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BEYOND AVERAGE RESULTS IN HYPERTENSION E-SUPPORT & SELF-MANAGEMENT; 3 PILOT STUDIES WITH SOCIAL LEARNING

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Abstract Hypertension is a major risk factor worldwide for early death. Well-established interventions like the Dash diet on average have modest results (5 mmHg systolic and 3 mmHg diastolic pressure improvement). We compare three employee eHealth intervention pilots with results that are three to six times larger, analysing them for eSupport design lessons. In these pilots, various tools and daily microlearning strategies have been used. Small-scale Self-Management Support (SMS) groups for hypertension control foster high degrees of learning, interaction, and personalization. Average blood pressure improvements in the pilots were 161/112 to 129/90 mmHg, resp. 145/92 to 126/86 mmHg, and 155/95 to 139/85 mmHg. User evaluation (n=20) showed the importance of core SMS components: information transfer, daily monitoring, promoting health competences and follow-up. A cross-case finding is that more daily social learning and ICT-enabled microlearning feedback increases success: for competence building and for blood pressure results.

Keywords: Hypertension, Self-Management Support, Microlearning, Social learning, eHealth, Employee health.

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1 Introduction

Hypertension, as per Lancet publications, is identified as the largest avoidable risk factor contributing to global mortality, based on the findings from the most extensive health study ever conducted (Lozano, 2012, Lim, 2012). However, we face a double challenge:

1. Even for one of the most well-established and -researched interventions like the Dash diet, a meta-analysis shows that average blood pressure reductions are about 5 mmHg systolic and 3 mmHg diastolic (Siervo, 2015). Larger reductions are indicated to be desirable and feasible (Greger & Stone, 2016).
2. We know that a key challenge in lifestyle interventions is achieving behaviour change that are large enough (Dineen-Griffin, 2019). Which is especially difficult when people have only limited time available, due to busy work lives (Emerson & Berge, 2018).

Hence our research focus of this paper: (a) comparing three intervention pilots that show average improvements that are three to six times larger than the 5 to 3 mmHg above; (b) explicating eSupport design lessons that foster increased health self-management in the busy real-life setting of modern employees. Hence, we aim to involve patients themselves in health- and value creation. Moreover, we include their work environment (where they spend 8 hours/day) in improved triggering for healthy patterns.

Despite its preventable and reversible nature, about half of us are diagnosed with hypertension before reaching retirement age (Ostchega, 2020, Zhou, 2021, Carey & Whelton, 2020). Consequently, there is an urgent need to promote healthier lifestyles. However, a challenge lies in effectively acquiring the necessary competencies and behaviours.

The conventional advice provided in healthcare for managing hypertension appears rather rudimentary when examined from a competency-building perspective. Furthermore, the feedback mechanism is often delayed. A typical recommendation might be: "Reduce your salt intake and engage in more physical activities. We will reassess your Blood Pressure (BP) after three months." This method starkly contrasts with the principles derived from Self-Management Support (SMS) literature which emphasize the importance of ***personalized learning support***, ***regular (e-)monitoring*** and ***ongoing coaching*** (Dineen-Griffin, 2019). Incorporating insights from microlearning studies on competency development (Emerson & Berge, 2018, Simons, 2015, 2020b), we can

hypothesize why many individuals fail to achieve satisfactory outcomes. Standard care provides virtually no support for competency development. By contrast, various forms of eSupport can enhance daily competence building.

In a prior research study, we presented a preliminary pilot (Simons, 2022a) that demonstrated the feasibility and perceived usefulness of daily hypertension feedback. However, a question remained unanswered: how consistent are the effects across different cases (external validity)? Additionally, at a more granular level of design analysis: which elements of the support intervention are most valued; how does this depend on the context of the intervention? Where can improvements be made? In this paper, we undertake an analysis across three distinct cases. We compare the results and user evaluations from three hybrid (or eSupported) Self-Management Support (SMS) pilots of 2 weeks each, conducted across various employee groups, organizations and intervention settings.

Research Question:
How do hybrid eSupport elements across the three cases relate to differences in health competences, -behaviours and blood pressure outcomes?

2 Theory and concepts

This paper utilizes five theoretical domains for its intervention and design analyses. These include: persuasive technology for eHealth, lifestyle medicine for hypertension, Self-Management Support (SMS), social learning, and Information- & Communication Technology (ICT)-supported microlearning.

It has been explored in other research how the challenges of ***persuasive technology*** (Fogg 2003, 2009) ***for eHealth*** are not solely situated in the ICT design, but also encompass the design of the overall service scape. This includes aspects such as health effectiveness and coaching performance (Starr 2008, Simons 2014b). The aim is to generate positive, mutually reinforcing service experiences across communication channels, leading to effective health behaviours and outcomes. This is encapsulated in the subsequent design evaluation framework for health improvement ICT solutions (Simons 2014), as depicted in Figure 1.

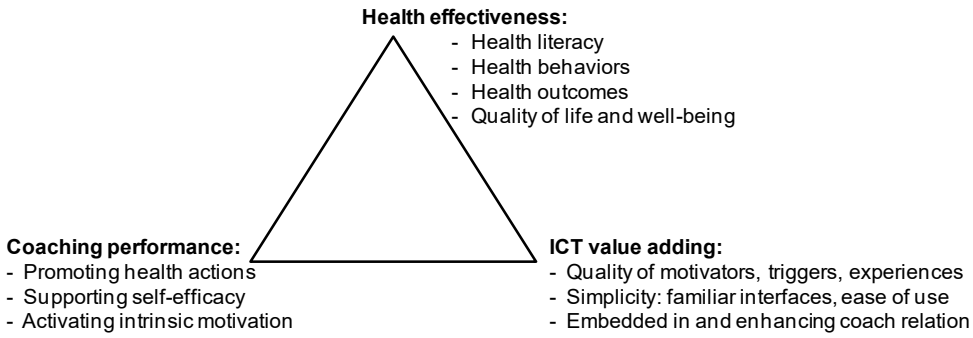

Figure 1: Design requirements for designing ICT-enabled healthy lifestyle support

Figure 1 delineates three domains to evaluate the impact of ICT-enabled health interventions: health effectiveness, coaching performance and ICT value adding. We employ this as an analysis framework for section 4, Results.

Lifestyle medicine for hypertension has an extensive research history: overall (Roberts & Barnard, 2005) and regarding powerful short term effects on hypertension, inflammation and endothelial health of for example antioxidant foods (Franzini, 2012), flaxseed (Rodriguez-Leyva, 2013), beetroot and nitrates (Kapil, 2015), salt reduction (Dickinson, 2014) and healthy, low-fat food choices (Siervo, 2015), combined with exercise (Greger & Stone, 2016, Simons, 2022c) and stress reduction (Pickering, 2001). We have translated this research into lifestyle advice aimed at generating measurable improvements for hypertension on a daily basis.

As elaborated in greater detail in other sources (Simons, 2022a), the domain of health ***Self-Management Support (SMS)*** encompasses various support process components. These extend beyond support for specific health behaviours such as exercise, diet, sleep, smoking and so on. They also include tailoring the action plan to align with a participant's unique context and priorities (Demark-Wahnefried, 2007, Jonkman, 2016, Dineen-Griffin, 2019, Simons, 2013, 2017, 2020a, 2021). This collection of SMS process components also forms the ***evaluation framework*** we employed for user evaluation in section 4. The components are as follows:

1. **Monitoring** of symptoms (regular, active self-monitoring)
2. **Information** transfer (throughout the learning process)
3. **Competence** building, which includes:
   a. ***Problem solving***/decision making
   b. ***Plan making***: self-treatment through use of an action plan

c. ***Coping management***: skills for handling challenges, frustrations etc
d. ***Resource utilization***: incl. social context or medication management

Another pertinent field is that of ***Social learning***. This is quite distinct from Social Cognitive Theory, which is a broad framework that is largely agnostic to the detailed distinctions between types of cognition and learning from the social learning literature. Social learning encompasses imitation, teaching and social norm compliance. It is rather dominant in humans and it is the type of learning where we most strongly outperform other primates like chimpanzees and orangutans (Herrmann et al, 2007). Interestingly enough, human toddlers do not exhibit this outperformance on causal, spatial or quantitative cognition. However, social learning appears to be largely a human trait. It is an efficient and preferred mode of learning throughout our lifespan and plays a large role in the development of human norms, culture and knowledge acquisition (Tian, 2011, Whiten & van de Waal, 2018). Not only does this help explain why our health behaviours are usually similar to the people around us (Latkin & Knowlton, 2015). Group-based social learning, a concept pioneered by Bandura in 1971 already, can also be an important basis for designing health interventions. For example using WhatsApp groups and peer coaching can be beneficial (Simons, 2020b).

Lastly, ***microlearning*** concepts are highly relevant to our objectives of increasing health behaviour competence levels of participants. This is especially true since our study took place in the busy work context of the participants. This creates a need for efficient learning and a fast demonstration of effectiveness. "Business is about productivity, not learning. [..] *Inserting learning interventions into a busy employee's schedule is a real challenge*" (Emerson & Berge, 2018). According to Giurgiu (2017), the concept of microlearning should be centred around the principle of focusing solely on what is essential to know. This approach aligns with the human propensity for instant gratification, thereby satisfying short-term objectives that contribute towards the achievement of long-term goals. This perspective underscores the importance of targeted learning that is both efficient and effective in meeting immediate needs while also supporting broader, long-term learning objectives. In a similar vein, Gabrielli et al (2017) emphasize the significance of "contextual" learning, which they describe as engaging in a "conversation with the world and oneself". It's a dynamic and interactive learning process that encourages learners to actively engage with their environment and their own thoughts and experiences. The process of competence building is

characterized by *embedded learning*, where *doing* and *achieving results* are at least as important as the learning itself (Emerson & Berge, 2018, Simons, 2010).

A multitude of research studies have demonstrated the efficacy of self-management tools and ***Information and Communication Technology (ICT) in a multichannel service-scape*** for the purpose of setting goals that are tailored to personal preferences. The use of ICT to support tracking and provide progress feedback has been shown to be particularly beneficial (Kari, 2017, Lehto, 2013, Lopez, 2011, Ricciardi, 2013, Wickramasinghe, 2010). In this context, several elements have been identified as instrumental in aiding motivation and success. These include individual coaching and eTools such as microlearning for health. The concept of Quantified Self (QS: Swan, 2012, 2013), which involves self-tracking with technology, has also been highlighted as a valuable tool. The use of WhatsApp groups and peer coaching in virtual support teams have been shown to be effective strategies for enhancing motivation and success (Simons, 2015, 2016, 2020b, 2022b).

3 Methods and Materials

In this research, we adopt a ***design research*** approach, specifically following the design cycle methodology as proposed by Vaishnavi & Kuechler, (2004). This methodology provides a structured framework that guides us through various stages of the research process. It begins with the identification and awareness of the problem at hand, followed by the suggestion of potential solutions. The next stage involves the development of these solutions, creating and refining the proposed ideas. Following the development stage, we move into the evaluation phase. Here, we assess the effectiveness and applicability of the developed solutions in addressing the identified problem. The final stage of this methodology is the conclusion, where we summarize our findings and discuss their implications.

We present our multiple-case study results in section 4 of our report. Following the presentation of our results, we delve into a discussion of design lessons in section 5.

The ***hybrid healthy lifestyle eSupport with twice-daily biofeedback*** consisted of:

- Telephone intake & instructions for BP home measurements

- Start- and final group sessions (2 weeks apart, face-to-face)
- Daily MS Teams eCoaching in week 1
  (Case A: individual and group; Case B: group; Case C: only email tips)
- Twice-daily BP measurements and logging email (Case A & B)
- Feedback on group progress after 1st week (Case A & B)
- Healthy recipe suggestions
- Content (portal and/or email) on health, BP, and behaviour strategies

From November 2021 to February 2023, a ***multiple-case study*** was carried out involving three distinct employee groups. All participants signed a consent form for anonymized publication of the case results. Since this was not a study of a medical intervention but of lifestyle support, medical ethical clearance was not required.

The primary objective of this study was to evaluate the real-world impacts of a healthy lifestyle intervention designed for group-based hypertension Self-Management within Dutch work settings. Specifically, the focus was on competence building, group learning, and the question which support tools were most helpful for participants for supporting healthy lifestyle behaviours.

The study was conducted as small-scale pilots, with participant numbers per group ranging from 8 to 4 individuals. The decision to conduct small-scale pilots was driven by three key factors. Firstly, previous research (Simons, 2022a) demonstrated robust Blood Pressure (BP) effects across users, which suggested that meaningful results could be obtained even with small group sizes. Secondly, our research approach was guided by the design principle of conducting multiple small tests to collect and test a variety of improvement options, rather than conducting a single large-scale test (Cennamo, 2019). Lastly, our participant recruitment relied on employer organizations for volunteers.

Table 1: Case description and start situation

Aspects	**Case A (n=8)**[1]	**Case B (n=6)** [2]	**Case C (n=4)**
Case start	Nov '21	Nov '22	Jan '23
Participants	4 men, 4 women	3 men, 3 women	4 men

[1] One of the participants had a user evaluation outlier pattern, see Table 3.
[2] One of the participants had a user evaluation outlier pattern, see Table 3.

Avg. start blood pressure (mmHg)	145/92	161/112	155/95
Intervention duration	11 days	11 days	17 days
Final user evaluation	10 weeks after start	5 weeks after start	5 weeks after start
Support format specifics	Extra App for healthy menus	In week 1: longer daily e-Sessions, with more content & group interaction	*Light-weight*: * no coaching * no daily BP log-mail * info via mail instead of portal

In total, the study involved 20 volunteer participants, see Table 1. Cases A and B were conducted with mixed groups from university settings, primarily involving support staff but also including some academic personnel. Case C involved ICT professionals. The Socio-Economic Status (SES) and education levels of the participants were either average or above average for the Netherlands. All participants had hypertensive BP at the start of the study and volunteered for these 2-week in-company BP interventions.

There were some differences across the cases in terms of the intervention service mix, group composition, and organizational context. These differences provided an opportunity for interesting cross-case observations, which are discussed in the following section.

4 Results & Cross-Case Comparisons

A first question for the research findings is: were there meaningful ***BP improvements*** across these cases? For each of the three cases this turned out to be true.

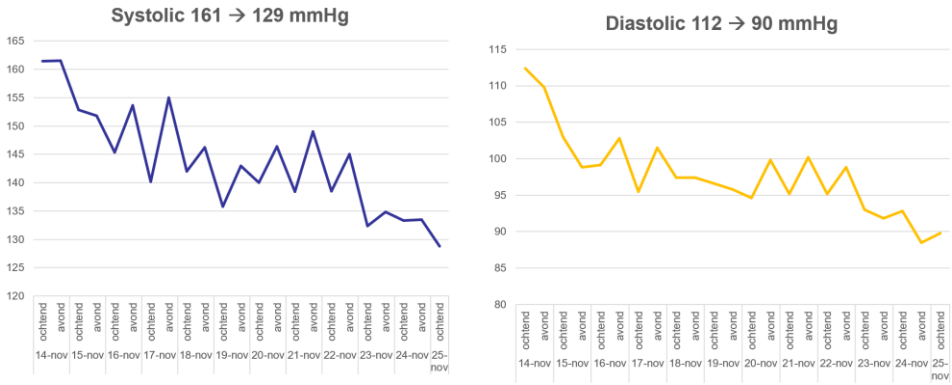

Figure 2: Average blood pressure drop in Case B (n=6)

In a previous report, we detailed the significant Blood Pressure (BP) improvements observed in case A (Simons, 2022a). The BP readings dropped from an initial 145/92 mmHg to 126/86 mmHg over the course of 11 days, starting from Monday morning and ending on Friday morning of the second week. Similarly, case C also demonstrated BP improvements, as shown in Table 2, with readings decreasing from 155/95 to 139/85 mmHg. The most substantial improvements were observed in Case B, as depicted by the BP trend line in Figure 2.

Given that participants were instructed to measure their BP every morning and evening, an 11-day (average) 'spiky' trend line was created for each pilot. The term 'spiky' is used to describe the trend line because evening BP readings tend to be higher than morning readings. Based on our user evaluations, it was found that participants generally found it highly motivating to observe their individual and collective trends. One participant noted: "I was positively and strongly surprised how large the impacts of our behaviour changes were." In case B, hypertension dropped from an initial reading of 161/112 mmHg to 129/90 mmHg over an 11-day period.

A second observation from this study is that the intended outcome of this intervention on BP occurs quite ***robustly across individuals***. This observation also has methodological implications as it enables us to work with small pilot groups and still observe robust effects per group. The extent of BP effect robustness across individuals is indicated in Table 2, with the 'High BP Responder' percentage per case. We defined a 'High BP Responder' as a participant who had an average or above-average BP improvement.

Which brings us to a third observation: Cases A and B have more 'High Responders' than Case C. While this could be due to chance, we think that this discrepancy is due to the lesser degree of competence support provided in Case C. This idea is supported by the qualitative user- and case evaluations presented in Tables 2 and 3. We will further elaborate on in this point in the discussion section.

Table 2: Cross-Case findings and authors' design evaluation, on design requirements from Figure 1 (authors' opinions, 5-point scale from - - to ++)

Findings	**Case A (n=8)**	**Case B (n=6)**	**Case C (n=4)**
Final Blood Pressure (BP, Avg. mmHg)	126/86	129/90	139/85
BP drop, mmHg	-19/-6	-32/-22	-16/-10
% of High BP Responders[3]	63%	66%	25%
Health behaviours	+ Healthier diet + Avg. 10.000 steps/day	++ Largest diet improvements ++ Highest physical activity	- No changes in intensive exercise - Most are still searching how to implement in daily patterns
Coaching performance	+ Raise efficacy + Adoption (except by some: time constraints)	++ Largest information transfer & impact from assignments ++ Largest social learning	+ Relevance of content was valued - Progress depends on user him/herself, without daily coaching
ICT value add	+ BP log mails daily; impact + Daily coaching (indiv & group) + Info in portal	+ BP log mails daily; impact + Daily digital 'day-start' sessions + Info in portal	- Portal and daily logging not used + Daily mail tips were appreciated

[3] This the % of participants in a case that had average or above average BP improvments. This is an indicator of robustness of BP results across participants.

Table 2 presents a comprehensive ***design evaluation*** across the cases, based on the theoretical framework encompassing health behaviours, coaching performance, and ICT value addition.

Firstly, in terms of health, all cases demonstrated improvements in both BP and health behaviours. Case B exhibited the most significant improvements, while Case C showed the least. From our observations, we deduced that this variation was a result of the second aspect: coaching. The coaching assignments for behaviour improvement were more explicit in case B than in case A. For instance, participants were instructed to abstain from cheese or meat for two weeks and consume at least 800 grams per day of fruits or vegetables. Additionally, there was extensive daily group coaching and content on everyday challenges. In contrast, Case C did not involve any coaching beyond an initial workshop to explain what participants should do, followed by daily content emails until the final workshop. Therefore, the extent of behaviour progress largely depended on a person's self-management skills. The third aspect of the design evaluation, ICT value addition, was higher in Cases A and B than in C. This included twice-daily BP logging emails, portal information on health and BP, healthy recipes, daily e-coaching in week 1 (with a focus on individual learning in Case A and group-level learning in Case B), and feedback on group-level BP progress after week 1. In Case C, these elements were replaced with daily email tips on hypertension, health, and behaviour change tactics.

From the ***user evaluations***, we discuss the perceived usefulness of the various intervention components across cases, see Table 3. Scores were given on a 7-point Likert scale, ranging from 'totally disagree' to 'totally agree', in answer to the question: 'Which components stimulated you to adopt healthier behaviours?' The components are clustered in the SMS process framework, even though some components support more than one SMS process.

Table 3: Components that stimulated healthier behaviours (7-point (dis)agree, Avg)

Monitoring:	Case A[4]	Case B[5]	Case C[6]
1. Mail triggers for blood pressure logging	4.9	6.2	n.a.
2. Daily management	5.4	5.6	6.0
3. Gaining more blood pressure control	6.3	6.4	6.5
Information transfer:			
4. Start workshop	6.4	6.4	6.8
5. Healthy menu suggestions (App/portal)	4.4	4.8	n.a.
6. Health and blood pressure information in portal/mails	5.4	5.2	6.3
7. More understanding of blood pressure & health	6.1	6.2	6.0
Competence building:			
8. Follow-up workshops	6.3	6.2	7.0
9. Individual tips and answers to my questions from the coaches	6.6	6.2	6.8
10. Doing this as a group	6.4	5.8	5.5
11. Tips in dealing with challenges	6.0	6.2	6.0

Table 3 reveals that the main perceived benefit from *Monitoring* was the control participants gained over their blood pressure (3.). For the second SMS process element, *Information transfer*, participants valued the start workshop (4.) and increased understanding of blood pressure and health (7.) most. These two intervention components (4. & 7.) were not just about information transfer but also about increasing competencies for effective plan making and prioritizing efforts on those lifestyle choices that have the best combination of short-term effectiveness and long-term perceived attractiveness/feasibility for a participant. The element of *Competence building* is key for training sustainable self-management skills and coping strategies. All four components (8. to 11.) received relatively high scores. For case B, the perceived value of doing this as a group (10.) was explicitly stressed by participants in the joint group evaluation after 5 weeks. Thus, support for competence building was generally valued by the participants.

[4] One of the participants had an outlier pattern of scoring (since she could not be present at several of the group coach sessions, due to illness plus family logistics). Table 3 displays the average scores of the other 7. (Score 4=neutral) Her scores were resp.: 6; 6; 6/3; 3; 4; 5/3; 6; 3; 3.

[5] One of the participants had an outlier pattern of scoring (she had hereditary hypertension since 18 years old and her BP values did not change, despite her best efforts). Table 3 displays the average scores of the other 5. (Score 4=neutral) Her scores were resp.: 4; 4; 4/4; 4; 4; 5/4; 4; 6; 5.

[6] n.a. = not applicable

In a previous report, we detailed several health behaviour challenges, as well as what helped participants (Simons et al., 2022a). In answer to our Research Question (How do hybrid eSupport elements relate to differences in health competences, -behaviours and blood pressure outcomes), multiple ***elements for promoting health improvements*** which we found before, have been confirmed in this cross-case analysis (Simons et al., 2023):

a) Rapid feedback: twice-daily measurement of progress
b) Achieving results and enhancing self-efficacy
c) 'Quick results'-tips & education: which large steps for large benefits
d) Practical tips for every-day choices and practicing new behaviour patterns
e) High quality coaches and coach sessions to increase health competence
f) Doing this in a group and teaching each other
g) Coaching on coping strategies

One element that consistently stood out across all three cases, as per the user feedback, was the ***high value placed on the quality of information and tips*** provided. Participants found these particularly effective in facilitating rapid BP improvements. In all three cases, the information provided was deemed not only relevant – with comments such as "these really helped" – but also highly valued, with one participant stating it was the "most useful information in years". This feedback underscores the significance of providing high-quality, relevant information in health support programs.

Next, we underscore findings derived from the primary ***cross-case differences***. Following the completion of Case A, we implemented three adaptations to the support components, based on feedback from the users. A first adaption regarded the healthy menu App. Initially, we had rented a commercial mobile application for the users, which offered numerous easy and adaptable 'hypertension-friendly' menu options, including a 'home-delivery' function. However, the App was scarcely utilized and home delivery not at all. Hence the App was subsequently discarded.

In addition to this, our initial approach relied heavily on individual coaching. However, given the substantial benefits we observed from group learning in Case A, we made a second and third significant change for Case B: (1) we replaced individual coaching with longer, information-intensive daily digital group workshops as day-starters in the first week, and (2) we provided more explicit daily assignments specifying what experiments and behaviours to practice each

day. As a result of these changes, we observed larger improvements in healthy eating and exercise in Case B, as shown in Table 2.

In contrast, the support provided in Case C was more lightweight due to the different organisational context and participants' preferences for a less time-intensive approach. Therefore, there was no coaching between the start and final workshop, each lasting two hours. Furthermore, daily logging and portal access were not utilized, although the participants did monitor their blood pressure themselves during the two weeks. Instead, they received daily email tips on health behaviours, self-management, and blood pressure. An overall finding from Case C is that health behaviour changes were smaller and only one participant achieved above-average BP improvements.

The cross-case analysis reveals that ***most individuals encounter difficulties when acting purely based on information, when they attempt to make substantial improvements in their health choices. Hence, they need additional support.*** This observation is particularly evident in Cases A and B, as compared to Case C. The latter case was mostly driven by information provisioning, leading to fewer improvements in health behaviour competences and blood pressure. In cases A and B, the majority of participants indicate they needed the daily support mechanisms, such as coaching, education, group learning processes, but especially hearing from others what worked for them and what not, and exchanging coping strategies for various situations, in order to implement sufficient improvements in health behaviours. Next, the confirmation of daily Blood Pressure (BP) improvements is what provides additional learning incentives. Still, it's important to note that even with the provision of daily support, not every participant in Cases A and B experienced the desired level of improvement. Thus, even though this daily support helps significantly, it does not provide 100% guaranteed success.

5 Discussion

This cross-case design analysis is subject to several ***limitations*** that should be considered when interpreting the results. Firstly, due to its small scale, encompassing a total of 20 participants across three cases, our research question is answered in a qualitative manner rather than a quantitative one. This means that while we can draw insights and understand trends from the data, we cannot make definitive statistical conclusions.

Secondly, the Blood Pressure (BP) trends are based on self-reported measures. While the participants did practice these measurements during a wash-in period of three days before the start of the study, which aids in creating robustness, there is still potential for variability and error inherent in self-reported data.

Thirdly, we assessed health competence growth, changes in lifestyle behaviours, and learning strategies in a qualitative manner. In future research, it would be beneficial to use more formal and validated surveys to generate health competence improvement scores, for example. However, this is not a straightforward task for two reasons: (1) competences to improve hypertension are not the same as general health competences and (2) in these participants of this study health competence was already well above average (which makes it more difficult to measure significant improvements, when using standard surveys).

Fourthly, each of the three case interventions tested multiple intervention components together, without a control group for comparison. Therefore, while cross-case intervention differences provide some insights, interpretations are qualitative and subjective. This means that while we can draw some conclusions from the differences observed between cases, these should be interpreted with caution as they are based on subjective assessments and not controlled comparisons.

These limitations highlight areas for improvement in future research and underscore the importance of interpreting the results of this study within the context of its design and methodology.

5.1 Implications for theory

Based on our cross-case analysis we will outline several ***intervention design lessons*** and link them to existing theories on learning effectiveness and social learning mechanisms.

Overall, in addition to the contributions to self-management support theory mentioned previously, this study highlights potential benefits of *group and social learning* beyond just motivational and affective aspects (Molka-Danielsen, 2009, Simons, 2018, 2019, 2020b). While SMS and microlearning theory often focus

on managing an individual's learning process, the power of social learning observed in this study can enhance competence building through the sharing of results and experiences among participants. This is consistent with *Social learning theory*, which emphasizes the importance of seeing, discussing, and reflecting on the experiences of others (Herrmann et al, 2007, Whiten & van de Waal, 2018).

More specifically, as stated in our findings, several participants say they find it ***hard to make large health behaviour changes based solely on information***. Given that there is a lot of conflicting health advice in the world around them, they have to deal with incertainty and difficulties in assessing the context and value of new health advise. It has been known for quite some time (Laland, 2004) that 'copy when uncertain' and 'copy if better' became attractive as social learning strategies in settings similar to our intervention. Besided (Hwang, 2022), practically learning new behaviours is about learning through experimentation. Hence, the ***first design lesson*** is: ***besides clear information, extra support is needed: daily group coaching speeds up social learning processes*** and stimulates participants to try new health experiments and coping strategies. As part of this proces, 'vacarious interaction' has been coined by Swan (2003): even as virtually 'silent' participant in experiences and discussions of the others that you recognize as relevant to you, you learn new strategies.

As a ***second design lesson: it does not suffice to have just any group information sharing process***. Our participants and user evaluations confirmed what Swan (2003) stated about social learning effectiveness resulting from (a) 'instructor-participant-interaction' and (b) 'course content'. Firstly, regarding 'instructor-participant-interaction' for social learning, the theory states that both quantity and quality of interaction with an instructor are important. Which includes the fact that learning increases with the number remarks that participants make and with the value that instructors place on those that are most useful for the other participants. In the findings of our study, see also the 10-weeks-evaluation of case A (Simons et al., 2022a, 2023), participants explicitly value the quality and relevance of instructor feedback to help them become effective as fast as possible. Secondly, quality of course content is more than clear course design and execution, the quality, information and tips must be high, and it is also about providing immediate feedback and instruction on participant inputs and behaviours. Following 'copy if better' and 'copy if clear', ***information, instructions and tips are only applied if participants recognize them as effective for generating rapid BP improvements***. ***This requires trust in the***

instruction and instructors, plus daily 'proof' from BP improvements in the group.

Third, the ***power of the 'Challenge Regime'*** was mentioned in many evaluations. There are at least three important elements to this regime: (1) making a commitment for large health changes and experiments, (2) knowing that it is for only two weeks, (3) doing it together with peers who are in a very similar situation. The combination of factors (1) and (2) enhances temporary attention, motivation, effort, and willingness to experiment. The result is: more improvement, more learning, a positive experience, plus a desire to continue using some of the lessons learned in the longer run. Factor (3), doing it with peers who are perceived as being similar, is highlighted by research of BerYishay & Mobarak (2019). They show that investing time and effort, plus adopting new behaviours of participants increases when the peers are perceived as more representative of themselves. We see this reflected in our group coaching processes: participants find it ***most interesting what works for their peers*** (in contrast to outsiders or theory), because this is seen as feasible for themselves.

Fourth, ***light-weight support*** (like in Case C, which had informational, measurement and instructor support, but much fewer social learning instances) ***only works if self-management competences of participants are high***. This makes sence, especially given the benefits of social learning discussed above. In Case C, this limitation in social learning processes, needed to be compensated by other learning processes of the participants themselves, with more of the effectiveness depending on self-management. Besides, in Case C we saw participants struggle more with establishing the more structural health patterns for the longer term.

Finally, these positive group support effects may be about more than just competence building. It may also be about ***enhancing your (virtual) support team***. In the moments of learning, but also with a more 'virtual' presence: *'tomorrow I will see them again and will have to tell my coaches and the others how I fared.'* It builds extra commitment, provides extra inspiration, and most importantly: it combines with mentally preparing for (daily or difficult) situations which one expects to occur. Making 'plans to ensure that I will do better in situation XYZ today' fits behaviour literature (Schwarzer, 2008) but should maybe also be connected to the social aspects to understand the powerful peer group effects: not just 'doing better' but also 'looking better, in their eyes' (Khan, 2017).

Overall, this study provides valuable insights into the potential benefits of group support for competence building and learning through the lens of *Social learning theory*. This approach challenges the traditional focus on individual learning processes in SMS and microlearning theory and highlights the importance of group learning and sharing experiences. The efficiency of social learning is especially valuable in modern workplaces where time and 'mind space' for health self-management are often limited.

5.2 Implications for practice

Practically, the intervention was highly dependent on ***technology*** and tools, which provided important benefits.

- First, affordable and reliable blood pressure consumer electronics made it possible for participants to daily monitor their blood pressure at home. This allowed for more accurate and timely data collection than would have been possible with traditional clinic visits.
- Second, our mail/web-based coaching portal enabled real-time progress tracking by participants and coaches alike. This allowed coaches to provide more personalized and timely feedback to participants, and it also allowed participants to see their own progress and stay motivated.
- Third, daily MS Teams meetings enabled high quality group and individual coaching without travel- or time constraints. This made the intervention more accessible to participants from a variety of backgrounds and locations.
- Fourth, our portal content database supported participants with multiple lessons on blood pressure and healthy lifestyle. This provided participants with the knowledge and skills they needed to make lasting changes to their health.
- Fifth, the healthy menu App offered even included a button to directly order/deliver the ingredients to participants' homes (although this latter option was not used by the participants). In short, technology was a key enabler for the delivery of daily health support for high impact results.

By contrast, ***microlearning*** is sometimes framed as 'a tool' or technology. But we saw that it is much more. Its value ***as an embedded learning strategy*** (Gabrielli et al, 2017, Emerson & Berge, 2018) to create daily, relevant, and 'rich' learning instances was key in our case implementations: creating multiple, daily competence-building microlearning and social learning opportunities. This happens not only via regular mails with health tips or micro-learning quiz tools (Simons et al, 2015), but also via face-to-face and in group discussions.

In addition to the theory implications (5.1), a practical lesson is that a ***social learning approach is particularly useful for a target population of employees, given their busy (work-life) schedules***. There are two main reasons for this. Firstly, observing the success of others may have a greater emotional and learning impact compared to simply hearing about it through individual learning experiences. This emotional connection can be a powerful motivator for learning and behaviour change (amidst other competing priorities in their busy schedules). Secondly, learning from the experiences of others can be *time-efficient*, as it allows individuals to gain knowledge and insights without having to directly experiment with everything themselves: *"By doing this together, I get much further. I learn a lot from the others' examples, suggestions and discussions."*

Next steps in our research are: (a) further enhancing the social learning impacts and (b) upscaling via implementing 'Train-The-Trainer' best practices (Pearce, 2012, Tobias, 2012, McGushin, 2023) and building an AI Research Assistant for health professionals and experienced patients and employees who want to improve their hypertension self-management, based on the latest available medical evidence (Simons et al., 2024). In the coming years we aim to involve the first 10% of 'early adopters' within the Dutch population of people with chronic conditions. The goal is to minimize their need to visit hospitals and to maximize their self-management capabilities, by building a self-support community. This includes a support structure with sharing of responsibilities between a central body and local resource users, plus adaptive co-management with existing local networks (Berkes, 2009).

In ***conclusion***, this hybrid eSupported intervention helped achieve relatively large BP improvements in two weeks, quite robustly across participants and organisation settings. Second, this 'challenge' was feasible, fitting into the busy lives of participating employees, and the intervention was highly appreciated. The value was confirmed of the hybrid Self-Management Support (SMS), microlearning and social learning approaches for competence building. Specifically, our study illustrates the value of: (a) peer group coaching combined with daily social learning; (b) a 'Challenge Regime' with high commitments for a short time; (c) self-efficacy growth for users from large health results within days; (d) using 'BP behaviour hacks' and qualified instructors to achieve maximum learning and daily BP improvements (e) multiple technology-enabled health competence building lessons each day. These options hold promise for future health Self-Management eSupport innovations.

References

Bandura, A. (1971). *Social learning theory* (Vol. 1). Prentice Hall, Englewood cliffs.

Berkes, F. (2009). Evolution of co-management: role of knowledge generation, bridging organizations and social learning. *Journal of environmental management*, *90*(5), 1692-1702.

BenYishay, A., & Mobarak, A. M. (2019). Social learning and incentives for experimentation and communication. *The Review of Economic Studies*, *86*(3), 976-1009.

Carey, R. M., & Whelton, P. K. (2020). Evidence for the universal blood pressure goal of< 130/80 mm Hg is strong: controversies in hypertension-pro side of the argument. *Hypertension*, *76*(5), 1384-1390.

Cennamo, K., & Kalk, D. (2019). *Real world instructional design: An iterative approach to designing learning experiences*. Routledge, Oxfordshire, UK.

Demark-Wahnefried, W., Clipp, E., Lipkus, I., Lobach, D. et al. (2007). Main Outcomes of the FRESH START Trial: A Sequentially Tailored, Diet and Exercise Mailed Print Intervention Among Breast and Prostate Cancer Survivors. *J Clin Oncol, 25*(19), pp. 2709-2718.

Dickinson, K. M., Clifton, P. M., Burrell, L. M., Barrett, P. H. R., & Keogh, J. B. (2014). Postprandial effects of a high salt meal on serum sodium, arterial stiffness, markers of nitric oxide production and markers of endothelial function. *Atherosclerosis*, *232*(1), 211-216.

Dineen-Griffin, S., Garcia-Cardenas, V., Williams, K., & Benrimoj, S. I. (2019). Helping patients help themselves: a systematic review of self-management support strategies in primary health care practice. *PloS one*, *14*(8), e0220116.

Emerson, L. C., & Berge, Z. L. (2018). Microlearning: Knowledge management applications and competency-based training in the workplace. *Knowledge Management & E-Learning*, 10 (2), pp.125-132.

Fogg, B. J., & Fogg, G. E. (2003). *Persuasive Technology: Using Computers to Change What We Think and Do*. Morgan Kaufmann, San Francisco.

Fogg, B. J. (2009). A behavior model for persuasive design. *Proceedings of the 4th international conference on persuasive technology*. ACM, 2009.

Franzini, L., Ardigo, D., Valtuena, S., Pellegrini, N., Del Rio, D., Bianchi, M. A., ... & Zavaroni, I. (2012). Food selection based on high total antioxidant capacity improves endothelial function in a low cardiovascular risk population. *Nutrition, Metabolism and Cardiovascular Diseases*, *22*(1), 50-57.

Gabrielli, S., Kimani, S., & Catarci, T. (2017). The design of microlearning experiences: A research agenda (on microlearning).

Giurgiu, L. (2017). Microlearning an evolving elearning trend. *Scientific Bulletin*, *22*(1), 18-23.

Greger, M., & Stone, G. (2016). *How not to die: discover the foods scientifically proven to prevent and reverse disease*. Pan Macmillan, New York City.

Herrmann, E., Call, J., Hernández-Lloreda, M. V., Hare, B., & Tomasello, M. (2007). Humans have evolved specialized skills of social cognition: The cultural intelligence hypothesis. *Science*, *317*(5843), 1360-1366.

Hwang, G. J., Chang, C. Y., & Ogata, H. (2022). The effectiveness of the virtual patient-based social learning approach in undergraduate nursing education: A quasi-experimental study. *Nurse Education Today*, *108*, 105164.

Jonkman, N. H., Schuurmans, M. J., Jaarsma, T., Shortridge-Baggett, L. M., Hoes, A. W., & Trappenburg, J. C. (2016). Self-management interventions: proposal and validation of a new operational definition. *Journal of clinical epidemiology*, *80 (*December 2016*)*, 34-42. DOI: https://doi.org/10.1016/j.jclinepi.2016.08.001

Kapil, V., Khambata, R. S., Robertson, A., Caulfield, M. J., & Ahluwalia, A. (2015). Dietary nitrate provides sustained blood pressure lowering in hypertensive patients: a randomized, phase 2, double-blind, placebo-controlled study. Hypertension, 65(2), 320-327.

Kari, T., Koivunen, S., Frank, L., Makkonen, M., & Moilanen, P. (2017). The expected and perceived well-being effects of short-term self-tracking technology use. *International Journal of Networking and Virtual Organisations*, *17*(4), 354-370.

Laland, K. N. (2004). Social learning strategies. *Animal Learning & Behavior*, *32*, 4-14.

Latkin, C. A., & Knowlton, A. R. (2015). Social network assessments and interventions for health behavior change: a critical review. *Behavioral Medicine*, *41*(3), 90-97.

Lozano, R., Naghavi, M., Foreman, K., Lim, S., Shibuya, K., Aboyans, V., ... & Remuzzi, G. (2012). Global and regional mortality from 235 causes of death for 20 age groups in 1990 and 2010: a systematic analysis for the Global Burden of Disease Study 2010. *The lancet*, *380*(9859), 2095-2128.

Lim, S. S., Vos, T., Flaxman, A. D., Danaei, G., Shibuya, K., Adair-Rohani, H., ... & Pelizzari, P. M. (2012). A comparative risk assessment of burden of disease and injury attributable to 67 risk factors and risk factor clusters in 21 regions, 1990–2010: a systematic analysis for the Global Burden of Disease Study 2010. *The lancet*, *380*(9859), 2224-2260.

Lehto, T., Oinas-Kukkonen, H., Pätiälä, T., & Saarelma, O. (2013). Virtual health coaching for consumers: a persuasive systems design perspective. *International Journal of Networking and Virtual Organisations 4*, *13*(1), 24-41.

Lopez, G., Shuzo, M., & Yamada, I. (2011). New healthcare society supported by wearable sensors and information mapping-based services. *International Journal of Networking and Virtual Organisations*, *9*(3), 233-247.

McGushin, A., de Barros, E. F., Floss, M., Mohammad, Y., Ndikum, A. E., Ngendahayo, C., ... & Abelsohn, A. (2023). The World Organization of Family Doctors Air Health Train the Trainer Program: lessons learned and implications for planetary health education. *The Lancet Planetary Health*, *7*(1), e55-e63.

Molka-Danielsen, J., Carter, B. W., & Creelman, A. (2009). Empathy in virtual learning environments. *International journal of Networking and Virtual Organisations*, *6*(2), 123-139.

Ostchega, Y., Fryar, C. D., Nwankwo, T., & Nguyen, D. T. (2020). Hypertension prevalence among adults aged 18 and over: United States, 2017–2018, NCHS, National Health and Nutrition Examination Survey, 2017–2018: https://stacks.cdc.gov/view/cdc/87559.

Pearce, J., Mann, M. K., Jones, C., Van Buschbach, S., Olff, M., & Bisson, J. I. (2012). The most effective way of delivering a Train-the-Trainers program: A systematic review. *Journal of Continuing Education in the Health Professions*, *32*(3), 215-226.

Pickering, T. G. (2001). Mental stress as a causal factor in the development of hypertension and cardiovascular disease. *Current hypertension reports*, 3(3), 249-254.

Ricciardi, F., Rossignoli, C., & De Marco, M. (2013). Participatory networks for place safety and livability: organisational success factors. *International Journal of Networking and Virtual Organisations 4*, *13* (1), 42-65.

Roberts, C. K., & Barnard, R. J. (2005). Effects of exercise and diet on chronic disease. *Journal of applied physiology*, *98*(1), 3-30.

Rodriguez-Leyva, D., Weighell, W., Edel, A. L., LaVallee, R., Dibrov, E., Pinneker, R., ... & Pierce, G. N. (2013). Potent antihypertensive action of dietary flaxseed in hypertensive patients. *Hypertension*, *62*(6), 1081-1089.

Siervo, M., Lara, J., Chowdhury, S., Ashor, A., Oggioni, C., & Mathers, J. C. (2015). Effects of the Dietary Approach to Stop Hypertension (DASH) diet on cardiovascular risk factors: a systematic review and meta-analysis. *British Journal of Nutrition*, *113*(1), 1-15.

Simons, L. P. A., & Hampe, J. F. (2010). Service Experience Design for Healthy Living Support; Comparing an In-House with an eHealth Solution. The *23rd Bled eConference*, pp. 423-440. Accessed 2010 from www.bledconference.org

Simons LPA, Hampe JF, Guldemond NA. (2013). Designing Healthy Living Support: Mobile applications added to hybrid (e)Coach Solution. *Health and Technology*. 3 (1) pp.85-95. DOI 10.1007/s12553-013-0052-9

Simons LPA, Hampe JF, Guldemond NA. (2014). ICT supported healthy lifestyle interventions: Design Lessons. *Electronic Markets*. 24 pp. 179-192. DOI 10.1007/s12525-014-0157-7.

Simons LPA, Foerster F., Bruck PA, Motiwalla L & Jonker CM. (2014b). Microlearning mApp to Improve Long Term Health Behaviours: Design and Test of Multi-Channel Service Mix. Paper presented at the 27th Bled eConference. Bled, Slovenia, Proceedings. Retrieval from www.bledconference.org and http://aisel.aisnet.org/bled2014/4

Simons LPA, Foerster F., Bruck PA, Motiwalla L & Jonker CM. (2015). Microlearning mApp Raises Health Competence: Hybrid Service Design. *Health and Technology*, 5 pp 35-43.

Simons, L. P., Pijl, H., Verhoef, J., Lamb, H. J. et al (2016). Intensive Lifestyle (e) Support to Reverse Diabetes-2. In *Bled eConference* (p. 24), accessed Dec 20, 2016 www.bledconference.org.

Simons LPA, Hafkamp MPJ, Bodegom D, Dumaij A, Jonker CM. (2017). Improving Employee Health; Lessons from an RCT. *Int. J. Networking and Virtual Organisations*, Vol. 17, No. 4, pp.341–353. DOI https://doi.org/10.1504/IJNVO.2017.088485

Simons, LPA, Heuvel, AC van den, Jonker CM. (2018). eHealth WhatsApp Group for Social Support; Preliminary Results, pp. 225-237, *presented at the 31st Bled eConference*. Bled, Slovenia, Proceedings retrieval from www.bledconference.org. ISBN-13: 978-961-286-170-4, DOI: https://doi.org/10.18690/978-961-286-170-4

Simons, LPA., van den Heuvel, W. A., & Jonker, C. M. (2019). WhatsApp Peer Coaching Lessons for eHealth. In *Handbook of Research on Optimizing Healthcare Management Techniques* (pp. 16-32). IGI Global, ISBN 9781799813712.

Simons, LPA, (2020a). Health 2050: Bioinformatics for Rapid Self-Repair; A Design Analysis for Future Quantified Self, pp. 247-261, *33rd Bled eConference*. June 28-29, Bled, Slovenia, Proceedings retrieval from www.bledconference.org. ISBN-13: 978-961-286-362-3, DOI: https://doi.org/10.18690/978-961-286-362-3.17.

Simons, LPA, Heuvel, AC van den, Jonker CM. (2020b). eHealth WhatsApp for social support: design lessons. *International Journal of Networking and Virtual Organisations*, *23*(2), 112-127. DOI https://doi.org/10.1504/IJNVO.2020.108857.

Simons, LPA, Neerincx MA, Jonker CM (2021). Health Literature Hybrid AI for Health Improvement; A Design Analysis for Diabetes & Hypertension, pp. 184-197, *34th Bled eConference*. June 27-30, Bled, Slovenia, Proceedings retrieval from www.bledconference.org. ISBN-13: 978-961-286-385-9, DOI: https://doi.org/10.18690/978-961-286-385-9 .

Simons, LPA, Gerritsen, B, Wielaard, B, Neerincx MA (2022a). Health Self-Management Support with Microlearning to Improve Hypertension, pp. 511-524, *35th Bled eConference*. June 26-29, Bled, Slovenia, Proceedings retrieval from www.bledconference.org. ISBN-13: 978-961-286-616-7, DOI: 10.18690/um/fov.4.2022

Simons, LPA, Pijl M, Verhoef J, Lamb HJ, van Ommen B, Gerritsen B, Bizino MB, Snel M, Feenstra R, Jonker CM. (2022b). e-Health Diabetes; 50 Weeks Evaluation. *Int. J. Biomedical Engineering and Technology*, *38*(1), 81-98.

Simons, LPA, Neerincx MA, Jonker CM (2022c). Is Google Making us Smart? Health Self-Management for High Performance Employees & Organisations, *International Journal of Networking and Virtual Organisations,* Vol 27, No 3, pp.200-216. DOI: 10.1504/IJNVO.2022.10053605

Simons, LPA, Gerritsen, B, Wielaard, B, Neerincx MA (2023). Hypertension Self-Management Success in 2 weeks; 3 Pilot Studies, pp.19-34, *36th Bled eConference*. June 25-28, Bled, Slovenia, Proceedings. ISBN-13: 978-961-286-751-5, DOI: 10.18690/um.feri.6.2023

Simons, LPA, Murukannaiah, PK, Neerincx, MA (2024). Designing and Evaluating an LLM-based Health AI Research Assistant for Hypertension Self-Management; Using Health Claims Metadata Criteria, pp.283-298, *37th Bled eConference*. June 9-12, Bled, Slovenia, Proceedings. ISBN-13: 978-961-286-871-0, DOI: 10.18690/um.fov.4.2024

Starr, J. (2008). *The coaching manual: the definitive guide to the process, principles and skills of personal coaching*. Prentice Hall, New York.

Swan, K. (2003). Learning effectiveness online: What the research tells us. *Elements of quality online education, practice and direction*, *4*(1), 13-47.

Swan, M. (2012). Health 2050: The realization of personalized medicine through crowdsourcing, the quantified self, and the participatory biocitizen. *Journal of personalized medicine*, *2*(3), 93-118.

Swan, M. (2013). The quantified self: Fundamental disruption in big data science and biological discovery. *Big data*, *1*(2), 85-99.

Tian, S. W., Yu, A. Y., Vogel, D., & Kwok, R. C. W. (2011). The impact of online social networking on learning: a social integration perspective. *International Journal of Networking and Virtual Organisations*, *8*(3-4), 264-280.

Tobias, C. R., Downes, A., Eddens, S., & Ruiz, J. (2012). Building blocks for peer success: lessons learned from a train-the-trainer program. *AIDS patient care and STDs*, *26*(1), 53-59.

Vaishnavi, V and Kuechler, W. 2004. Design Research in Information Systems. Last updated August 16, 2009 from http://desrist.org/design-research-in-information-systems

Whiten, A., & van de Waal, E. (2018). The pervasive role of social learning in primate lifetime development. *Behavioral Ecology and Sociobiology*, *72 (80)*, 1-16.

Wickramasinghe, N., & Goldberg, S. (2010). Transforming online communities into support environments for chronic disease management through cell phones and social networks. *International journal of Networking and Virtual Organisations*, *7*(6), 581-591.

Zhou, B., Perel, P., Mensah, G. A., & Ezzati, M. (2021). Global epidemiology, health burden and effective interventions for elevated blood pressure and hypertension. *Nature Reviews Cardiology*, *18*(11), 785-802.