, Regional Innovation System approach, Sectoral Innovation System approach, Technological Innovation System approach	Framework by Leonard, De Kock, & Bam (2019)
Underpinning: Technology Acceptance Model, Task-Technology Fit Framework, Unified Theory of Acceptance and Use of Technology 2	Model by Shanko, Negash, & Bandyopadhyay (2016)
Underpinning: Consolidated Framework for Implementation Research, Integrated Promoting Action of Research Implementation in Health Services Framework	Framework by Leonard et al. (2020)
Underpinning: Fit-variability Model, Task-Technology Fit Framework	Model by Archer et al. (2021)

Continuation of Table A4	
Underpinning: Unified Theory of Acceptance and Use of Technology, Unified Theory of Acceptance and Use of Technology 2, Extended Unified Theory of Acceptance and Use of Technology, Patient Activation Measure, Consumer Health Informatics: Levels of Service	Model by Yakubu et al. (2021)

Appendix C: Interview protocol

Semi-structured interviews were conducted according to a pre-set interview protocol. Here, the interview protocol is presented, including that of the mock interview. Interview questions were adjusted according to the stage of the product, e.g. whether the product was in the design/proof-of-concept phase or launched into the market, as outlined below. In short, the protocol indicated that questions 1 through 7 and 14 and 15 should be asked for products that did not leave the design/proof-of-concept phase, and questions 1 through 15 should be asked for products that were introduced into the market. In some cases, questions were already answered by the participants prior to asking those questions and consequently these questions were not deliberately asked.

General information on the interview structure

The interview consisted of an introduction, general questions, research-specific questions, and an ending. The research-specific questions were further divided into a-priori market introduction questions, ex-ante market introduction questions, and continued-use questions in order to maintain focus during the interview and adopt the interview according to the stage of the product. Prompts were included in case the participant was struggling with answering the question, as outlined below, to help the participant think about their answer. In case the responses by the participants were too brief or unclear, follow-up questions were asked on the spot to obtain clarifying information. This was done because it was deemed worthwhile to understand why a certain process impacted the adoption of the innovation. For example, if the response given by the participant was “Regulatory factors.”, the following follow-up questions were asked “What particular factors are you referring to, and can you explain why these factors were considered important for your customers?”. As with any semi-structured interview, the possibility remained to ask follow-up questions in case relevant insights were discovered during the interview.

Interview introduction

Prior to starting the interview, an introduction to the interview was given, consisting of stating the background of the researcher and purpose of the research, defining FHIs and adoption, stating why the participant and their input were considered relevant for the interview and that their specific input was considered valuable, stating the structure, language, and time of the interview, checking the informed consent of the participant, and provide the opportunity to ask clarifying questions by the interviewee. For the definition of FHIs, the following was communicated “For this interview, when I refer to frugal health innovations, I refer to low-cost or resource-efficient health solutions designed to provide maximum value, particularly in resource-constrained environments.”, whereas for the definition of adoption the following was communicated “For this interview, when I refer to adoption, I refer to the process of how your innovation is accepted and used by individuals or institutions.”. This introduction served to establish report with the participant, to ensure that the participant understood common topics returning in the interview, and to ask for any questions or remarks prior to the interview, helping to reduce response bias due to misunderstandings and social desirability. After confirming the informed consent and whether all questions by the interviewee were asked, the interview recording, and automatic transcription of the interview was started.

General questions

1) Can you provide a brief overview of your background and your current role?

2) Can you describe your experience with frugal health innovations?

3) How long have you been working in the field of frugal health innovations?

All three questions were deemed relevant to establish report and to obtain background information that could be of importance for the interpretation and reliability of the results.

Research-specific questions

a-Priori market introduction questions

4) What product characteristics did you consider during the design and production phase, that would help to align your product with your customers?
   Prompt: For example, were there any technical and/or market-related characteristics that you considered?

5) What external, facilitating and hampering, factors outside of your control did you consider when thinking about marketing or introducing your product in its target region/context?
   Prompt: For example, can you think of any regulatory-, economic-, infrastructural- or other factors?

Both questions were deemed relevant to obtain rich data on potential factors facilitating or hampering the adoption from the perspective of the participant. Question 4 particularly focussed on factors that were under the influence of the developer of the FHI as these components could be adjusted in the design or production phase, whereas question 5 focussed on components that were not under the control of the developers. Further, question 4 and 5 were divided up to cover both factors under the influence of the developer and not under the influence of the developer, to maintain focus during the interview. The open character of both questions helped to reduce bias due to leading questions and provided the possibility for the participant to come up with any components that were not yet identified by the interviewer from the literature review.

ex-Ante market introduction questions

6) Did you introduce the product into the market?

If the answer to question 6 is "No", ask question 7:

7) Why did you abandon the project?
   Prompt: For example, were there any specific market-related or technical features that resulted in the abandonment of the product?

If the answer to question 6 is "Yes", ask questions 8 and 9:

8) What unforeseen situations, both under your control and external, resulted in more interest in your product?

9) What unforeseen opposing forces or challenges, both under your control and external, did you encounter during the market introduction?

Question 6 was asked to check whether the product was introduced into the market or not. If the product was not introduced into the market, question 7 provided an opportunity to understand why the product was not introduced. The answer to this question gave insight in possible barriers to adoption. If the product was, however, introduced into the market, question 8 and 9 provided the opportunity to understand whether there were any barriers or facilitators observed during the market introduction phase. It is possible that during the design and production phase, the developer did not think of certain factors that may have shown to be important later on during the market introduction phase, which was the reason for asking questions 8 and 9. Further, question 8 and 9 were divided up to cover both facilitators and barriers to maintain focus during the interview. For question 7, 8, and 9, again, the open character provided the opportunity to obtain rich data from the participants and helped to decrease bias due to leading questions.

Continued-use questions

10) Is your product currently in use by customers?

If the answer to question 10 is "No", ask question 11:

11) Can you describe the process of product abandonment?
    Prompt: For example, can you mention the moment you observed a decrease in sales or when you noticed that certain parties were not interested in your product anymore, or was there anything particular addressed by your customers?

If the answer to question 10 is "Yes", ask questions 12 and 13:

12) What features are customers positive about?

13) What features are customers negative about?

Question 10 was asked to check whether the product was still in use by customers. If the product was not in use anymore, question 11 provided the opportunity to extract reasons for product abandonment that could be acting as a barrier to the continued use of the product. If the product was still in use by the customers, question 12 provided the opportunity to understand what possibly resulted in the continued use of the product, whilst question 13 provided the opportunity to obtain insights in possible barriers to adoption, albeit weaker than the facilitators addressed in question 12 as the product would still be in use. Besides, question 12 and 13 explicitly focus on the consumer rather than the producer, to obtain information from a different perspective as was done for the previous questions. For question 11, 12, and 13, again, the open character provided the opportunity to obtain rich data from the participants and helped to decrease bias due to leading questions.

Ending

If time allowed, the list of factors that were identified during the literature review were briefly scanned through. In case factors were not mentioned yet by the participant, it was stated that the relevance of some components not yet mentioned in the interview, but found to be relevant in the literature, were going to be checked, and that either way, if these components were considered important or not by the interviewee, the answer would be relevant. Consequently, the following question was asked:

14) I have not heard you mention **x**, do you think that **x** is important for the adoption of your product?

The interview was concluded by thanking the participant for their input and asking the following final question:

15) Is there anything that we may have missed during this interview that you consider to be important in the context of adoption of frugal health innovations?

Question 14 and 15 were considered of importance as this helped to gain insight in any concepts that were not yet addressed by the interviewee. Question 15 provided the opportunity to obtain this information without the bias of leading questions, whilst question 14 did not provide this opportunity. However, prior to asking question 14, it was introduced that either way, whether the participant did think about the component addressed or not, the answer to the question was deemed relevant, to decrease bias due to leading questions and social desirability. In question 14, **x** referred to either of the following concepts:

- Lifestyle Compatibility
- Consumer Literacy
- Trust
- Performance Expectancy
- Effort Expectancy
- Social Influence
- Price Value
- Facilitating Conditions

Innovation stage-dependent questions

Depending on the stage of the innovation, different interview questions were asked (Table A5). For the developer of the mosquito-killing algae, question 6 was not asked because it was already evident prior to the interview that the developer was transitioning from the design phase to the proof-of-principle phase. Similarly, for the developer of the low-cost Magnetic Resonance Imaging scanner, question 6 was not asked as it became evident during the interview that the innovation was still being developed. For the developer of the point-of-care tuberculosis diagnostic kit, the interviewee stated themselves already that the project was abandoned prior to being able to ask question 6, which was therefore not asked. Some errors were made, where question 15 was asked prior to question 14, after which question 15 was asked again during the interview with the developer of the point-of-care tuberculosis diagnostic kit, question 3 and questions 6, 8, 9, 14, and 15 were not asked during the interview with the developer of the portable Polymerase Chain Reaction workstation because question 3 was already answered earlier and the other questions could not be asked due to time constraints, and question 14 was not asked during the interview with the developer of the low-cost Magnetic Resonance Imaging scanner due to time constraints.

Table A5. *Questions asked during the interviews depending on the stage of the innovation.* The innovation (Innovation), stage of the innovation (Stage), and asked interview questions (Question) are presented.

Innovation	Stage	Question
Mosquito-killing algae	Design phase, continuing	1, 2, 3, 4, 5, 14, 15
Point-of-care tuberculosis diagnostic kit	Proof-of-concept, abandoned	1, 2, 3, 4, 5, 7, 14, 15
Portable Polymerase Chain Reaction workstation	Market introduction, adopted	1, 2, 4, 5, 10, 12, 13
Low-cost Magnetic Resonance Imaging scanner	Proof-of-concept, continuing	1, 2, 3, 4, 5, 15

Mock interview

The mock interview followed the same protocol and questions as described above, with the addition of finding definitions of concepts and higher orders of constructs, by asking the following two questions:

1) How would you describe **x**?

2) Do you consider **x**, **y**, and **z** to correspond to **1**, **2**, or **3**?

Question 1 was asked to understand how the participant would describe a certain concept, in order to determine how the constructs of framework 2.0 could be better defined with **x** referring to the concepts shown for question 15 above. Question 2 was asked to understand which constructs could correspond to a higher order construct, where **x**, **y**, and **z** correspond to lower order constructs and **1**, **2**, and **3** correspond to higher order constructs.

Appendix D: Diffusion, gratification, user-acceptance, and unified theories, models, and frameworks

To determine which theories, models, and frameworks are most appropriate in the context of FHIs, their limitations were analysed in terms of the context of FHIs. Here, an in-depth overview of the theories, models, and frameworks is provided, including construct definitions where needed.

Diffusion theories

Based on empirical evidence and previous research by other scholars, Rogers (1983, pp. 163 – 238) constructed the DoIT (Figure A2). The DoIT argues that four main elements influence the diffusion process, being *(i)* the Innovation; *(ii)* Communication Channels; *(iii)* Time; and *(iv)* the Social System. It further divides the consumers' decision process to use an innovation into five stages, being the *(i)* Knowledge Stage; *(ii)* Persuasion Stage; *(iii)* Decision Stage; *(iv)* Implementation Stage; and *(v)* Confirmation Stage, where Communication Channels are used for information exchange about the Innovation over Time in a Social System. Briefly, in that same order, the process is described as the individual being exposed to the innovation and gaining some understanding of its' function, forming a(n)

(un)favourable attitude toward the innovation, deciding to accept or reject the innovation, putting the innovation to use, and seeking reinforcement of the innovation-decision. Throughout the entire process, Prior Conditions, including Previous Practices, Felt Needs or Problems, the Innovativeness of the individual, and the Social System Norms affect the innovation-decision process. Importantly, the Characteristics of the Individual, being the Socio-economic, Personality, and Communication Behaviour, differentiates between early or late adopters of the innovation during the Knowledge Stage. Furthermore, during the Persuasion Stage, the Perceived Characteristics of the Innovation, being Relative Advantage, Compatibility, Complexity, Trialability, and Observability of the innovation affect whether the attitude is positive or negative. More specifically, Relative Advantage is achieved when the innovation proposes a better alternative than incumbent innovations in terms of economic advantages or social benefits, Compatibility is achieved when the innovation fits well with the current practices and needs of the individual, Complexity refers to the ease-of-use of the innovation, Trialability is achieved when the individuals can do experiments on a limited basis with the innovation, and Observability is achieved when the benefits of the innovation are observable by the individuals and those surrounding them. Additionally, due to inherent uncertainties in the innovation, the Practicality of the innovation is evaluated during the Implementation Stage. Throughout the Decision, Implementation, and Confirmation Stage, the innovation can be adopted or rejected, which occurs either actively or passively. During active adoption or rejection, the innovation is either continuously used or rejected, whereas the process is inverted during passive adoption or rejection.

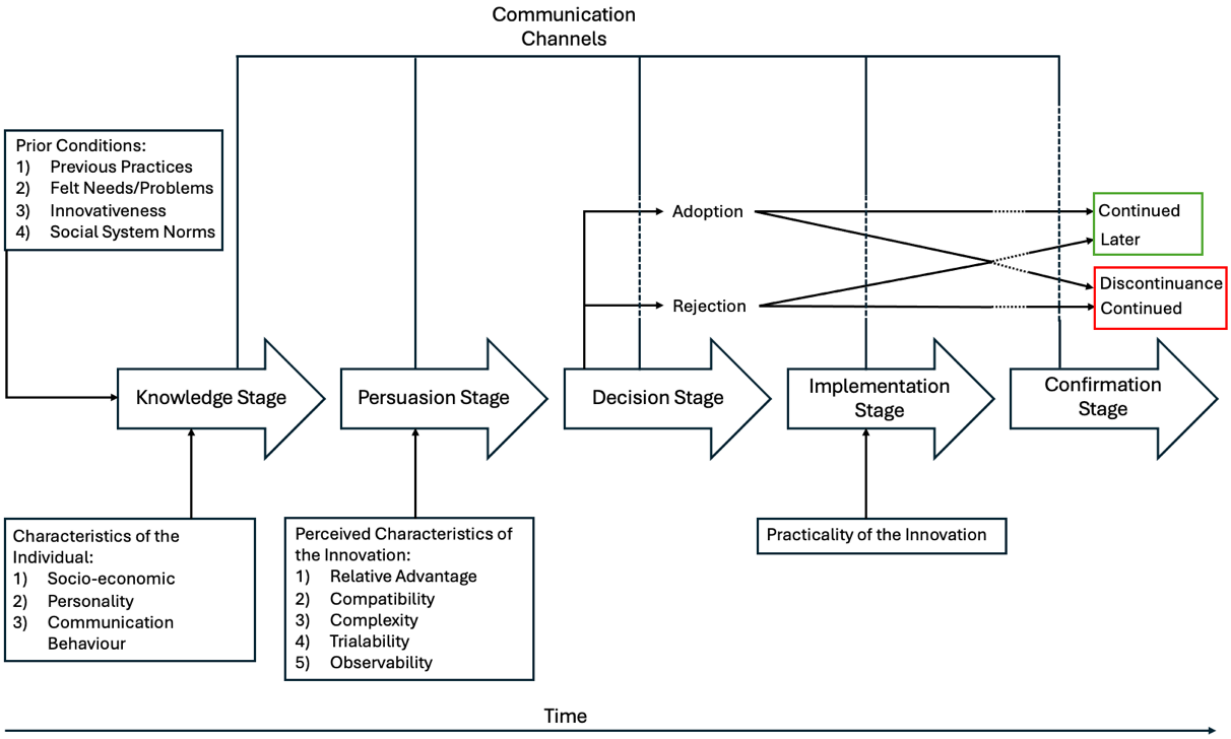

Figure A2. *Schematic representation of the Diffusion of Innovations Theory*. The theory describes five stages, being the Knowledge Stage, Persuasion Stage, Decision Stage, Implementation Stage, and Confirmation Stage. The individual goes through these stages across Time where Communication Channels are used for exchange of information. Throughout the entire process, Prior Conditions affect all stages, which include Previous Practices, Felt Needs or Problems, Innovativeness, and Social System Norms. The Characteristics of the Individual during the Knowledge Stage, determined by Socio-economic characteristics, the Personality, and the Communication Behaviour, determine whether the individual is an early or a late adopter. The Perceived Characteristics of the Innovation affect the Persuasion Stage, which include Relative Advantage, Compatibility, Complexity, Trialability, and Observability. During the Decision Stage, the individual either adopts or rejects the innovation, which is a process that continues during the Implementation Stage and the Confirmation Stage, ultimately resulting in Continued Adoption or Later Adoption (green box) or Discontinuance or Continued Rejection (red box). During the Implementation Stage, the Practicality of the Innovation is also considered. Adapted from Rogers (1983, pp. 163 – 238).

Gratification theories

The UGT was developed by Katz et al. (1973) to understand the decision of media usage by individuals (Figure A3). The theory's main proposal is that media users seek Gratification which results in Media Usage. Gratification refers to the fulfilment of using an innovation whereas Media Usage refers to the actual usage of the medium. The theory

proposes that users are active media members that consciously and with full control select preferred, competing content, and that media usage is goal-oriented and based on psychological factors. Further, Gratification is fulfilled by meeting a certain set of Needs, which are Cognitive Needs, Affective Needs, Personal Integrative Needs, Social Integrative Needs, and Tension Release Needs. In that same order, these components refer to provision of information and knowledge, experienced emotions, exploration and expression of values and identities, facilitation of social interaction, connection, and a sense of belonginess, and experience of relaxation and stress relief.

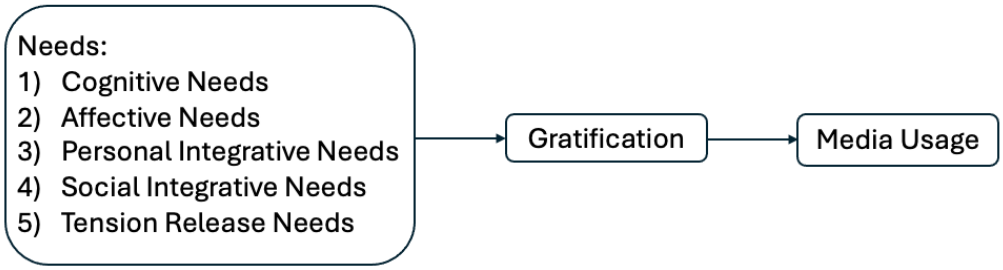

Figure A3. *Schematic representation of the Uses and Gratification Theory*. Gratification affects Media Usage and Gratification is fulfilled by meeting the five Needs, being Cognitive Needs, Affective Needs, Personal Integrative Needs, Social Integrative Needs, and Tension Release Needs.

Behavioural intention models and frameworks

Behavioural intention models and frameworks aim to describe the factors that affect the Behavioural Intention of an individual, defined as the likelihood for an individual to conduct a particular behaviour, which ubiquitously results in the actual Behaviour, defined as the act of doing something (Fishbein, & Ajzen, 1975). Behavioural intention models and frameworks include the TRA, TPB, TAM, CATM, and the VAM.

In the socio-psychological literature, Fishbein, and Ajzen (1975) constructed the TRA (Figure A4A). The TRA argues that individuals make cognitive decisions by continuously calculating and evaluating the outcome of a particular behaviour, and introduces Behaviour affected by an individuals' Behavioural Intention. The Behavioural Intention, in turn, is affected by the individuals' Attitude and Subjective Norms, with the former referring to the way the individual feels toward the Behaviour, including whether or not the outcome is probable and whether or not the outcome is positive or not, and the latter referring to the perceived social pressure to perform or not perform the Behaviour, including the standpoint of the social group toward the Behaviour and the need to comply with the social group. The TRA further states that the Behaviour must be defined in terms of Action, Target, Context, and Time. In that same order, these components refer to a particular performable activity, the actual innovation, where it takes place, how the innovation is used and what is done with the innovation, and a particular timespan. To predict the actual Behaviour from the Behavioural Intention, three conditions must be met, being *(i)* the Behavioural Intention is specific; *(ii)* the Behavioural Intention does not change before conducting the Behaviour; and *(iii)* there exists ultimate voluntariness, i.e. the individual has complete control over Behaviour. The TPB, in contrast, aims to overcome the issue with complete voluntariness of the Behaviour by introducing Perceived Behavioural Control, referring to the perceived ease or difficulty in performing the Behaviour (Ajzen, 1991) (Figure A4A). The TPB builds further on the TRA, by introducing bidirectional relations between Perceived Behavioural Control, Attitude, and Subjective Norms. Further, Perceived Behavioural Control also affects Behavioural Intention and Behaviour directly.

The TAM is a derivative of the TRA constructed by Davis (1989) to study information and communication technology adoption in organizations (Figure A4B). Specifically, Davis (1989) translated the Behavioural Intention and the Behaviour from the TRA and TPB to the Behavioural Intention to adopt an innovation and the Adoption, respectively. In that sense, Behavioural Intention to adopt refers to the likelihood for an individual to adopt the innovation and Adoption refers to the actual use of the innovation. Based on empirical evidence, Davis (1989) confirmed that the Behavioural Intention to adopt is affected by the Perceived Usefulness and the Perceived Ease of Use of the innovation. Further, Perceived Usefulness directly affects Adoption and Perceived Ease of Use affects Perceived Usefulness. In short, Perceived Usefulness refers to the degree to which an individual believes using the particular innovation enhances their job performance and Perceived Ease of Use refers to the degree to which an individual believes the use of the innovation is free from effort. Considering TAM's lack of emotional factors and

particular product characteristics, Kulviwat et al. (2007) introduced the CATM to study the adoption of information and communication technologies in the consumer context (Figure A4C). The CATM reintroduces Attitude from the TRA and TPB, which ultimately affects the Behavioural Intention to adopt. Further, it relates the constructs Perceived Usefulness from the TAM to Attitude, and only describes a statistically significant relationship for Perceived Ease of Use on Perceived Usefulness. For newly introduced constructs, the CATM describes an effect of Relative Advantage on Perceived Usefulness and Pleasure and Arousal on Attitude. The CATM follows the same definitions as the TAM, as well as the DoIT for Relative Advantage, and defines Pleasure as the degree to which an individual experiences an enjoyable reaction to a certain stimulus and Arousal as a combination of mental alertness and physical response toward a certain stimulus. Considering the limitations of the TAM in individual contexts, Kim et al. (2007) developed the VAM by looking into the trade-off between benefits and sacrifices of the use of information and communication technologies (Figure A4D). The VAM maintains the core structure and definition of the TAM, that is, the Intention to adopt, but replaces Perceived Usefulness and Perceived Ease of Use by Perceived Value, which refers to the comparison of Perceived Benefits and Perceived Sacrifices of using an innovation. Perceived Benefits are defined as Usefulness and Enjoyment, where Usefulness refers to extrinsic and cognitive benefits and is defined as the total value that an individual experiences from using a technology, and Enjoyment refers to intrinsic and affective benefits and is defined as the extent to which the activity of using the innovation brings joy. Perceived Sacrifices are defined as the Technicality and Perceived Fee of the innovation, where the Technicality of the innovation refers to non-monetary sacrifices and is defined as the degree to which the innovation is perceived as technically relevant, and Perceived Fee of the innovation refers to monetary sacrifices and is defined as the direct fee required to use the innovation. Naturally, Perceived Sacrifices are negatively related to Perceived Value.

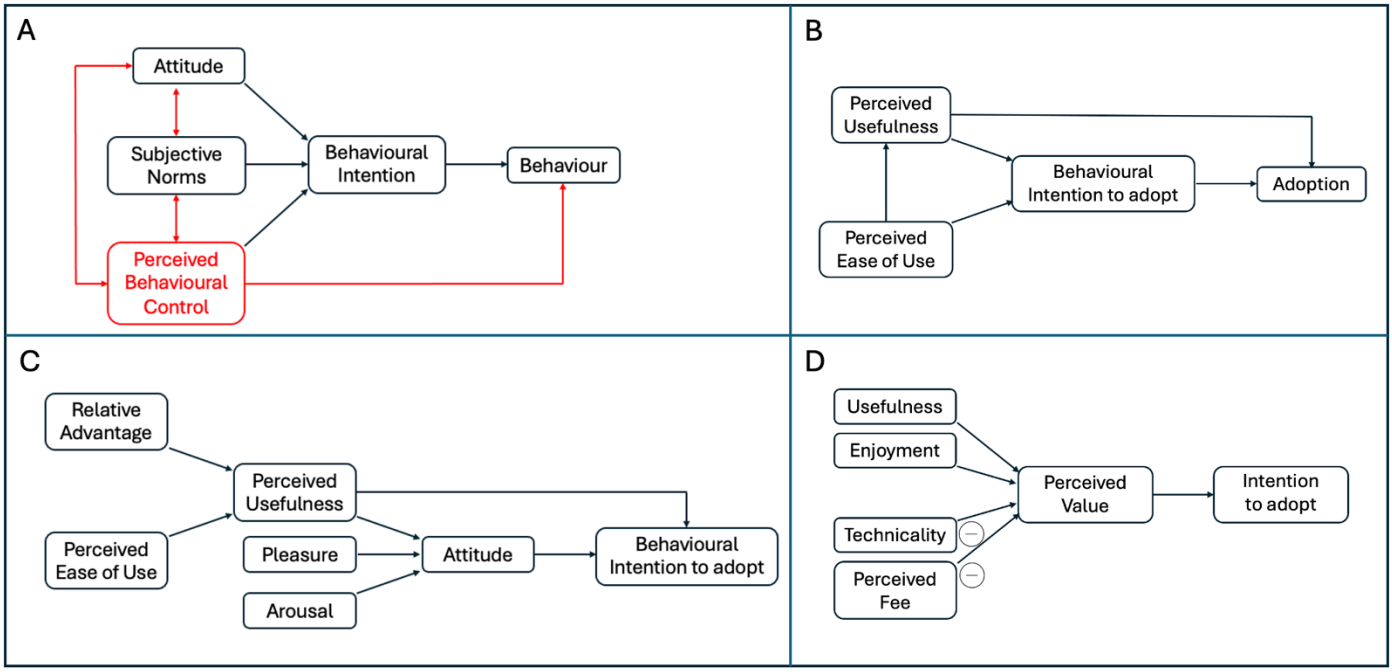

Figure A4. *Schematic representation of behavioural intention models and frameworks.* **A:** The Theory of Reasoned Action (black) and the Theory of Planned Behaviour (red). Behavioural Intention and Perceived Behavioural Control affect Behaviour. Attitude, Subjective Norms, and Perceived Behavioural Control affect Behavioural Intention. Further, bidirectional relationships exist between Attitude, Subjective Norms, and Perceived Behavioural Control. Adapted from Fishbein, and Ajzen (1975) and Ajzen (1991). **B:** Technology Acceptance Model. The Behavioural Intention to adopt and Perceived Usefulness affect the Adoption of an innovation. Perceived Ease of Use and Perceived Usefulness affect the Behavioural Intention to adopt, and Perceived Ease of Use also affects Perceived Usefulness. Adapted from Davis (1989). **C:** The Consumer Acceptance of Technology Model. Attitude and Perceived Usefulness affect the Behavioural Intention to adopt. Perceived Usefulness, Pleasure, and Arousal affect Attitude, and Relative Advantage and Perceived Ease of Use affect Perceived Usefulness. Adapted from Kulviwat et al. (2007). **D:** Value-based Adoption Model. Perceived Value affects the Intention to adopt, whereas Usefulness, Enjoyment, Technicality, and Perceived Fee affect Perceived Value. Usefulness and Enjoyment are defined as Perceived Benefits, and Technicality and Perceived Fee are defined as Perceived Sacrifices. Negative relationships are presented by the minus sign. Adapted from Kim et al. (2007).

A unified theory

According to the empirical evidence from Venkatesh et al. (2003), the constructs of the UTAUT, and thus also those present in the UTAUT 2, encompass the constructs of eight different theoretical perspectives, including the constructs of some of the theoretical perspective used to study the adoption of FIs, being the TAM, TRA, TPB, and DoIT (Table A6). Although Venkatesh et al. (2003) did not consider the VAM, CATM, and UGT in their framework, which have also been used to study the adoption of FIs as presented above, it can be argued that the UTAUT 2 also encompasses their constructs (Table A6). As the CATM contain several constructs with the same definition as the TAM, DoIT, TRA, and TPB, being Perceived Usefulness, Perceived Ease-of-Use, and Relative Advantage, it follows from the same argumentation of Venkatesh et al. (2003) that the UTAUT 2 also encompasses the constructs of the CATM. Although the CATM also includes Attitude, Attitude does not affect Behavioural Intention to adopt significantly when Performance Expectancy and Effort Expectancy are present in the framework (Venkatesh et al., 2003), and thus it can be argued that this construct does not need to be represented in the UTAUT 2. Further, it can be argued that Hedonic Motivation in UTAUT 2 represents Pleasure and Arousal in the CATM and Enjoyment in the VAM, as Hedonic Motivation refers to the fun or pleasure derived from using a technology. Furthermore, Price Value in UTAUT 2 refers to the trade-off between benefits of the technology and the monetary costs, thereby possibly relating the benefits to Technicality in the VAM, monetary costs to Perceived Fee in the VAM, and the cognitive trade-off to Perceived Value in the VAM and Usefulness in the CATM. However, Needs in the UGT, referring to specific user-related needs that need to be fulfilled, and Gratification in the UGT, referring to the fulfilment of these needs, do not seem to be represented by any construct in the UTAUT 2. Most interestingly, Habit in UTAUT 2 does not represent any constructs from the other theories, models, and frameworks.

Table A6. *Constructs of the Unified Theory of Acceptance and Use of Technology (2) that encompass constructs from the other theories, models, and frameworks used to study the adoption of frugal innovations.* The construct of the Unified Theory of Acceptance and Use of Technology (2) (Construct), the construct definition (Definition), and the incorporated constructs from the other theories, models, and frameworks (Incorporates) are presented. Note that the constructs Behavioural Intention and Use Behaviour from the Unified Theory of Acceptance and Use of Technology (2) are not included, as they directly were adapted from the Theory of Reasoned Action and included in the other theories, models, and frameworks, except for the Uses and Gratification Theory. a: Constructs only present in the Unified Theory of Acceptance and Use of Technology 2; b: Constructs hypothesized to be included as argued in this research study and not by Venkatesh et al., 2003; *: Habit does not seem to represent any constructs from the other theories, models, and frameworks.

Construct	Definition	Incorporates	Definition
Performance Expectancy	"The degree to which an individual believes that using the system will help him or her to attain gains in job performance" (Venkatesh et al., 2003) "The degree to which using a technology will provide benefits to consumers in performing certain activities" (Venkatesh et al., 2012)	Perceived Usefulness (Technology Acceptance Model) (Venkatesh et al., 2003)	The degree to which an individual believes using the particular innovation enhances their job performance (Davis, 1989)
		Perceived Usefulness (Consumer Acceptance of Technology Model)[b]	The degree to which an individual believes using the particular innovation enhances their job performance (Kulviwat et al., 2007)
		Relative Advantage (Diffusion of Innovations Theory) (Venkatesh et al., 2003)	The innovation proposes a better alternative than incumbent innovations in terms of economic advantages or social benefits (Rogers, 1983, pp. 163 – 238)
		Relative Advantage (Consumer Acceptance of Technology Model)[b]	The innovation proposes a better alternative than incumbent innovations in terms of economic advantages or social benefits (Kulviwat et al., 2007)
Effort Expectancy	"The degree of ease associated with the use of the system" (Venkatesh et al., 2003)	Perceived Ease-of-Use (Technology Acceptance Model) (Venkatesh et al., 2003)	The degree to which an individual believes the use of the innovation is free from effort (Davis, 1989)
		Perceived Ease-of-Use (Consumer Acceptance of Technology Model)[b]	The degree to which an individual believes use of the innovation is free from effort (Kulviwat et al., 2007)
		Complexity (Diffusion of Innovations Theory) (Venkatesh et al., 2003)	The ease-of-use of the innovation (Rogers, 1983, pp. 163 – 238)

Continuation of Table A6.			
Social Influence	"The degree to which an individual perceives that important others believe he or she should use the new system" (Venkatesh et al., 2003)	Subjective Norms (Theory of Reasoned Action) (Venkatesh et al., 2003)	The perceived social pressure to perform or not perform behaviour (Fishbein, & Ajzen, 1975)
		Subjective Norms (Theory of Planned Behaviour) (Venkatesh et al., 2003)	The perceived social pressure to perform or not perform behaviour (Ajzen, 1991)
		Observability (Diffusion of Innovations Theory) (Venkatesh et al., 2003)	The benefits of the innovation are observable by the individuals and those surrounding them (Rogers, 1983, pp. 163 – 238)
Hedonic Motivation[a]	"The fun or pleasure derived from using a technology" (Venkatesh et al., 2012)	Pleasure (Consumer Acceptance of Technology Model)[b]	The degree to which an individual experiences an enjoyable reaction to a certain stimulus (Kulviwat et al., 2007)
		Arousal (Consumer Acceptance of Technology Model)[b]	A combination of mental alertness and physical response toward a certain stimulus (Kulviwat et al., 2007)
		Enjoyment (Value-based Adoption Model)[b]	Intrinsic and affective benefits and is defined as the extent to which the activity of using the innovation brings joy (Kim et al., 2007)
Price Value[a]	"The cognitive trade-off between the perceived benefits of the applications and the monetary cost for using them" (Venkatesh et al., 2012)	(Perceived) Usefulness (Value-based Adoption Model, Consumer Acceptance of Technology Model)[b]	The total value that an individual experiences from using a technology, both extrinsic and cognitive (Kim et al., 2007)
		Technicality (Value-based Adoption Model)[b]	Non-monetary sacrifices and is defined as the degree to which the innovation is perceived as technically relevant (Kim et al., 2007)
		Perceived Fee (Value-based Adoption Model)[b]	Monetary sacrifices and is defined as the direct fee required to use the innovation (Kim et al., 2007)
		Perceived Value (Value-based Adoption Model)[b]	The comparison of Perceived Benefits (Usefulness and Enjoyment) and Perceived Sacrifices (Technicality and Perceived Fee) of using an innovation (Kim et al., 2007)
Habit[a]	"The extent to which people tend to perform behaviours automatically because of learning" (Venkatesh et al., 2012)	*	*
Facilitating Conditions	"The degree to which an individual believes that an organizational and technical infrastructure exists to support use of the system" (Venkatesh et al., 2003) "The consumers' perceptions of the resources and support available to perform a behaviour" (Venkatesh et al., 2012)	Perceived Behavioural Control (Theory of Planned Behaviour), (Venkatesh et al., 2003)	The perceived ease or difficulty in performing the Behaviour (Ajzen, 1991)
		Compatibility (Diffusion of Innovations Theory) (Venkatesh et al., 2003)	The innovation fits well with the current practices and needs of the individual (Rogers, 1983, pp. 163 – 238)

Appendix E: Quality assessment of studies from the literature review

To conduct the quality assessment, the Mixed Methods Appraisal Tool was used (Hong et al., 2018). The screening questions, being the same for all studies, and the quality assessment questions, being dependent on the type of study, are presented in Table A7.

Table A7. *Screening questions to determine whether studies could be assessed with the Mixed Methods Appreciation Tool and corresponding quality assessment questions per study type.* The type of question (Type) and actual question (Question) for each type of study are represented. Q_{MM}: Mixed methods study assessment question; Q_{QL}: Qualitative study assessment question; $Q_{QT,Des}$: Quantitative descriptive study assessment question; $Q_{QT,N\text{-}ran}$: Quantitative non-randomized study assessment question; S: Screening question. Adapted from Hong et al. (2018).

Type	Question
S 1	"Are there clear research questions?"
S 2	"Do the collected data allow to address the research questions?"
Q_{QL} 1	"Is the qualitative approach appropriate to answer the research question?"
Q_{QL} 2	"Are the qualitative data collection methods adequate to address the research question?"
Q_{QL} 3	"Are the findings adequately derived from the data?"
Q_{QL} 4	"Is the interpretation of results sufficiently substantiated by data?"
Q_{QL} 5	"Is there coherence between qualitative data sources, collection, analysis and interpretation?"
$Q_{QT,N\text{-}ran}$ 1	"Are the participants representative of the target population?"
$Q_{QT,N\text{-}ran}$ 2	"Are measurements appropriate regarding both the outcome and intervention (or exposure)?"
$Q_{QT,N\text{-}ran}$ 3	"Are there complete outcome data?"
$Q_{QT,N\text{-}ran}$ 4	"Are the confounders accounted for in the design and analysis?"
$Q_{QT,N\text{-}ran}$ 5	"During the study period, is the intervention administered (or exposure occurred) as intended?"
$Q_{QT,Des}$ 1	"Is the sampling strategy relevant to address the research question?"
$Q_{QT,Des}$ 2	"Is the sample representative of the target population?"
$Q_{QT,Des}$ 3	"Are the measurements appropriate?"
$Q_{QT,Des}$ 4	"Is the risk of nonresponse bias low?"
$Q_{QT,Des}$ 5	"Is the statistical analysis appropriate to answer the research question?"
Q_{MM} 1	"Is there an adequate rationale for using a mixed methods design to address the research question?"
Q_{MM} 2	"Are the different components of the study effectively integrated to answer the research question?"
Q_{MM} 3	"Are the outputs of the integration of qualitative and quantitative components adequately interpreted?"
Q_{MM} 4	"Are divergences and inconsistencies between quantitative and qualitative results adequately addressed?"
Q_{MM} 5	"Do the different components of the study adhere to the quality criteria of each tradition of the methods involved?"

Using the screening questions and quality assessment questions, the quality of the studies was assessed (Table A8). The major limitation of the Mixed Methods Appraisal Tool is that no overall score can be assigned. Therefore, quality scoring remains subjective to the researcher. To omit bias as much as possible, it was decided to consider the quality of the articles in the context of this research study and the available data. According to the Mixed Methods Appraisal Tool, if studies do not report clear research questions, the study may not be an empirical study and should thus not be analysed with the Mixed Methods Appraisal Tool (Hong et al., 2018). However, as this was true for four studies (Ashoer et al., 2024; Joshi, 2024; Pipitwanichakarn, & Wongtada, 2019; Wentzel et al., 2013) and because relatively little data was obtained, it was decided that studies reporting a research objective, at least, were still included in the analysis. To that extent, it was decided to omit the study by Wentzel et al. (2013) as it also did not state a research objective. Besides, much information required to assess the quality of the study by Wentzel et al. (2013) was missing, no hypotheses were stated, and the measurement items seemed to cover a distinct topic than the topic of interest. The major limitation of the mixed methods studies was the absence of the qualitative analysis (Joshi, 2024; Pipitwanichakarn, & Wongatada, 2019). However, considering that the qualitative phase was used as an input for the quantitative phase, which outlined the factors affecting the adoption of the FIs, i.e. the concept of interest in this research study, it was decided to maintain both studies in the literature review. Interestingly, all remaining quantitative

studies scored poorly in terms of generalizability, either due to not considering a relevant sample strategy, underrepresentation of relevant samples, or a low response rate (Ashoer et al., 2024; Costa et al., 2021; Hasan et al., 2020; Hussain et al., 2019; Joshi, 2024; Osakwe, & Okeke, 2016; Pipitwanichakarn, & Wongtada, 2019; Purohit, & Arora, 2023; Sodhay et al., 2024). However, if the generalizability were to be a reason to omit studies in the literature review of this study, this would indicate that no studies would be included. Therefore, it was decided to exclude this quality criteria, whilst still mentioning this as a major limitation of the literature review. In contrast, for the quantitative study conducted by Osakwe, and Okeke (2016), it is important to note that no operationalization of constructs occurred. Instead, Osakwe, and Okeke (2016) asked participants to rate constructs on a Likert scale directly, introducing a high operationalization bias. Because of this, it cannot be said with certainty whether the considered constructs were actually measured, and hence it was decided to omit the study by Osakwe, and Okeke (2016). It is also important to note, that, although the study by Kumra et al. (2021) showed a high quality score, it was decided to omit this study from the literature review as a qualitative study was conducted, and not a quantitative study, making it difficult to validate the statistical significance of the results.

Table A8. *Quality assessment scoring of articles included in the literature review.* The study, including type of study relevant for the assessment questions and number of participants in the questionnaire (q) or interview (i) (Study), screening questions and quality assessment questions (Question), response to the questions (Response), and explanatory comments for the response (Comment) are indicated. For clarity, bad quality items according to the Mixed Methods Appreciation Tool that were excluded in this assessment are highlighted in orange, bad quality items that resulted in the omission of a research study are highlighted in red, and good quality items are highlighted in green. For the mixed methods studies by Joshi (2024) and Pipitwanichakarn, and Wongtada (2019), the fifth quality assessment question refers to the quality assessment questions of both qualitative- and quantitative research types, which are presented accordingly, including responses and comments. For both mixed methods studies, if more than one item showed a low quality in the sub-questions, i.e. "No" or "Can't tell", the response to the fifth quality assessment question was "No". No explanatory comment was given for the fifth quality assessment question of both mixed methods studies for brevity reasons. For a reference on the questions, see the work by Hong et al. (2018) (Table A7). Q_{MM}: Mixed methods study assessment question; Q_{QL}: Qualitative study assessment question; $Q_{QT,Des}$: Quantitative descriptive study assessment question; $Q_{QT,N\text{-}ran}$: Quantitative non-randomized study assessment question; S: Screening question. [] represents adjustments in the quotes used to make the quotes readable.

Study	Question	Response	Comment
Ashoer et al. (2024). Non-comparative quantitative descriptive study (q 200)	S 1	No	Only the research objective is stated: "To predict the determinants of mobile [finance technology] apps and [digital financial inclusion] among [Bottom-of-the-Pyramid] segment in Indonesia."
	S 2	Yes	Data was gathered from mobile phone users in Indonesia on the intention to use mobile finance technology apps
	$Q_{QT,Des}$ 1	Yes	Conducted convenience sampling, but the Bottom-of-the-Pyramid criteria, access to mobile phones, and internet penetration rate were considered
	$Q_{QT,Des}$ 2	No	Samples were drawn from one urban area, excluding rural participants, thus failing generalizability to the entirety of Indonesia. Other demographic variables were covered
	$Q_{QT,Des}$ 3	Yes	Measurements were not obtained from previous research, but represented the constructs well
	$Q_{QT,Des}$ 4	Can't tell	There is no information on the response rate, only on the number of quality responses
	$Q_{QT,Des}$ 5	Yes	Hypotheses were derived from the research objective and tested using statistical analyses. Internal consistency and convergent- and discriminant validity were determined
Costa et al. (2021). Non-comparative quantitative descriptive study (q 534)	S 1	Yes	"Are young consumers in developed countries likely to buy frugal innovations previously created for bottom of the pyramid (BoP) markets?" ***and*** "What are the main determinants of frugal innovation adoption by young consumers in developed nations?"
	S 2	Yes	Data was collected from young students in Portugal on the intention to use a frugal innovation
	$Q_{QT,Des}$ 1	Yes	The age of participants and developed country criteria were considered
	$Q_{QT,Des}$ 2	No	Data was gathered from students of one university in Portugal, failing generalizability to all developed countries. University students have less funds than working participants, introducing a bias to frugal innovations. Other demographic variables were covered

Continuation of Table A8					
	$Q_{QT,Des}$ 3	Yes	Questionnaire items were adapted from previous validated measurement scales		
	$Q_{QT,Des}$ 4	No	Response rate was 2 %, introducing a high nonresponse bias		
	$Q_{QT,Des}$ 5	Yes	Hypotheses were derived from the research questions and tested through statistical analyses. Internal consistency and convergent- and discriminant validity were determined		
Hasan et al. (2020). Quantitative non-randomized, cross-sectional analytical study (q 509)	S 1	Yes	"Which consumer-based innovation adoption models are most useful in explaining adoption intention in the context of subsistence marketplaces?" ***and*** "How this differs based on service type and geographic area?" ***and*** "How these antecedents affect adoption intention?"		
	S 2	Yes	Data was collected from rural and urban Bottom-of-the-Pyramid participants on the intention to use two services		
	$Q_{QT,N\text{-}ran}$ 1	No	Samples were drawn from participants in Bangladesh, failing generalizability to all subsistence marketplaces. Conducted convenience sampling, but Bottom-of-the-Pyramid criteria, rural and urban participant distribution, and service familiarity were considered. Other demographic variables were covered		
	$Q_{QT,N\text{-}ran}$ 2	Yes	Questionnaire items were adapted from previous validated measurement scales. Hypotheses were derived from the research questions and tested through statistical analyses. Internal consistency and discriminant- and convergent validity were determined		
	$Q_{QT,N\text{-}ran}$ 3	Yes	Data are presented for the suitability of the models, the effects of the antecedents, differences between geographic areas, and differences between service type		
	$Q_{QT,N\text{-}ran}$ 4	Yes	Differences between geographic areas and service type are accounted for and were as intended		
	$Q_{QT,N\text{-}ran}$ 5	Yes			
Hussain et al. (2019). Non-comparative quantitative descriptive study (q 247)	S 1	Yes	"What are the factors affecting the intention to adopt [mobile payment] for the [Bottom-of-the-Pyramid] segment in a developing country?"		
	S 2	Yes	Data was collected from participants in Bangladesh on the intention to use mobile payment systems		
	$Q_{QT,Des}$ 1	Yes	Conducted convenience sampling, but Bottom-of-the-Pyramid criteria were considered		
	$Q_{QT,Des}$ 2	No	Samples were drawn from urban areas in Bangladesh, excluding rural participants, thus failing generalizability to the entirety of a developing country. Other demographic variables were covered		
	$Q_{QT,Des}$ 3	Yes	Questionnaire items were adapted from previous validated measurement scales		
	$Q_{QT,Des}$ 4	Can't tell	There is no information on the response rate, only on the number of quality responses		
	$Q_{QT,Des}$ 5	Yes	Hypotheses were derived from the research question and tested through statistical analyses. Internal consistency and convergent- and discriminant validity were determined		
Joshi (2024). Sequential exploratory mixed methods study (i 26, q 423)	S 1	No	Only the research objective is stated: "To identify and examine factors influencing the development of behavioral intentions to use [unified payment interface] among [Bottom-of-the-Pyramid] segment users."		
	S 2	Yes	Data was gathered from unified payment interface, Bottom-of-the-Pyramid users on the intention to use the unified payment interface		
	Q_{MM} 1	Yes	The qualitative phase provides new information to be used subsequently in the qualitative phase		
	Q_{MM} 2	Can't tell	There is no information on the results of the qualitative phase. The results section jumps immediately into the results of the qualitative phase		
	Q_{MM} 3	Can't tell			
	Q_{MM} 4	Can't tell			
	Q_{MM} 5	No	**Question**	**Response**	**Comment**
			Q_{QL} 1	Yes	Interviews were conducted to obtain new, in-depth information on the constructs of the framework
			Q_{QL} 2	Yes	
			Q_{QL} 3	Can't tell	There is no information on the results of the qualitative

Continuation of Table A8

			Q_{QL} 4	Can't tell	phase
			Q_{QL} 5	Can't tell	
			$Q_{QT,Des}$ 1	Can't tell	There is no information on the sampling strategy, except for sampling unified payment interface users and conducting convenience sampling
			$Q_{QT,Des}$ 2	Can't tell	
			$Q_{QT,Des}$ 3	Yes	Questionnaire items were adapted from previous validated measurement scales
			$Q_{QT,Des}$ 4	Yes	The response rate was relatively high at 81.3 %
			$Q_{QT,Des}$ 5	Yes	Hypotheses were derived from the research objective and tested through statistical analyses. Internal consistency and convergent- and discriminant validity were determined
Pipitwanichakarn, & Wongtada (2019). Sequential exploratory mixed methods study (i 4, q 356)	S 1	No	Only the research objective is stated: "To investigate the applicability of technology acceptance model in explaining technology adoption among street vendors in Thailand as a representation of emerging economies."		
	S 2	Yes	Data was gathered from street vendors in Thailand on the intention to use mobile banking		
	Q_{MM} 1	Yes	The qualitative phase provides new information to be used subsequently in the qualitative phase		
	Q_{MM} 2	Yes	The information from the qualitative phase was extracted to guide the quantitative phase		
	Q_{MM} 3	Yes			
	Q_{MM} 4	Yes	There were no divergences and inconsistencies between the qualitative and quantitative results		
	Q_{MM} 5	No	**Question**	**Response**	**Comment**
			Q_{QL} 1	Yes	Interviews were conducted to obtain new, in-depth information on the constructs of the framework
			Q_{QL} 2	Yes	
			Q_{QL} 3	Can't tell	There is no information on the results of the qualitative phase
			Q_{QL} 4	Can't tell	
			Q_{QL} 5	Can't tell	
			$Q_{QT,Des}$ 1	Can't tell	There is no information on the sampling strategy, except for sampling street vendors who used a phone with internet access
			$Q_{QT,Des}$ 2	No	Samples were drawn from one urban area in Indonesia, excluding rural participants, thus failing generalizability to the entirety of Thailand. Other demographic variables were covered
			$Q_{QT,Des}$ 3	Yes	Questionnaire items were adapted from previous validated measurement scales
			$Q_{QT,Des}$ 4	Yes	The response rate was relatively high at 100 %
			$Q_{QT,Des}$ 5	Yes	Hypotheses were derived from the research objective and tested through statistical analyses. Convergent- and discriminant validity were determined
Purohit, & Arora (2023). Non-comparative quantitative descriptive study (q 332)	S 1	Yes	"What are the factors that affect the adoption of mobile banking among the [Bottom-of-the-Pyramid] in emerging markets?"		
	S 2	Yes	Data was collected from participants in India on intention to use mobile banking		
	$Q_{QT,Des}$ 1	Can't tell	There is no information on the sampling strategy		
	$Q_{QT,Des}$ 2	No	Samples were drawn from bank customers of an Indian bank, thus failing generalizability to all emerging markets. It is also possible that existing experience with the service of the particular bank could influence the willingness of adopting mobile banking. Other demographic variables were covered		
	$Q_{QT,Des}$ 3	Yes	Questionnaire items were adapted from previous validated measurement scales		

Continuation of Table A8			
	$Q_{QT,Des}$ 4	Yes	The response rate was relatively high at 95 %
	$Q_{QT,Des}$ 5	Yes	Hypotheses were derived from the research question and tested through statistical analyses. Internal consistency and convergent- and discriminant validity were determined
Sodhay et al. (2024). Non-comparative quantitative descriptive study (q 220)	S 1	No	Only the research objective is stated: "To analyze the factors influencing the adoption of mobile wallets by [Bottom-of-the-Pyramid] consumers in India."
	S 2	Yes	Data was collected from participants in India on the intention to use mobile wallets
	$Q_{QT,Des}$ 1	Yes	Conducted convenience sampling, but Bottom-of-the-Pyramid criteria were considered
	$Q_{QT,Des}$ 2	No	Samples were drawn from one urban area in India, excluding rural participants and thus failing generalizability to the entirety of India. Other demographic variables were covered
	$Q_{QT,Des}$ 3	Yes	Questionnaire items were adapted from previous validated measurement scales
	$Q_{QT,Des}$ 4	Can't tell	There is no information on the response rate
	$Q_{QT,Des}$ 5	Yes	Hypotheses were derived from the research question and tested through statistical analyses. Convergent- and discriminant validity were determined
Wentzel et al. (2013). Non-comparative quantitative descriptive study (q 341)	S 1	No	There are no research questions or research objectives stated, except for "By studying the determinants of adoption of technology-enabled financial services, it may be possible to improve adoption rates and thus expand financial inclusion."
	S 2	Can't tell	
	$Q_{QT,Des}$ 1	Can't tell	
	$Q_{QT,Des}$ 2	Can't tell	
	$Q_{QT,Des}$ 3	No	Assuming the goal was to determine factors affecting the adoption of technology-enabled financial services, the questionnaire covered questions relating to post office banking only
	$Q_{QT,Des}$ 4	Can't tell	There is no information on the response rate
	$Q_{QT,Des}$ 5	No	No hypotheses were stated
Osakwe, & Okeke (2016). Non-comparative quantitative descriptive study (q 127)	S 1	Yes	"What factors significantly influence the positive perception of [mobile money] perceived usefulness amongst prospective consumers in the Nigerian nation?"
	S 2	Yes	Data was collected from participants on the perceived usefulness of use mobile money
	$Q_{QT,Des}$ 1	Can't tell	There is no information on the sampling strategy
	$Q_{QT,Des}$ 2	No	Samples were drawn from urban areas in Nigeria, excluding rural participants and thus failing generalizability to the entirety of Nigeria. Other demographic variables were covered
	$Q_{QT,Des}$ 3	Yes	Questionnaire items were adapted from previous validated measurement scales
	$Q_{QT,Des}$ 4	Can't tell	There is no information on the response rate, only on the number of quality responses
	$Q_{QT,Des}$ 5	No	Hypotheses were derived from the research question and tested through statistical analyses, but constructs were not operationalized, and no reliability- and validity measurements were conducted
Kumra et al. (2021). Qualitative descriptive study (i 12)	S 1	Yes	"What factors are involved in the usage of [Peer-to-Peer] lending platforms by Bottom-of-the-Pyramid producers and its role in eradicating their financial constraints?" ***and*** "What are the factors that augment the intention to use (actual transaction) [Peer-to-Peer] lending platforms by lenders?"
	S 2	Yes	Data was collected from participants in India on the adoption of Peer-to-Peer lending platforms
	Q_{QL} 1	Yes	The interviews provide an insight into the factors that affect the willingness of lenders and borrowers to use Peer-to-Peer lending platforms in India
	Q_{QL} 2	Yes	
	Q_{QL} 3	Yes	Thematic analyses and in-depth interview quotes are presented, which align with the analysis of the results
	Q_{QL} 4	Yes	
	Q_{QL} 5	Yes	

Appendix F: Synthesis of framework 2.0

To synthesize framework 2.0, empirically determined- and FHI context relevant constructs affecting the adoption of FIs were derived from the literature. Departing from the study quality assessment (Appendix E), six steps were conducted, being *(i)* analysis of UTAUT 2 constructs; *(ii)* analysis of constructs from frameworks other than the UTAUT 2 and conversion to relevant UTAUT 2 constructs; *(iii)* analysis of newly identified constructs and merger of constructs, either as an UTAUT 2 construct or as newly identified construct; *(iv)* removal of irrelevant constructs in the context of FHIs, ambiguous constructs, and moderating variables; *(v)* combining the results of previous steps to arrive at a preliminary framework 2.0; and *(vi)* removing relationships that were significant and insignificant an equal number of times, insignificant relationships, and non-empirically tested relationships, and considering contradictory correlation directions to arrive at framework 2.0. Note that during the first four steps, the context of FHIs was also still considered, but that during the fourth step, constructs specifically removed are presented. During all steps, constructs statistically significant affecting Behavioural Intention to adopt, or another dependent variable, were interpreted as factors affecting the adoption of FIs, or the other dependent variable. Constructs statistically insignificant affecting Behavioural Intention to adopt, or another dependent variable, were interpreted as factors not affecting the adoption of FIs, or the other dependent variable. Further, positive correlation coefficients were interpreted as facilitators, whereas negative correlation coefficients were interpreted as barriers. The results from Hasan et al. (2020) were already discussed during the introduction of framework 1.0, aligning their observations to the UTAUT 2. Therefore, the results from Hasan et al. (2020) are not covered in the construction of framework 2.0, except for one particular observation that was not yet included in framework 1.0.

Constructs from the Unified Theory of Use and Acceptance of Technology 2

The UTAUT 2 provides a starting point to study the adoption of FHIs as presented by framework 1.0. Therefore, to start, constructs from the UTAUT 2 were first considered. In the literature studies, these constructs were defined in the same way as done by Venkatesh et al. (2003) and Venkatesh et al. (2012), apart for some exceptions as discussed below. As the results section already argues why the UTAUT 2 constructs are relevant to the adoption of FHIs, the inclusion argumentation of UTAUT 2 constructs is not included to prevent repetition.

Ashoer et al. (2024) studied the relationship between Behavioural Intention to adopt FIs and Use Behaviour, and observed that the Behavioural Intention to adopt FIs affects the Use Behaviour (Figure A5, Table A9). Because only Ashoer et al. (2024) studied the relationship between Behavioural Intention to adopt and Use Behaviour in the context of FIs, and all other studies focussed on Behavioural Intention to adopt only, it was assumed that factors affecting Behavioural Intention to adopt are facilitators of FI adoption, i.e. Use Behaviour.

For factors affecting Behavioural Intention to adopt, it has been shown that Performance Expectancy and Facilitating Conditions (Costa et al., 2021; Hussain et al., 2019; Joshi, 2024) and Habit (Hussain et al., 2019) are facilitators of FI adoption. In contrast, it has been observed that Hedonic Motivation does not affect the adoption of FIs (Hussain et al., 2019) (Figure A5, Table A9). It should be noted, however, that Hussain et al. (2019) hypothesized that Facilitating Conditions is a facilitator of FI adoption, yet their statistical analyses showed that Facilitating Conditions is a barrier to FI adoption. Unfortunately, Hussain et al. (2019) confirmed their hypothesis, did not address these differences in hypothesized- and empirical directionality, and numerical information is missing to calculate the correlation coefficients manually, e.g., there are no standard deviations and means reported. Therefore, the confirmation of the hypothesis by Hussain et al. (2019) was not reliable enough to include in the synthesis of framework 2.0, and, as such, the relationship between Facilitating Conditions and Behavioural Intention to adopt in Hussain et al. (2019) was not considered.

Interestingly, some factors affecting the Behavioural Intention to adopt FIs were relevant only in some instances. To that extent, Effort Expectancy has shown to be a facilitator of FI adoption (Costa et al., 2021; Hussain et al., 2019) and to be irrelevant to the adoption of FIs (Joshi, 2024). The same is true for Social Influence, which has been shown to be a facilitator (Hussain et al., 2019; Joshi, 2024; Sodhay et al., 2024), and to be irrelevant to the adoption of FIs (Costa et al., 2021) (Figure A5, Table A9). It should be noted that Joshi (2024) and Sodhay et al.

(2024) adhered to their own definition of Social Influence, but their definitions were similar to those of Venkatesh et al. (2003). Like Effort Expectancy and Social Influence, Price Value has been shown to be a facilitator (Joshi, 2024), and to be irrelevant for the adoption of FIs (Hussain et al., 2019) (Figure A5, Table A9). However, again, Hussain et al. (2019) hypothesized that both Effort Expectancy and Price Value are facilitators, but their statistical analysis showed a negative correlation. Here too, Hussain et al. (2019) confirmed their hypothesis, did not address this discrepancy, and did not provide sufficient information to manually calculate the correlation coefficients. As such, the relationship between Effort Expectancy and Behavioural Intention to adopt in Hussain et al. (2019) was not considered.

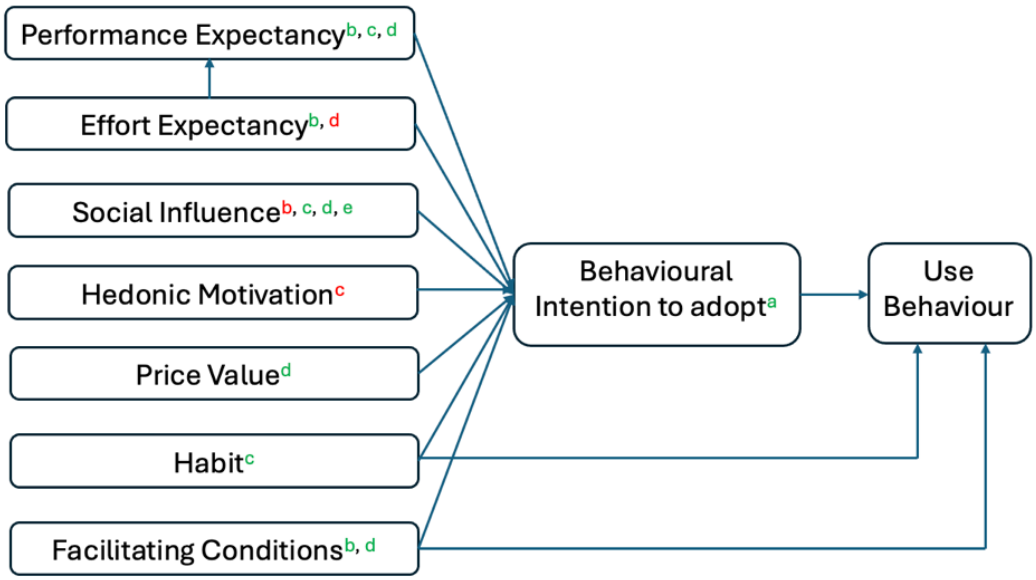

Figure A5. *Schematic representation of factors affecting the adoption of frugal innovations corresponding to the constructs in the Unified Theory of Acceptance and Use of Technology 2.* The original Unified Theory of Acceptance and Use of Technology 2 is presented, supplemented with the empirical evidence from the literature. Statistically significant (green) and insignificant (red) relationships are presented via superscripts, where the superscript is presented on the independent variable. Note that for Habit and Facilitating Conditions, only the relationships with respect to Behavioural Intention were tested. a: Obtained from Ashoer et al. (2024); b: Obtained from Costa et al. (2021); c: Obtained from Hussain et al. (2019); d: Obtained from Joshi (2024); e: Obtained from Sodhay et al. (2024).

Table A9. *Factors affecting the adoption of frugal innovations corresponding to the constructs of the Unified Theory of Acceptance and Use of Technology 2.* The study (Study), construct analysed in the study (Initial construct), the definition (Definition), and the related construct in framework 2.0 (Final construct) are presented. Construct definitions obtained directly from Venkatesh et al. (2003) and Venkatesh et al. (2012) are shown by "See Venkatesh et al. (2003)" and "See Venkatesh et al. (2012)", which are presented in Appendix D, Table A6.

Study	Initial construct	Definition	Final construct
Ashoer et al. (2024)	Behavioural Intention	The intention to use X (Ashoer et al., 2024)	Behavioural Intention
Costa et al. (2021)	Performance Expectancy	See Venkatesh et al. (2003)	Performance Expectancy
	Effort Expectancy	See Venkatesh et al. (2003)	Effort Expectancy
	Social Influence	See Venkatesh et al. (2003)	Social Influence
	Facilitating Conditions	See Venkatesh et al. (2003)	Facilitating Conditions
Hussain et al. (2019)	Performance Expectancy	See Venkatesh et al. (2012)	Performance Expectancy
	Social Influence	"The extent to which consumers perceive that important others (e.g. family and friends) believe they should use a particular technology" (Venkatesh et al., 2012 in Hussain et al., 2019)	Social Influence
	Hedonic Motivation	See Venkatesh et al. (2012)	Hedonic Motivation
	Habit	See Venkatesh et al. (2012)	Habit
Joshi (2024)	Performance Expectancy	See Venkatesh et al. (2012)	Performance Expectancy
	Effort Expectancy	See Venkatesh et al. (2003)	Effort Expectancy
	Social Influence	"An individual's perception that the majority of the people	Social Influence

Continuation of Table A9			
		important to him think that he should do or refrain from doing a specific behavior" (Fong, & Wong, 2015 in Joshi, 2024)	
	Price Value	See Venkatesh et al. (2012)	Price Value
	Facilitating Conditions	See Venkatesh et al. (2003)	Facilitating Conditions
Sodhay et al. (2024)	Social Influence	"An individual's perception of the opinions of significant others regarding whether they should or should not engage in a particular behaviour" (Sodhay et al., 2024)	Social Influence

Relating other framework constructs to constructs from the Unified Theory of Acceptance and Use of Technology 2

Besides the UTAUT (2), the TAM (Ashoer et al., 2024; Pipitwanichakarn, & Wongtada, 2019; Purohit, & Arora, 2023) and TRA and TPB constructs (Purohit, & Arora, 2023) were used. TAM, TRA, and TPB constructs are encapsulated by UTAUT 2 constructs (Appendix D, Table A6), and thus can be converted to UTAUT 2 constructs, reducing framework complexity and removing construct redundancy. Because Appendix D, Table A6 already presents the argumentation for TAM, TRA, and TPB construct encapsulation by UTAUT 2 constructs, the inclusion argumentation of (converted) TAM, TRA, and TPB constructs in the context of FHIs is not included to prevent repetition.

Purohit, and Arora (2023) observed that Attitude, being the cognitive positive or negative reaction regarding a certain behaviour (Ajzen, 1991), is a facilitator of FI adoption (Figure A6A, Table A10). Attitude is a tricky construct, as its' introduction results in framework complexity because of its' mediating role in only one study (Purohit, & Arora, 2023). Further, Attitude only significantly affects Behavioural Intention to adopt in case Performance Expectancy and Effort Expectancy are not considered in the framework (Venkatesh et al., 2003). As seen, Performance Expectancy and Effort Expectancy are facilitators of FI adoption. Attitude can be considered similar to Behavioural Intention to adopt, i.e. the intention to adopt, and, consequently, Attitude was converted to Behavioural Intention to adopt (Figure A6B, Figure A6C). It should be noted that, although Purohit, and Arora (2023) state that Attitude is present in the TAM, this is not the case (Davis, 1989). However, considering the narrative difficulty if Attitude were to be considered in a later analysis step, it was decided to cover Attitude in this analysis step.

Departing from the TAM, Perceived Usefulness and Ease-of-Use are facilitators of FI adoption (Ashoer et al., 2024; Pipitwanichakarn, & Wongtada, 2019; Purohit, & Arora, 2023), and Ease-of-Use affects Perceived Usefulness (Ashoer et al., 2024; Pipitwanichakarn, & Wongtada, 2019) (Figure A6A, Table A10). Note that Ashoer et al. (2024) introduced Mobile Usefulness and Mobile Ease-of-Use, but related these mobile-specific constructs to Perceived Usefulness and Ease-of-Use, respectively (Ashoer, et al., 2024; Davis, 1989). Further, Pipitwanichakarn, and Wongtada (2019) adhered to the same definitions as Davis (1989) did for the TAM. Likewise, Purohit, and Arora (2023) used a similar definition for Perceived Usefulness as given by Davis (1989) in the TAM, but did not define Perceived Ease-of-Use. As such, it was assumed that the definition of Perceived Ease-of-Use was the same as provided by Davis (1989) in the TAM. Perceived Usefulness and Ease-of-Use in the TAM are encapsulated by Performance Expectancy and Effort Expectancy in the UTAUT 2, respectively. Therefore, for framework 2.0, Perceived Usefulness and Ease-of-Use were converted to Performance Expectancy and Effort Expectancy, respectively. Accordingly, Performance Expectancy and Effort Expectancy are facilitators of FI adoption and Effort Expectancy affects Performance Expectancy statistically significant (Figure A6B, Figure A6C).

Departing from the TRA and TPB, Subjective Norms is a facilitator of FI adoption, but a barrier to Perceived Usefulness, i.e. Performance Expectancy following the argumentation from above (Purohit, & Arora, 2023) (Figure A6A, Table A10). Purohit, and Arora (2023) defined Subjective Norms as the opinion of others regarding the use of the system (Koksal, 2016), which is in line with the definition of Subjective Norms from the TRA and TPB, referring to the social pressure observed to perform a certain behaviour (Fishbein, & Ajzen, 1975; Ajzen, 1991). Subjective Norms in the TRA and TPB is encapsulated by Social Influence in the UTAUT 2. Therefore, for framework 2.0, Subjective Norms was converted to Social Influence. Accordingly, Social Influence is a facilitator of FI adoption and a barrier to Performance Expectancy (Figure A6B, Figure A6C).

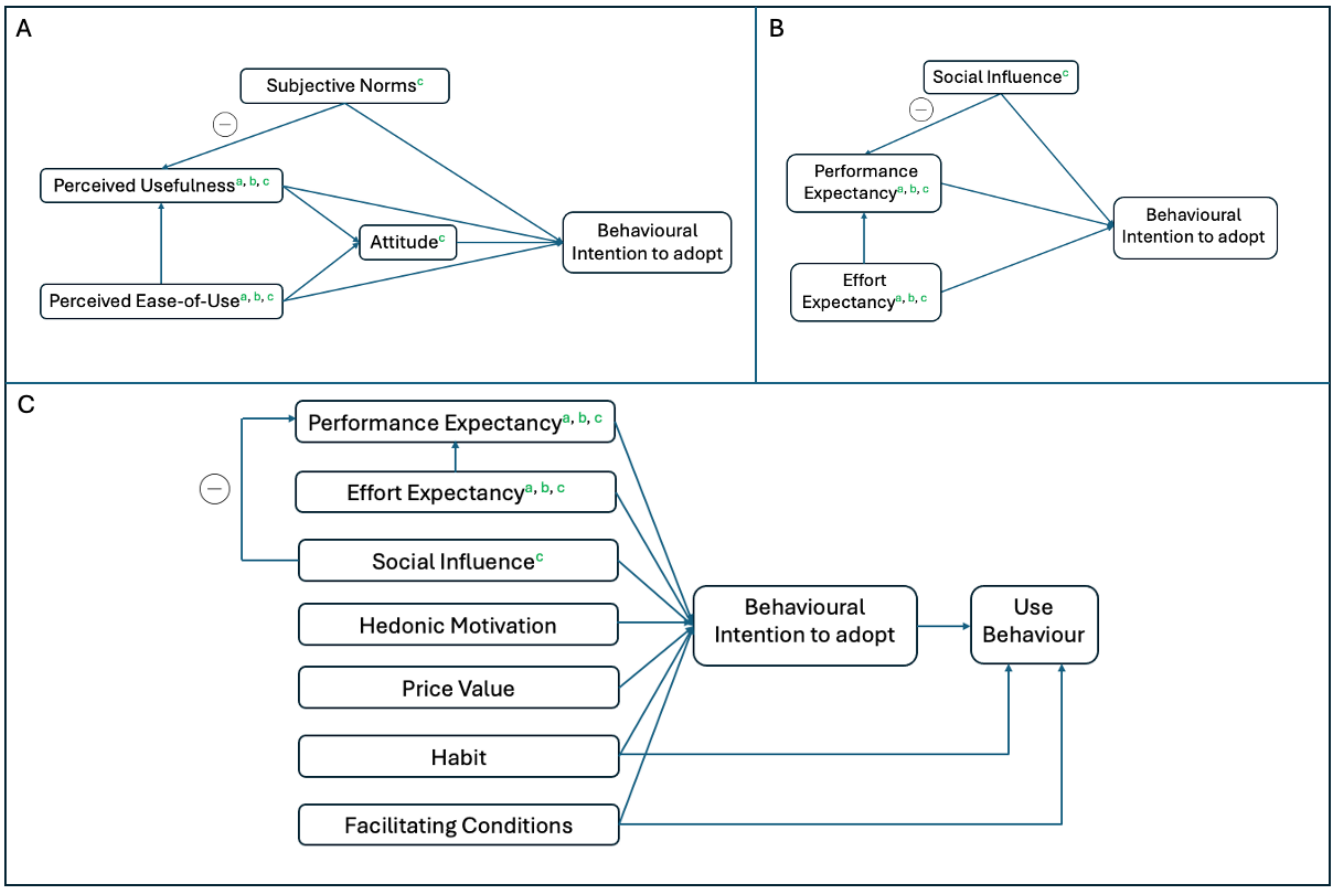

Figure A6. *Schematic representation of factors affecting the adoption of frugal innovations as present in frameworks other than the Unified Theory of Acceptance and Use of Technology 2 and converted to constructs for framework 2.0*. Statistically significant (green) relationships are presented via superscripts, where the superscript is presented on the independent variable. Negative correlations are represented by the minus sign. a: Obtained from Ashoer et al. (2024); b: Obtained from Pipitwanichakarn, and Wongtada (2019); c: Obtained from Purohit, and Arora (2023). **A:** Factors affecting the adoption of frugal innovations as observed from different frameworks. **B:** Factors affecting the adoption of frugal innovations as observed from different frameworks and converted to constructs for framework 2.0. **C:** Factors affecting the adoption of frugal innovations as observed from different frameworks, converted to constructs for, and presented in, framework 2.0. Note that the relationships between Perceived Usefulness and Behavioural Intention, Perceived Ease-of-Use and Behavioural Intention, and Perceived Ease-of-Us and Perceived Usefulness were only observed by Ashoer et al. (2024) and Pipitwanichakarn, and Wongtada (2019) (**A**), the relationships between Perceived Usefulness and Attitude and Perceived Ease-of-Use and Attitude was only observed by Purohit, and Arora (2023) (**A**), and the relationship between Effort Expectancy and Performance Expectancy was only observed by Ashoer et al. (2024) and Pipitwanichakarn, and Wongtada (2019) (**B** and **C**).

Table A10. *Constructs from frameworks other than the Unified Theory of Acceptance and Use of Technology 2 converted to constructs for framework 2.0*. The study (Study), construct analysed in the study (Initial construct), corresponding framework (Framework), the definition (Definition), and the related construct in framework 2.0 in this research study (Final construct) are presented. [] represents adjustments in the definitions used to make the definitions readable, with X referring to the innovation studied. N.A.: Not applicable.

Study	Initial construct	Framework	Definition	Final construct
Ashoer et al. (2024)	Perceived Usefulness	Technology Acceptance Model	"The perceived increase in utility that the adoption of [X] provides to potential adopters" (Ashoer et al., 2024)	Performance Expectancy
	Perceived Ease-of-Use	Technology Acceptance Model	"The degree to which consumers perceive learning and utilizing [X] to be effortless" (Ashoer et al., 2024)	Effort Expectancy
Pipitwanichakarn, & Wongtada (2019)	Perceived Usefulness	Technology Acceptance Model	"The degree to which an individual believes that using a particular technology would enhance his task performance" (Pipitwanichakarn, & Wongtada, 2019)	Performance Expectancy
	Perceived Ease-of-Use	Technology Acceptance Model	"The degree to which users believe that using a particular technology would be free of effort" (Pipitwanichakarn, & Wongtada, 2019)	Effort Expectancy

Continuation of Table A10				
Purohit, & Arora (2023)	Attitude	N.A.	"The cognitive positive or negative reaction about performing a particular behaviour" (Ajzen, 1991 in Purohit, & Arora, 2023)	Behavioural Intention
	Perceived Usefulness	Technology Acceptance Model	"The benefits associated with the use of technology pretraining the improvement of job performance" (Purohit, & Arora, 2023)	Performance Expectancy
	Perceived Ease-of-Use	Technology Acceptance Model	N.A.	Effort Expectancy
	Subjective Norms	Theory of Reasoned Action, Theory of Planned Behaviour	"The perception of an individual about the opinion of people concerning the use of a system or performance of certain behavior" (Koksal, 2016 in Purohit, & Arora, 2023)	Social Influence

Newly identified constructs and conversion thereof

Most studies introduced new constructs (Ashoer et al., 2024; Hussain et al., 2019; Joshi, 2024; Pipitwanichakarn, & Wongtada, 2019; Purohit, & Arora, 2023; Sodhay et al., 2024). Therefore, the construct relevance was considered in the context of FHIs. However, a broad range of newly identified constructs was observed. Further, some newly identified constructs seemed to encapsulate the same concept as constructs from the UTAUT 2 or were similar to other newly introduced constructs. Thus, to reduce framework complexity, newly identified constructs were merged into one construct where possible. Note that no inclusion argumentation is provided in case constructs were converted to already existing constructs, to prevent repetitiveness.

Newly introduced constructs

Hussain et al. (2019) observed that Lifestyle Compatibility is a facilitator of FI adoption (Figure A7A, Table A11). Lifestyle Compatibility refers to the compatibility between the values offered by the innovation and the values of the lifestyle of the consumer (Hussain et al., 2019). Alignment between consumer and producer in terms of cultural values, especially in developing economies, is relevant for FHIs (Arshad, 2021; Mills, 2014; Sarkar, & Mateus, 2022; Zanello et al., 2016). Therefore, it is likely that Lifestyle Compatibility facilitates the adoption of FHIs, and, as such, Lifestyle Compatibility was included in framework 2.0 (Figure A7B, Figure A7C). Hasan et al. (2020) found that Trialability, referring to the possibility to experience with the innovation (Rogers, 1983, pp. 163 – 238), is a facilitator of FI adoption (Figure A7A, Table A11). Indeed, the ability to use FHIs beforehand increases consumers' willingness to continue with the innovation (Arshad, 2021). As such, it was decided to include Trialability in framework 2.0 (Figure A7B, Figure A7C). Pipitwanichakarn, and Wongtada (2019) observed that Trust is a facilitator of FI adoption, affects Perceived Usefulness, i.e. Performance Expectancy according to above argumentation, and Perceived Ease-of-Use, i.e. Effort Expectancy (Figure A7A, Table A11). Trust refers to the degree of consumer confidentiality due to a suppliers' reliability and integrity, and plays an important role in healthcare innovation acceptance, especially in marginalized communities (Schmidt-Sane et al., 2023). Therefore, it is likely that Trust facilitates the adoption of FHIs, and, as such, it was decided to include Trust in framework 2.0 (Figure A7B, Figure A7C). Interestingly, however, Sodhay et al. (2024) observed that Trust, defined similarly as by Pipitwanichakarn, and Wongtada (2019) (Morgan, & Hunt, 1994), is not a barrier to the adoption of FI, i.e. statistically and negatively affects Behavioural Intention to adopt insignificant (Figure A7A, Figure A7B, Figure A7C, Table A11).

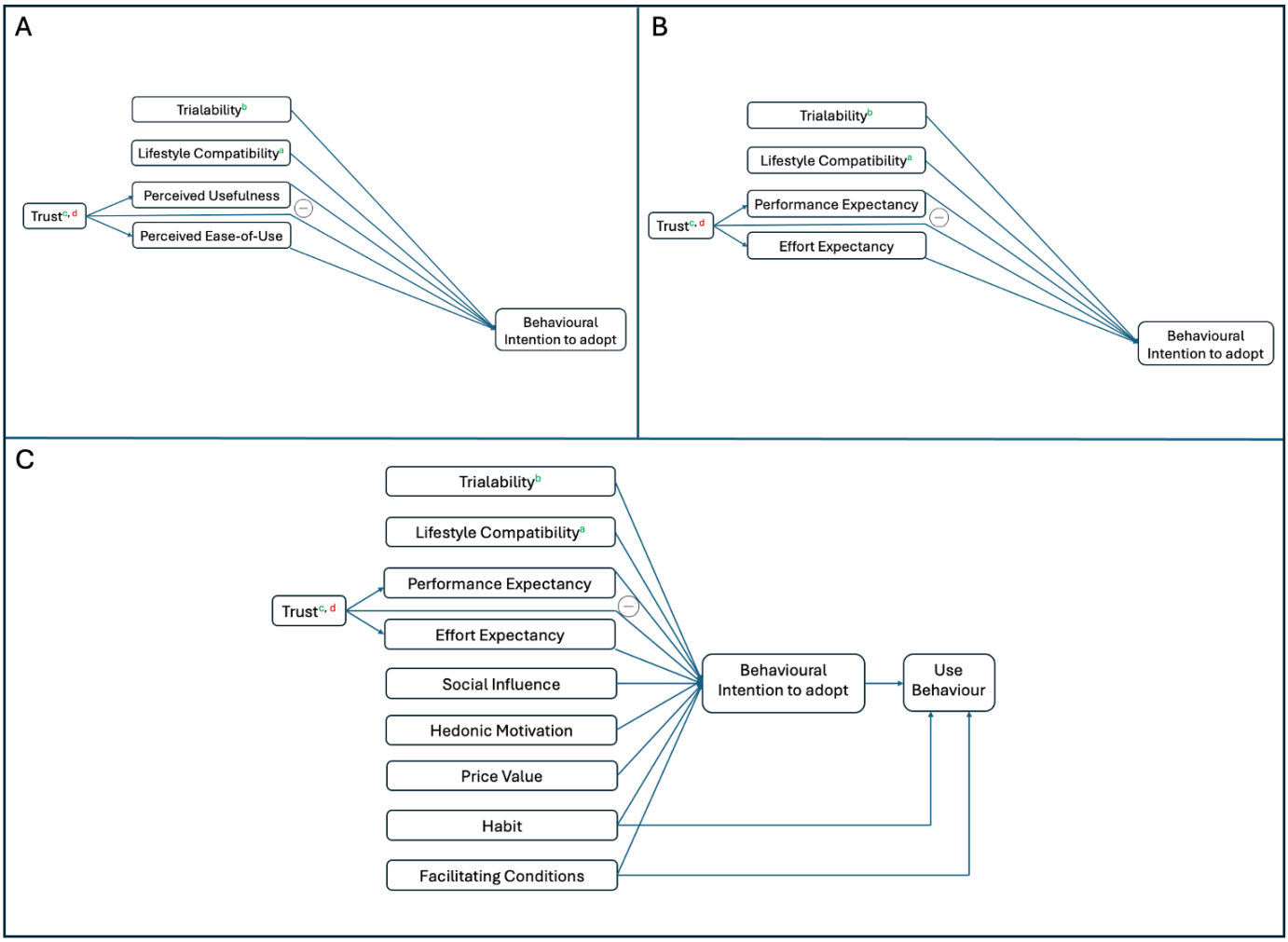

Figure A7. *Schematic representation of newly introduced factors affecting the adoption of frugal innovations, converted to and presented in framework 2.0.* Statistically significant (green) and insignificant (red) relationships are presented via superscripts, where the superscript is presented on the independent variable. Negative correlations are represented by the minus sign. a: Obtained from Hussain et al. (2019); b: Obtained from Hasan et al. (2020); c: Obtained from Pipitwanichakarn, and Wongtada (2019); d: Obtained from Sodhay et al. (2024). **A:** Newly introduced factors affecting the adoption of frugal innovations. **B:** Newly introduced factors affecting the adoption of frugal innovations with previously introduced conversions for Perceived Usefulness and Perceived Ease-of-Use to Performance Expectancy and Effort Expectancy, respectively. **C:** Newly introduced factors affecting the adoption of frugal innovations presented in framework 2.0. Note that Sodhay et al. (2024) only tested the relationship between Trust and Behavioural Intention (**A**, **B**, **C**).

Table A11. *Newly identified constructs affecting the adoption of frugal innovations*. The study (Study), construct analysed in the study (Construct), the definition (Definition), and the reason for inclusion in framework 2.0 (Reason) are presented.

Study	Construct	Definition	Reason
Hussain et al. (2019)	Lifestyle Compatibility	The compatibility between the values offered by the innovation and the values of the lifestyle of the consumers (Hussain et al., 2019)	It is imperative that there exists an alignment between cultural values of the consumer and the product, especially in developing economies (Arshad, 2021; Mills, 2014; Sarkar, & Mateus, 2022; Zanello et al., 2016)
Hasan et al. (2020)	Trialability	"The degree to which an innovation is able to be tested on a limited basis" (Rogers, 1983 pp. 163 – 238 in Hasan et al., 2020)	The ability to use FHIs beforehand ensures consumers are more willingly to continue with the innovation (Arshad, 2021).
Pipitwanichakarn, & Wongtada (2019)	Trust	The degree to which a consumer is confident in an exchange because of the suppliers' reliability and integrity (Pipitwanichakarn, & Wongtada, 2019)	Trust plays an important role in healthcare innovations, especially in marginalized communities (Schmidt-Sane et al., 2023)
Sodhay et al. (2024)	Trust	The presence of "a situation wherein one party has confidence in an exchange as a consequence of partner's reliability and integrity" (Morgan, & Hunt, 1994 in Sodhay et al., 2024)	

Converted newly introduced constructs

Several newly introduced constructs were converted to UTAUT 2 constructs. Ashoer et al. (2024) observed that Mobile Perceived Financial Costs is a barrier to FI adoption (Figure A8A, Table A12). Mobile Perceived Financial Costs refers to affordability requirements of innovations (Ashoer et al., 2024). Price Value covers a similar concept, referring to the trade-off between costs and benefits (Venkatesh et al., 2012). Therefore, Mobile Perceived Financial Costs was converted to Price Value. Further, Joshi (2024) observed that Psychological Inertia is not a facilitator of FI adoption (Figure A8A, Table A12). Psychological Inertia refers to actions following past behaviour (Wood, & Neal, 2007) and covers a similar concept as Habit, referring to performing actions due to previous learning (Venkatesh et al., 2012). Therefore, Psychological Inertia was converted to Habit. Purohit, and Arora (2023) observed that Perceived Deterrents are a barrier to FI adoption (Figure A8A, Table A12). Perceived Deterrents refer to problems related to the infrastructure (Purohit, and Arora, 2023). The availability of infrastructure is encapsulated by Facilitating Conditions (Venkatesh et al., 2003; Venkatesh et al., 2012). As such, Perceived Deterrents was converted to Facilitating Conditions. Thus, according to these conversions, Price Value is a barrier, Habit does not affect FI adoption, and Facilitating Conditions is a barrier (Figure A8B, Figure A8C). Note that according to this conversion and the findings by Ashoer et al. (2024) and Purohit, and Arora (2023), Price Value and Facilitating Conditions are barriers, whilst being facilitators in the UTAUT 2 (Venkatesh et al., 2012). This discrepancy will be further discussed below.

Several newly introduced constructs were merged with other newly introduced constructs. Sodhay et al. (2024) observed that Compatibility is not a barrier to FI adoption, i.e. Compatibility statistically and negatively affects Behavioural Intention to adopt insignificant (Figure A8A, Table A12). Compatibility refers to the alignment of the innovation with values, experiences, lifestyles, and preferences (Lin, 2011). Lifestyle Compatibility refers to the compatibility between values offered by the innovation and those from the consumer (Hussain et al., 2019). Therefore, Compatibility was converted to Lifestyle Compatibility. Joshi (2024) observed that Social Benefits is a facilitator of FI adoption (Figure A8A, Table A12). Social Benefits refer to the beliefs of the consumer that the adoption of the innovation results in overall benefits to society (Rejikumar, 2013). As these social benefits are important values for collectivistic societies (Hasan et al., 2020), Social Benefits is likely a sub-construct of Lifestyle Compatibility, which relates to the values offered by the innovation and those of the consumer (Hussain et al., 2019). Therefore, Social Benefits was converted to Lifestyle Compatibility. Further, Joshi (2024) observed that Perceived Security Risks are a barrier to FI adoption. The same was observed for Perceived Risk in Purohit, and Arora (2023) (Figure A8A, Table A12). Perceived Security Risks relates to the possibility of loss of information or loss of funds (Lee, & Song, 2013), whereas Perceived Risk refers to a multitude of different risks, including Performance Risk, Security Risk, Social Risk, and Financial Risk (Lee, 2009; Purohit, & Arora, 2023). For similar innovations as studied by Joshi (2024) and Purohit, and Arora (2023), risk is related to the trust observed by consumers, i.e. when risks are absent, trust in the innovation is observed (Yang et al., 2015). Therefore, to reduce the complexity of the framework, it was decided to convert Perceived Security Risks and Perceived Risk to Trust. Thus, according to these conversions, Lifestyle Compatibility is a facilitator of FI adoption, but also has shown to not affect FI adoption, and Trust is a barrier to FI adoption (Figure A8B, Figure A8C). Note that according to this conversion and the findings by Joshi (2024) and Purohit, and Arora (2023), Trust is a barrier, whilst being a facilitator in Pipitwanichakarn, and Wongtada (2019). This discrepancy will be further discussed below.

Two newly introduced constructs were merged with each other into a different, new construct. Ashoer et al. (2024) observed that Digital Financial Literacy affects Perceived Ease-of-Use, i.e. Effort Expectancy according to previous argumentation, but does not affect Perceived Usefulness, i.e. Performance Expectancy according to previous argumentation. The same pattern was observed for the independent variable Knowledge in Purohit, and Arora (2023), whereas Joshi (2024) observed that Knowledge is a facilitator of FI adoption (Figure A8A, Table A12). Digital Financial Literacy refers to the prior knowledge and skills of consumers required to use the innovation (Ashoer et al., 2024). As the term Digital Financial Literacy does not translate to FHIs, and no related construct was introduced yet, Digital Financial Literacy was converted to a new construct Consumer Literacy. Similarly, Knowledge in Purohit, and Arora (2023) refers to the degree of knowledge and understanding of the innovation. Although Joshi (2024) referred to Knowledge in terms of general knowledge about the features of the innovation (Eriksson, Gökhan, & Stenius, 2021), the measurements were conducted in terms of understanding the innovation. Therefore, Knowledge in Purohit, and

Arora (2023) and in Joshi (2024) was converted to Consumer Literacy. Indeed, the lack of knowledge on the use of FHIs often acts as a constraint to use FHIs is, especially in developing economies (Arshad, 2021; Leonard et al., 2020; Mills, 2014; Sarkar, & Mateus, 2022). Thus, according to this conversion, Consumer Literacy affects Effort Expectancy and Behavioural Intention to adopt, but does not affect Performance Expectancy (Figure A8B, Figure A8C).

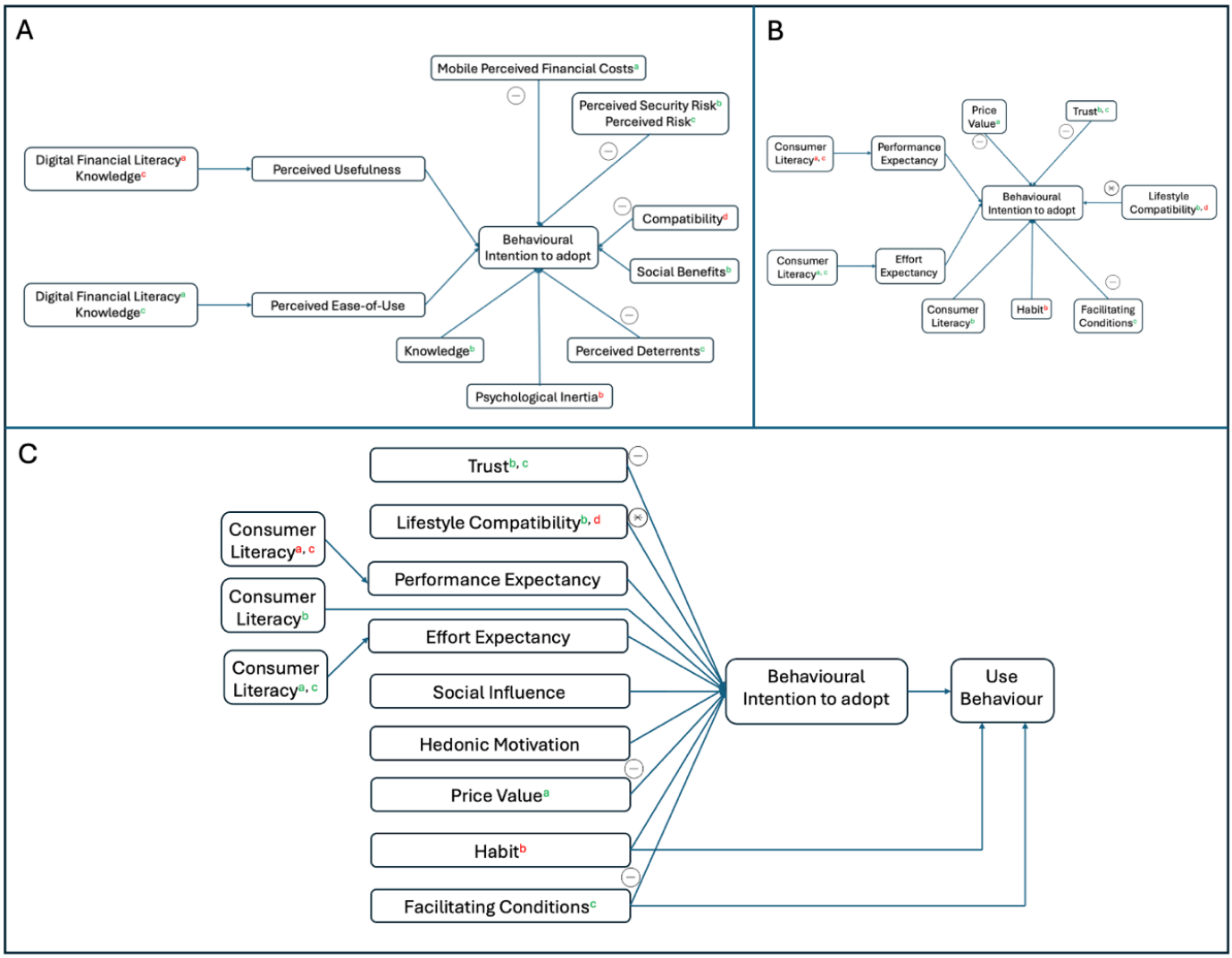

Figure A8. *Schematic representation of converted newly introduced factors affecting the adoption of frugal innovations and presented in framework 2.0.* Statistically significant (green) and insignificant (red) relationships are presented via superscripts, where the superscript is presented on the independent variable. Negative correlations are represented by the minus sign, and the cross sign represents a positive and negative correlation simultaneously. a: Obtained from Ashoer et al. (2024); b: Obtained from Joshi (2024); c: Obtained from Purohit, and Arora (2023); d: Obtained from Sodhay et al. (2024). **A:** Newly introduced factors affecting the adoption of frugal innovations. **B:** Converted newly introduced factors affecting the adoption of frugal innovations. **C:** Converted newly introduced factors affecting the adoption of frugal innovations presented in framework 2.0. Note that the relationships between Perceived Usefulness, i.e. Performance Expectancy and Behavioural Intention and Perceived Ease-of-Use, i.e. Effort Expectancy and Behavioural Intention was part of a different analysis step, but that these relationships are shown nonetheless to show the effects of their antecedents toward Behavioural Intention (**A**, **B**), for Habit and Facilitating Conditions, only the relationships with respect to Behavioural Intention were tested (**C**), and more than one box is presented for Digital Financial Literacy (**A**) and Consumer Literacy (**B**, **C**) due to presentation complexity issues.

Table A12. *Converted newly identified constructs affecting the adoption of frugal innovations*. The study (Study), construct analysed in the study (Initial construct), the definition (Definition), and the related construct in framework 2.0 in this research study (Final construct) are presented. [] represents adjustments in the definitions used to make the definitions readable, with X referring to the innovation studied.

Study	Initial construct	Definition	Final construct
Ashoer et al. (2024)	Mobile Perceived Financial Costs	"Emphasizes the importance of considering the affordability aspect of [X] services, not only encompasses the cost of acquiring the necessary devices but also factors such as transaction fees and additional charges imposed by [using X]" (Ashoer et al., 2024)	Price Value

Continuation of Table A12			
	Digital Financial Literacy	"The knowledge, skills, and understanding required to effectively and safely navigate and utilize [X] and systems" (Ashoer et al., 2024)	Consumer Literacy
Joshi (2024)	Psychological Inertia	"Learned dispositions to repeat past responses" (Wood, & Neal, 2007 in Joshi, 2004)	Habit
	Perceived Security Risk	"The extent to which users believe that using a service may result in a potential loss of information or funds" (Lee, & Song, 2013 in Joshi, 2024)	Trust
	Knowledge	"Respondents' general lack of knowledge regarding features of a new technology" (Eriksson et al., 2021 in Joshi, 2024)	Consumer Literacy
	Social Benefits	"The extent to which a person believes that adopting a new policy or application would impart benefits to society in general" (Rejikumar, 2013 in Joshi, 2024)	Lifestyle Compatibility
Purohit, & Arora (2023)	Perceived Deterrents	"The problems related to the infrastructure" required for [X] (Purohit, & Arora, 2023)	Facilitating Conditions
	Perceived Risk	Includes *(i)* Performance Risk, which refers to "the losses resulting from [X] deficiencies or breakdowns" (Lee, 2009 in Purohit, & Arora, 2023); *(ii)* Security Risk, which refers to "the violation of a[n X] user resulting in potential loss" (Purohit, & Arora, 2023); *(iii)* Social Risk, which refers to "the possibility of disapproval by one's friends, family, or workgroup on the use of [X]" (Lee, 2009 in Purohit, & Arora, 2023); and *(iv)* Financial Risk, which refers to "the possibility of [misuse of X] resulting in monetary loss" (Lee, 2009 in Purohit, & Arora, 2023)	Trust
	Knowledge	The degree of knowledge and understanding of the innovation (Purohit, & Arora, 2023)	Consumer Literacy
Sodhay et al. (2024)	Compatibility	"The degree to which [X] is aligned with their values, experiences, lifestyle, and preferences" (Lin, 2011 in Sodhay et al., 2024)	Lifestyle Compatibility

Removing irrelevant and ambiguous constructs and moderating variables

Several studies included new constructs that were deemed irrelevant in the context of FHIs (Ashoer et al., 2024; Pipitwanichakarn, & Wongtada, 2019), were highly ambiguous (Sodhay et al., 2024), or included moderating variables (Ashoer et al., 2024; Pipitwanichakarn, & Wongtada, 2019). Therefore, these constructs were removed. An overview of the removed constructs is shown in Table A13.

For irrelevant constructs in the context of FHIs, Ashoer et al. (2021) reported that FI adoption results in Digital Financial Inclusion. Digital Financial Inclusion refers to the utilisation of financial services by marginalised communities (Ashoer et al., 2024). First, Digital Financial Inclusion is a consequence of FI adoption, and not a factor affecting the adoption. Second, Digital Financial Inclusion refers specifically to users utilizing financial services and is therefore not relevant in the context of FHIs. Therefore, Digital Financial Inclusion was omitted. Pipitwanichakarn, and Wongtada (2019) included the antecedent Entrepreneurial Orientation, referring to entrepreneurs willing to take risks and being pro-active toward innovativeness (Lumpkin, & Dess, 1996). Because Entrepreneurial Orientation relates specifically to entrepreneurs, and not to consumers of FHIs, it was omitted.

Two ambiguous constructs were introduced by Sodhay et al. (2024), measuring multiple concepts. Sodhay et al. (2024) observed that Convenience is a facilitator of FI adoption, and that Innovativeness is not a barrier to FI adoption, i.e. statistically and negatively affects Behavioural Intention to adopt insignificant. Convenience refers to the perceived value offered by the innovation (Pal, Vanijja, & Papasratorn, 2015) and Innovativeness refers to the efficiency and novelness of the innovation and enriched consumer experiences (Sodhay et al., 2024). However, Sodhay et al. (2024) measured Convenience in terms of access to the innovation infrastructure, fulfilment of customer needs, and compatibility with current lifestyles. Further, Sodhay et al. (2024) measured Innovativeness in terms of excitement about the innovation, benefits from the innovation, and the presentation and design of the innovation. As such, Convenience and Innovativeness do not measure one concept, but multiple concepts. To derive meaningful information that fits framework 2.0, these constructs thus have to be dissected into different constructs. However,

Sodhay et al. (2024) did not report on the statistical analysis results of individual items, making it impossible to do so. Therefore, Convenience and Innovativeness were dropped.

For moderating variables, Ashoer et al. (2021) and Sodhay et al. (2024) observed that Gender moderates several relationships. Further, Pipitwanichakarn, and Wongtada (2019) observed that Product Differentiation, referring to the degree of differentiation between product offered by the entrepreneur (Pipitwanichakarn, & Wongtada, 2019), also was a moderating variable. Considering that moderating variables were out of scope for this research study, it was decided to omit these moderating variables.

Table A13. *Removed constructs and variables.* The study (Study), construct, or in the case of Gender and Product Differentiation moderating variable, analysed in the study (Construct/Variable), the definition (Definition), and the reason for omission from framework 2.0 (Reason) are presented.

Study	Construct/Variable	Definition	Reason
Ashoer et al. (2021)	Digital Financial Inclusion	"The digital availability and utilisation of formal financial services by marginalised and underprivileged groups" (Ashoer et al., 2024)	Digital Financial Inclusion is a consequence of, and not a factor affecting, the adoption of mobile finance technologies, and relates to financial services specifically and not to frugal health innovations
	Gender	Male or female (Ashoer et al., 2024)	Moderating variables are outside the scope of this research study
Pipitwanichakarn, & Wongtada (2019)	Entrepreneurial Orientation	"The methods and practices used in acting entrepreneurial", referring to innovativeness, risk-taking, and pro-activeness of entrepreneurs (Lumpkin, & Dess, 1996 in Pipitwanichakarn, & Wongtada, 2019)	Relates to the degree of different products offered by entrepreneurs that wish to adopt new innovations, and thus not to consumers of frugal health innovations
	Product Differentiation	The degree of differentiation between products offered by the entrepreneur (Pipitwanichakarn, & Wongtada, 2019)	Relates to the degree of different products offered by entrepreneurs that wish to adopt new innovations, and thus not to consumers of frugal health innovations
Sodhay et al. (2024)	Gender	Male or female (Sodhay et al., 2024)	Moderating variables are outside the scope of this research study
	Convenience	"A product of time and place utility that has the power to influence users' decisions in favour of using a particular system and the perceived value of the system" (Pal et al., 2015 in Sodhay et al., 2024)	Covers multiple concepts and has to be dissected into different constructs in order to fit in the current framework. However, information is lacking on the statistical results of the individual items
	Innovativeness	Relates to the efficiency and novelness of the innovation, and enriched consumer experiences (Sodhay et al., 2024)	Covers multiple concepts and has to be dissected into different constructs in order to fit in the current framework. However, information is lacking on the statistical results of the individual items

Combining previous steps and arriving at the preliminary framework 2.0

To arrive at the preliminary framework 2.0, the results from previous analysis steps were combined. Particularly, the results as presented in framework 2.0 were combined (Figure A5, Figure A6C, Figure A7C, Figure A8C). The results are presented in Figure A9. To that extent, the preliminary framework 2.0 contains non-redundant, non-ambiguous, FHI relevant constructs, informing on what factors may affect the adoption of FHIs. Note that discrepancies between statistically significant and insignificant relationships and directionalities were not considered, as this is conducted in the next step.

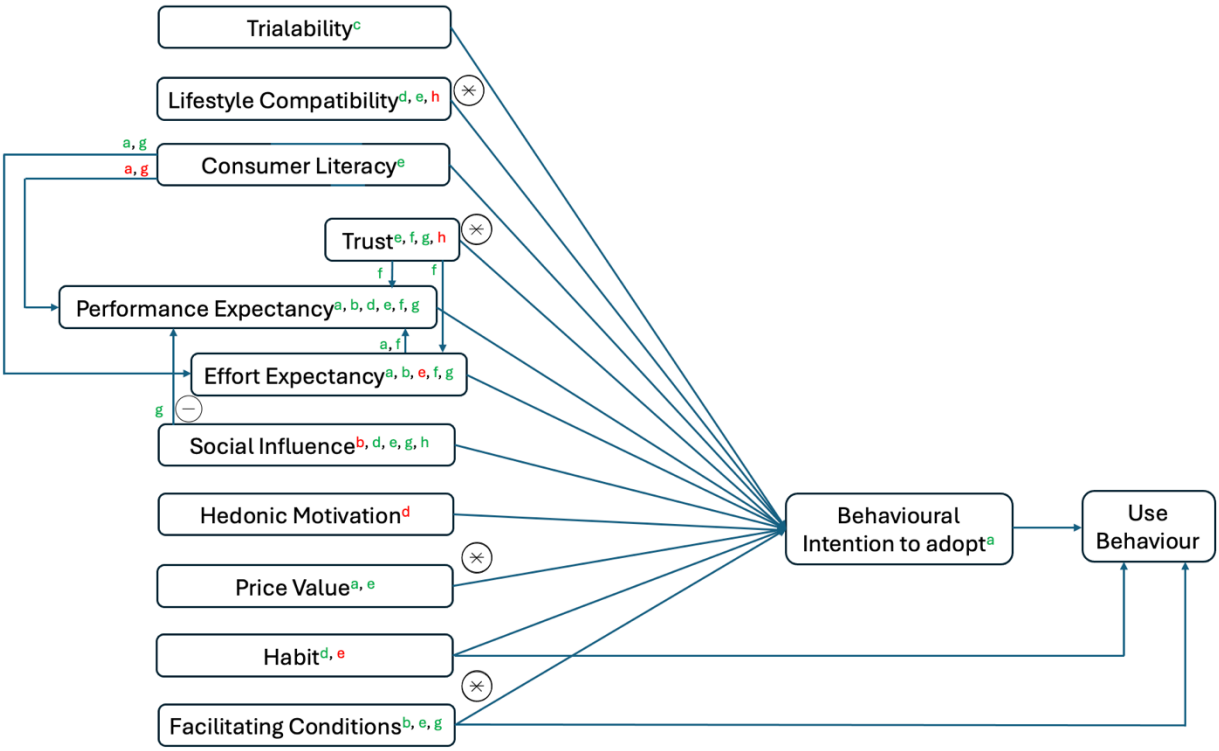

Figure A9. *Schematic representation of the preliminary framework 2.0.* Statistically significant (green) and insignificant (red) relationships are presented via superscripts, where the superscript is presented on the independent variable. Negative correlations are represented by the minus sign, and the cross sign represents a positive and negative correlation simultaneously. a: Obtained from Ashoer et al. (2024); b: Obtained from Costa et al. (2021); c: Obtained from Hasan et al. (2020); d: Obtained from Hussain et al. (2019); e: Obtained from Joshi (2024); f: Obtained from Pipitwanichakarn, and Wongtada (2019); g: Obtained from Purohit, and Arora (2023); h: Obtained from Sodhay et al. (2024).

Removing situational factors, non-empirically verified factors from framework 1.0, and considering contradictory directionality correlations to arrive at framework 2.0

The preliminary framework 2.0 contains non-redundant, non-ambiguous, FHI relevant constructs (Figure A9). However, several considerations were not yet included in the synthesis to arrive at the final framework 2.0. Firstly, it is important to consider factors that insignificantly affect the adoption of FIs or factors that affect the adoption of FIs significantly in one instance and insignificantly in another instance. The latter is especially important considering the lack of generalizability of the studies (Appendix E). Therefore, to arrive at a somewhat generalizable framework, it was decided to remove independent variables that only affected the dependent variable statistically insignificant and to remove independent variables that affected the independent variable an equal number of times statistically significant and insignificant. Factors that occurred to be statistically significant more times than statistically insignificant were included in the final framework 2.0, as empirical evidence showed that, overall, the trend is that these factors affect the adoption of FIs. Further, as the goal of the synthesis of framework 2.0 was to include empirically derived factors, it was decided to remove all non-empirically tested relationships present from framework 1.0. Further, the work on the preliminary framework 2.0 showed that in some instances factors were a facilitator and in other cases factors were a barrier. As such, these discrepancies also must be considered for the final framework 2.0.

For discrepancies in the statistical significance of factors, Lifestyle Compatibility (Hussain et al., 2019; Joshi, 2024; Sodhay et al., 2024), Trust (Joshi, 2024; Pipitwanichakarn, & Wongtada, 2019; Purohit, & Arora, 2023; Sodhay et al., 2024), Effort Expectancy (Ashoer et al., 2024; Costa et al., 2021; Joshi, 2024; Pipitwanichakarn, & Wongtada, 2019; Purohit, & Arora, 2023), Social Influence (Costa et al., 2021; Hussain et al., 2019; Joshi, 2024; Purohit, & Arora, 2023; Sodhay et al., 2024), and Habit (Hussain et al., 2019; Joshi, 2024) were found to be statistically affecting the intention to adopt FIs significant in certain instances and in other cases not (Figure A9). Further, Consumer Literacy affected Performance Expectancy statistically insignificant in all cases, and the same was observed for the effect of Hedonic Motivation on the intention to adopt FIs. Following above argumentation, the relationships between Lifestyle Compatibility and Behavioural Intention to adopt, Trust and Behavioural Intention to adopt, and Social

Influence and Behavioural Intention to adopt were included, whereas the relationship between Consumer Literacy and Performance Expectancy, Hedonic Motivation and Behavioural Intention to adopt, and Habit and Behavioural Intention to adopt were excluded (Figure A10).

For non-empirically tested relationships, it is worth noting that the relationship between Habit and Use Behaviour and Facilitating Conditions and Use Behaviour were not empirically tested in the context FIs. Of course, these relationships were empirically derived for the original UTAUT 2 (Venkatesh et al., 2012), i.e. framework 1.0, but as framework 2.0 deals with empirically derived factors in the context of FIs, it was decided to remove the relationship between Habit and Use Behaviour and Facilitating Conditions and Use Behaviour (Figure A10).

For discrepancies between the directionality of factors, Lifestyle Compatibility, Trust, Price Value, and Facilitating Conditions showed to have a bi-directional relationship toward Behavioural Intention to adopt. More specifically, Lifestyle Compatibility is a facilitator according to Hussain et al. (2019) and Joshi (2024), whilst a statistically insignificant barrier according to Sodhay et al. (2024). As such, empirical evidence shows that Lifestyle Compatibility is a facilitator and not a barrier. Therefore, Lifestyle Compatibility was converted to a facilitator (Figure A10). Further, Trust was shown to be a facilitator (Pipitwanichakarn, & Wongtada, 2019), a barrier (Joshi, 2024; Purohit, & Arora, 2023), and a statistically insignificant barrier (Sodhay et al., 2024). Similarly, Price Value was shown to be a facilitator (Joshi, 2024) and a barrier (Ashoer et al., 2024), and the same was observed for Facilitating Conditions, being a facilitator (Costa et al., 2021; Joshi, 2024) and a barrier (Purohit, & Arora, 2023). As Trust, Price Value, and Facilitating Conditions were shown to be a statistically significant facilitator and barrier, it was decided to maintain the bi-directional relationships in framework 2.0 (Figure A10).

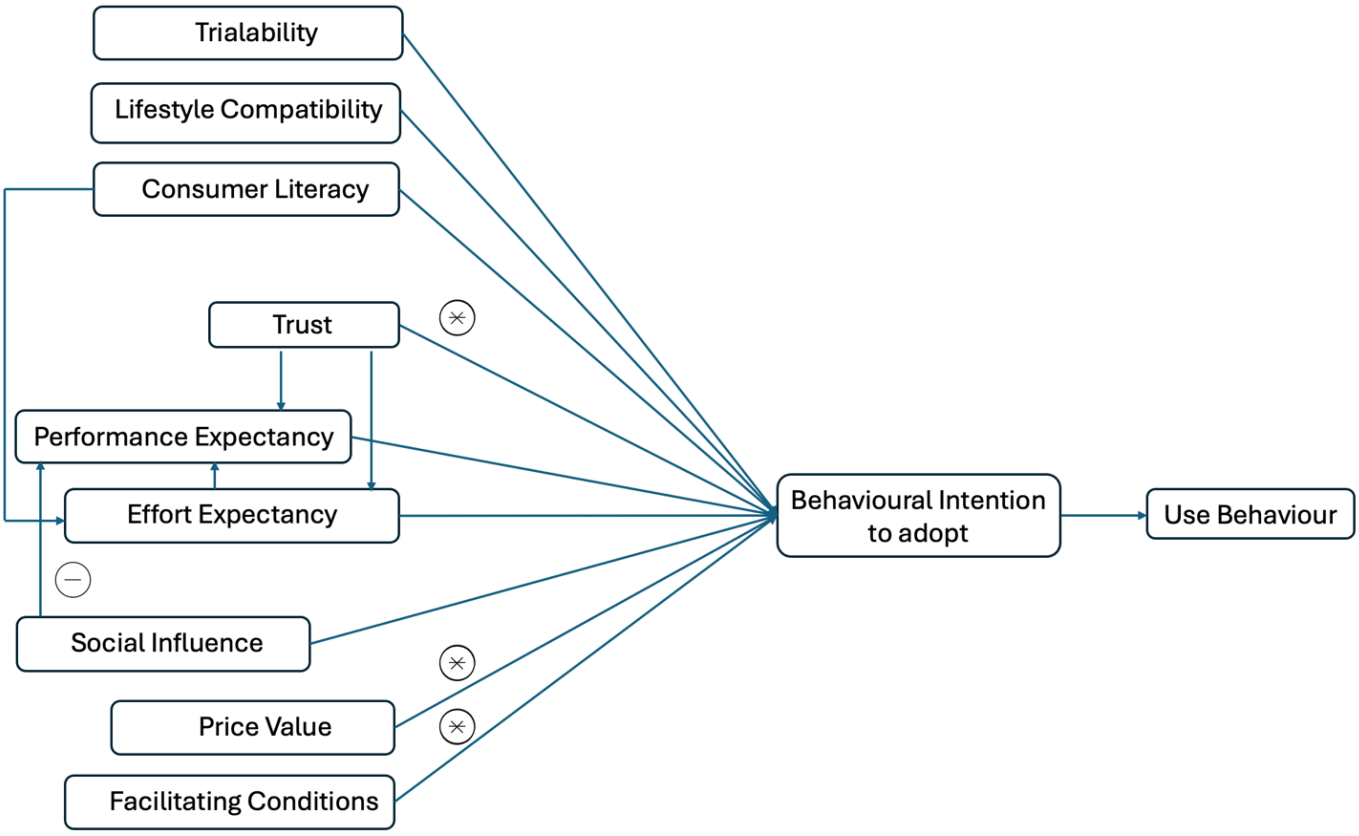

Figure A10. *Schematic representation of framework 2.0*. Empirical evidence on factors affecting the adoption of frugal innovations is shown. Negative correlations are represented by the minus sign, and the cross sign represents a positive and negative correlation simultaneously.

Appendix G: Interview results

All relevant identified concepts from the interviews, corresponding quotes from the interviews, and identified factors, as well as the identified issue with frugality, are presented in Table A14.

Table A14. *Concepts and factors identified from the interviews.* The identified factors, or in case for the identified issue with frugality the identified issue, (Factor/Issue), corresponding concepts identified from the interviews (Concept), and corresponding quotes from the interviews (Quote) and are presented. Quotes from different interviewees are represented by Roman numerals. [] represents quote adjustments used for readability purposes.

Factor/Issue	Concept	Quote
Performance Expectancy	Frugal health innovations must be superior if traditional innovations show poor performance or side effects	***I:*** *"The current products in the market are either inefficient or toxic. […] The major problem for [people installing the traditional product] is feeling nausea and being allergic to the product. So that is an aspect we are considering while building the product."*
	Frugal health innovations can be inferior if traditional innovations are of high quality, provided that frugal health innovations are used as an indicative measurement instead of a confirmative measurement	***I:*** *"No, [the frugal innovation didn't have to perform better than conventional methods]. We thought this was going to be a first screening. We knew that we were going to have false negative results, but we didn't care, […] [because] if you were positive, [you'd be referred to do the traditional screening method where you are more certain of your result]."* ***II:*** *"[The frugal innovation shows a] poorer performance compared to [the traditional innovation]. […] If you are in a remote area, and you have no access to a scanner and you have a stroke, there is something that is important, and that is time. […] It is more sensible to have a screening machine that tells you very quickly in a remote place that [a person] has a headache or a stroke as a first resource. [It does not matter] if the stroke is well defined, [it just has to be known] that [the person] has a stroke. And with that information [the person can go] to a proper place. […] So, it's more sensible, more cost-effective to have a kind of bridge process. […] You don't need a perfect quality image. You just need to discriminate a [stroke from a headache]."*
	Inferior frugal health innovations must perform sufficiently to address the healthcare problem	***I:*** *"[The readout] was not good enough. We were seeing a difference in colour, but not enough to be observed or used in the light of the day […]."* ***II:*** *"[We are] setting up something that we know works, up to some extent and quality […].*
Effort Expectancy	Frugal health innovations must be easy to use	***I:*** *"[We] designed the product in such a way that people don't have to put in a lot of effort [to use the product]. You just have to keep it, and that's all. You don't have to do anything about it. Probably, when you're refilling and trying to change the base of the product, there is [something] that you will have to understand, but you don't have to understand the technicalities or have in-depth knowledge [about the innovation]. Because people don't like complex stuff."* ***II:*** *"An invasive way like blood would be difficult […]. The urine sample is much easier to take. There are no specific needs to store urine. […] It was a big advantage [to have an easy-to-use innovation] to have access to these markets. […] We didn't want someone too specialized, like a doctor, to do the test. A nurse would be fine to do it […]. […] So low-experienced people were going to use it."* ***III:*** *"If you put [the innovation] in the […] countryside, […] there is no access to radiographers. [These innovations] are very complicated to manipulate. So, you need to include in your design, something that facilitates the process of manipulating the scanners. […] The manipulation process, how to run the scan, must be easy."*

Continuation of Table A14		
	Frugal health innovations must be easy to install	***I:*** *"They can install it themselves. That's a primary thing that we're taking into consideration while designing the product, because that really matters."* ***II:*** *"The installation process should be easy."*
Price Value	Frugal health innovations are cheaper than traditional innovations	***I:*** *"If you consider the amount of people that need to be tested and multiply it with € 45.00, it is a very big cost. So, [lowering the price] was a third adjustment we did."* ***II:*** *"We wanted to make a lab that would be affordable."* ***III:*** *"The main idea is to lower down the price, […] [by doing some simplifications and reduce the size of the scanner]. […] [Further,] the manipulation process, how to run the scan, must be cheap."*
	There is a cognitive trade-off between the price and perceived benefits of the frugal health innovations	***II:*** *"People are ready to pay a premium price if it solves a problem. So, when I ask [the customers] what sort of price range they would be happy to [pay for this innovation], they say "anything works, if [the innovation] works." […] I mean, price was a point, but it was not at the cost of [the innovations'] efficiency. […] It depends on how big the pain point that you are trying to solve is. If the pain of the problem is much higher than any other sort of factor, then definitely [the price] doesn't matter. But if there are okay-ish products […], the prices are a very big [concern]."*
	The price of facilitating infrastructure, installation, and maintenance of frugal health innovations also must be cheaper	***I:*** *"The installation process should be cheap."* ***I:*** *"You need to add on top a room that contains a Faraday cage, because you need to have electromagnetic isolation from outside. So again, [you need] a huge amount of money to build a room like that."* ***I:*** *"You need to sign a[n expensive] contract to get the maintenance for [the traditional Magnetic Resonance Imaging] scanners. […] [Thus, the frugal innovation] must be cheap to maintain as well."*
Facilitating Conditions	Facilitating conditions should be present when implementing frugal health innovations	***I:*** *"You need to include in your design something that facilitates the process of manipulating [the frugal innovation]. […] [Thus,] you need to have somebody that is well enough to conduct the examination, to produce the image, and send that image to another place and have an expert analyse the images. […] And you need to have a good supply chain where you have parts, so you can send those parts to the place where your scanner is installed and have a technician that is able to replace whatever is broken."*
	The lack of facilitating conditions provides an opportunity for frugal health innovations, prevented frugal health innovations solve the lack thereof	***I:*** *"You cannot have access to electricity all the time. So, addressing this problem began with seeing this huge gap within the market and that is why we thought to use biocontrol."* ***II:*** *"The problem is that [there is a lack of] appropriate machinery and infrastructure [to test for tuberculosis]. […] So, we thought to do something about it and use a portable sample, like urine. […] There are no specific needs in order to store urine […], [and for the moveable infrastructure it would be difficult] to consistently have electricity. So, our test doesn't use electricity. […] We had lyophilized reaction molecules [which didn't require a fridge to be stored]."* ***III:*** *"[The customer] really [wants to use the innovation in a portable way with batteries]. […] But the [frugal innovation] doesn't have a battery, [which] would also be very hard to do […]. […] We didn't really think that anyone would actually want to use it like that. That's a sizeable customer group for us that uses it [in a portable way]. […] And we sort of recommended some workflows for [these customers] and we started to have carry cases for [these customers]. But fundamentally it is not designed for that, and there are some places where it shows."*

Continuation of Table A14		
Trust	Consumers must feel that buying the frugal health innovation is safe	***I:*** *"It was all about kind of the trust association. Like, you're supposed to look at [the frugal innovation] and you think "Oh, I can buy that, that's cool, that's safe to buy. If I don't like it, I can return it as there is a return policy". […] [Consumers should] feel that it's something real and that it's something safe to buy, I think."*
Lifestyle Compatibility	The product image should align with the customers' expectations	***I:*** *"Rather than just present it as an open-source hobby, we kind of presented it as if it was a company because we wanted people to look at it like a real product […]. […] We tried to make it look like very consumer-electronically. […] We wanted it to look friendly and accessible and not like other lab equipment, but kind of cool and something that you'd want to pick up."* ***I:*** *"And some of that may have worked against us. Because I know we have scientific customers, or used to anyway before we were known, who thought "Well, is this actually a real thing, or is this kind of more like a toy? Is this actually meant to me?"*
Problem Severity	The number of cases should be sufficiently high	***I:*** *"We have like 50 cases per year, and we have a [traditional innovation], so as a develop country we don't need [the frugal innovation]. So that's why we were redirected to a low-resource country."*
Frugality Issue	Frugal refers to using limited resources, which decreases the expected performance and credibility of the frugal health innovation, resulting in a lack of funding for development	***I:*** *"Definitely lack of funding. Because when we talk about lack of funding, along with that comes lack of credibility. And this again, in turn, is driven by the absence of people having trust in you because they think this [innovation] is frugal. So, when you build something frugal, […] you are using limited resources and creating something valuable. And when this comes into play, people have a problem with the word "limited", right? And when they actually think about limited, they think that [the frugal innovation] might be less effective. And when they think [the frugal innovation] might be less effective, the [credibility of the innovation is decreased]. So, nobody is ready to fund you."*
	Frugal refers to reduced pricing. Yet, consumers use price as a quality proxy and thus expect a decreased innovation performance	***I:*** *"The problem with frugality is that it is about low cost, and people use money as quality proxy. […] So, the problem with frugal is that our psychology thinks "Well, that must be crap.". So, you really need to work on creating other marketing associations that say "Yeah, we've worked super hard, it's so sophisticated, and that's why we can make it so affordable.", and that's really hard."*