From dialogue to decision

Using technology to facilitate shared decision-making in a fall prevention context

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CHAPTER 7

General discussion

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The central aim of this dissertation was to systematically develop and evaluate a technological intervention that can provide personalized decision support to general practitioners (GPs) and older patients to facilitate shared decision-making (SDM) for medication optimization in the context of fall prevention. For the development and evaluation of the intervention, the Medical Research Council (MRC) guideline for complex interventions was followed (Skivington et al., 2021). This dissertation combined qualitative and quantitative methods and showcased the entire development and evaluation process, from identifying existing theoretical evidence (**chapter 3**) to gaining new empirical evidence (**chapter 4** and **chapter 5)**, and from testing prototypes (**chapter 5**) to evaluating the implemented intervention (**chapter 6**). The research presented in this dissertation was part of the interdisciplinary SNOWDROP[1] project. Each study is described in detail in the individual chapters of this dissertation. The current chapter provides a summary of the most important findings, theoretical and methodological reflections, strengths and limitations, implications and directions for future research, and final conclusions.

Summary of Results

Chapter 2 – General overview of the SNOWDROP project

To illustrate the context of the SNOWDROP project as a whole, **chapter 2** provided a broad description of the project and its objectives. The project had an interdisciplinary nature and integrated data science and communication science perspectives. The data science component of the project aimed to develop and validate prediction models from electronic health record data for assessing individualized risk of medication-related falls (Dormosh, 2023). The communication science component aimed to develop and evaluate a joint medication management strategy for older patients and GPs, which comprised a clinical decision support system (CDSS) and a patient portal. Within this chapter, we argue that the insights gained from this project, along with the architecture underpinned by predictive modeling to support both GPs and patients, have the potential to be applied to other significant health issues in the future. The overview provided in **chapter 2** helps to put the studies presented in the following chapters into perspective and to fully grasp the project in its entirety.

1 **S**e**N**iors emp**OW**red via big **D**ata to joint-manage their medication-related **R**isk **O**f falling in **P**rimary care

Chapter 3 – Identifying barriers and facilitators for CDSS usage

In **chapter 3**, the current state of knowledge regarding CDSS usage was established. In this chapter, the first central research question of this dissertation was addressed:

> *RQ1: Which barriers and facilitators for using a medication-based CDSS have been indicated by clinicians in existing literature?*

To do so, a systematic literature review providing an overview of clinician-reported barriers and facilitators for CDSS usage was conducted. In total, 63 articles containing barriers and/or facilitators for medication-based CDSS acceptance as experienced by clinicians were included. From these 63 articles, a total of 327 barriers and 291 facilitators were identified. Barriers and facilitators that were mentioned in multiple studies were consolidated, resulting in 195 unique barriers and 174 unique facilitators. All barriers and facilitators were categorized into the human (e.g. user expectations/beliefs), organization (e.g. workflow), and technology (e.g. efficiency of the system) fit model (HOT-fit; Yusof et al., 2008). The most frequently reported barriers and facilitators were categorized as technological and were related to (a lack of) usefulness and relevance of the presented information, ease of use of the CDSS, and the efficiency of the system. Other often mentioned barriers and facilitators were related to the format of the information presented by the CDSS (e.g. with highlights or colors), the usefulness of the system's features and functions, the flexibility of the system (e.g. being able to tailor it to the clinician's personal preferences), and expectations or beliefs held by the end user (e.g. the belief that clinicians might become too dependent on a CDSS). A new and important factor that is not currently part of the HOT-fit model was also identified within the extracted data. This concerns the context in which the CDSS is used, acting as a barrier or a facilitating factor. For instance, clinicians mentioned as a barrier that the CDSS was not useful in a specific ward, such as the intensive care unit or the emergency department. In short, **chapter 3** provided a valuable overview of barriers and facilitators for medication-related CDSS usage among clinicians. The majority of the identified barriers and facilitators were technological factors rather than human or organizational factors. The identified barriers and facilitators informed the development process of the CDSS used in the SNOWDROP intervention.

Chapter 4 – Exploring GPs' needs and wishes for the intervention

To complement the findings of the systematic review, **chapter 4** presented the results of a focus group study with GPs. This chapter answered the second central research question of this dissertation:

RQ2: What are general practitioners' needs and wishes for a CDSS as part of an intervention targeting the medication-related fall risk?

To answer this research question, two moderators led three online focus groups, with a total of 13 GPs. The focus groups covered four core themes: workflow, risk presentation, advice provided, and general factors facilitating or impeding system usage. Participants expressed various needs and wishes related to these themes. Regarding workflow, GPs expressed a desire to generate a list of at-risk patients proactively, and indicated they envisioned an active role for the general practice-based nurse specialist for elderly care and the pharmacist. Regarding the risk presentation, GPs strongly preferred a visual risk presentation in the form of a gradient scale ranging from bright green to dark red. Some GPs asked for a comparative fall risk (i.e. what is my patient's fall risk, and what is considered 'normal' for this patient population), but consensus was not reached on this topic. In the end, the comparative fall risk was not implemented into the intervention for technological reasons but also because showing a comparative fall risk could have a demotivating effect. If a patient's fall risk is just slightly increased, the GP might be less motivated to take action even though lowering the fall risk might be possible and is always desirable. GPs wanted individual pieces of advice to be presented with an expand button to avoid screen clutter. They also expressed a need for non-medication-related advice, even if this advice would be generic. They did not see a need for extra advice on engaging in SDM within the CDSS. More general themes discussed included the possibility of a training session to learn how to use the system, the importance of the system's integration into each GP's individual workflow, and lastly, the timing of the presented advice (i.e. an alert should not pop up when they are working on a different issue). In conclusion, **chapter 4** revealed an overview of needs and wishes for the SNOWDROP intervention as expressed by GPs. The needs and wishes guided the development of the first prototype of our CDSS and can also be applied in the development process of CDSSs in other health contexts.

Chapter 5 – Developing the SNOWDROP intervention

Chapter 5 described the development process of the SNOWDROP intervention, answering both the third and fourth research questions:

RQ3: What are older patients' needs and wishes for a patient portal as part of an intervention targeting their medication-related fall risk?
RQ4: How can the SNOWDROP intervention be systematically developed and feasibility-tested?

The chapter described how the findings of **chapter 3** and **chapter 4** informed the development of the CDSS. Furthermore, the prediction model for predicting the probability of a fall in the upcoming 12 months was developed (Dormosh, Schut, et al., 2022). Besides the prediction model, the CDSS also automatically generates personalized advice for each patient, informed by a knowledge base of if-then rules derived from existing guidelines. For developing the patient portal, semi-structured interviews with older patients (*n* = 12) focused on their needs and wishes were conducted. Patients emphasized the importance of a clear design with easy navigation and adjustable sizing of the presented text. They also expressed an interest in accessing general information on fall prevention and completing a Question Prompt List (QPL) to prepare for the consultation. A QPL is a list of example questions that the patient receives ahead of the consultation, and can be used by patients to select questions or concerns that they would like to discuss during their consultation (Dimoska et al., 2012). The results of the interview study were used to develop a prototype of the patient portal. The prototypes of both systems (i.e. CDSS and patient portal) underwent think-aloud usability tests with GPs (*n* = 5) and older patients (*n* = 5), respectively. These tests revealed usability issues, ranging from minor cosmetic problems to usability catastrophes. For the CDSS, usability issues included the wording of the advice (e.g. wording was sometimes considered too long), (a lack of) background information on the prediction model, and the layout of the non-medication-related advice (e.g. aggregating the separate pieces of advice). For the patient portal, usability issues included confusing navigation, scrolling issues, and the layout of the general information page (e.g. making the layout more attractive with icons). The results of the usability tests were used to improve the first prototypes into a ready-to-implement CDSS and patient portal.

Chapter 6 – Evaluating the SNOWDROP intervention

The ready-to-implement systems developed in the previous chapter were implemented and evaluated in **chapter 6**. This chapter aimed to answer the fifth and final research question:

> *RQ5: What are the effects of the SNOWDROP intervention on patient-provider communication, patient-reported outcomes, and medication changes?*

This chapter presented the main results of the randomized controlled trial (RCT) conducted to evaluate the effects of the SNOWDROP intervention on the level of SDM during the consultation, satisfaction with communication, decisional conflict, beliefs about medication, and medication changes. Seven participating GPs in six general practices were randomized at practice level. In the intervention group, patients had access to the patient portal to prepare for the consultation, and GPs had access to the CDSS through the electronic medical record. In the control group, a standard medication review focused on the fall risk was performed without access to the systems. Consultations with 84 patients (41 intervention and 43 control) were recorded and transcribed verbatim, and all patients completed questionnaires before the consultation and two weeks after the consultation. The results indicated that the SNOWDROP intervention significantly improved engagement in SDM for both the patients and the GPs. The intervention also significantly improved patients' satisfaction with the communication during the consultation. The amount of decisional conflict experienced by patients two weeks after the consultation was significantly lower in the intervention group compared to the control group. The intervention did not significantly influence beliefs about medication held by the patient. Effects on medication changes made during the consultation remain somewhat inconclusive. Initially, no effect was found. However, after removing an outlier results indicated that medication changes were made for a larger number of patients in the intervention group than in the control group. In summary, **chapter 6** showed that the SNOWDROP intervention effectively influenced SDM, satisfaction with the communication, and decisional conflict.

Discussion

Theoretical and Methodological Reflections

Evidence-based Intervention Development

The intervention presented in this dissertation was evidence-based and developed in close collaboration with its intended end users. Successful health interventions are developed in a methodologically rigorous manner and are evidence-based, building on scientific evidence and theory (Duncan et al., 2020; Turner et al., 2019). However, an empirical evidence base is often lacking for the development of eHealth technologies such as clinical decision support (Black et al., 2011). To ensure the development and evaluation of the SNOWDROP intervention was systematic and evidence-based, the MRC guideline for complex interventions was followed (Skivington et al., 2021). The MRC guideline highlights the importance of integrating established theoretical and empirical evidence, complemented by further primary research where necessary (Skivington et al., 2021). The findings presented in this dissertation covered all four phases of the guideline, consisting of Development, Feasibility, Implementation and Evaluation. To further enhance the potential effectiveness of the intervention, a user-centered design (UCD) methodology was applied throughout the development process. UCD entails closely involving end users of the intervention in all stages of the development process (Mao et al., 2005). Applying a UCD approach enhances acceptance rates (both initial adoption and continued use) of technological systems in healthcare, such as CDSSs and patient portals (Brunner et al., 2017; Nazi et al., 2018). It is expected that this approach markedly contributed to the effectiveness of the intervention, as it was tailored to the needs and wishes of the end users (Perski & Short, 2021). It is important to reflect on the UCD approach taken in this dissertation. It was a primarily qualitative approach, complemented with findings about user needs found in the literature review. However, there are many more UCD techniques that could have resulted in different insights. All in all, applying a UCD approach has been very valuable, and makes an important contribution to the development of evidence-based health interventions that fit user needs. This dissertation can serve as an example of how the MRC framework and UCD can be applied to achieve systematic, evidence-based intervention development.

In relation to the development process, an important learning underpinned by this dissertation is that effective development of digital health interventions requires interdisciplinary expertise (Blandford et al., 2018). A lack of cross-disciplinary understanding can lead to difficulties in the development and implementation process of digital interventions (Marcu et al., 2022). Interdisciplinary research in healthcare has a long history, and becomes increasingly important as healthcare becomes more complex (Smye & Frangi, 2021; Witteman & Stahl, 2013). While developing and evaluating the SNOWDROP intervention, knowledge from several research fields was combined. Medical informatics was used for the development of the prediction model that helps GPs with the identification of at-risk patients. General practice and geriatrics were used for medical knowledge about our study population, consisting of GPs and older patients. Lastly, health communication knowledge was applied to the patient-provider communication process, UCD, and technology acceptance. Intervention developers are advised to apply a similar, interdisciplinary approach, as combining knowledge from several relevant disciplines contributes to the overall effectiveness of health interventions (Murray et al., 2016). For the project presented in this dissertation, collaborations with external, non-academic partners were also fostered. We know from the literature that a major setback in the development process of new health interventions is their eventual implementation into clinical practice (Eldh et al., 2017). For the development of the

CDSS and patient portal in this dissertation, we collaborated with two external parties that provide a CDSS and a patient portal in Dutch clinical practice. By leveraging their already existing infrastructure, it was possible to expedite the development process of a fully integrated CDSS. Furthermore, because of these collaborations, future implementation of the intervention into practice automatically becomes much more feasible. It helps overcome potential technical barriers and barriers related to regulations such as the medical device regulation (MDR), meant to guarantee the safe usage of medical devices like the ones developed in this dissertation (Kramer et al., 2012). Successful implementation of similar health interventions requires thinking about the long-term sustainability and implementation of the intervention in the early stages of the development process (Turner et al., 2019), and collaborations with external partners can be very valuable in this regard.

Effects of the SNOWDROP Intervention

The primary outcome and objective of the SNOWDROP intervention was to utilize innovative technology to facilitate SDM between GPs and older patients. The intervention significantly influenced the communication process between GPs and older patients, and resulted in improved SDM during the consultations. This dissertation points out that technology has the potential to support the SDM process. Previous research has already suggested the potential of using technology to facilitate SDM, but it also underlines that interventions often consist of either a CDSS or an SDM tool, and rarely a combination of both (Vaseur et al., 2024). Furthermore, previous research highlights that studies on CDSS use rarely assess SDM outcomes, this means that there is a lack of evidence on the extent to which CDSSs can effectively facilitate SDM (Vaseur et al., 2024). This dissertation provides a valuable contribution to this knowledgebase, as the CDSS is a major component of the intervention, and SDM was the main outcome measure assessed in an observational manner. Research has shown that multicomponent interventions using QPLs are effective in encouraging SDM (Brandes et al., 2015), and in general, effective SDM interventions often consist of multiple active ingredients (Legar et al., 2012). Furthermore, research suggests that it is important to target both healthcare professionals and patients when stimulating SDM (Stiggelbout et al., 2015). The SNOWDROP intervention is a unique and innovative combination of multiple components, all contributing to SDM in their own way and targeting both the patient and the GP. The QPL and general information within the patient portal empower patients and motivate them to voice their questions and/or concerns towards their GP. The fully integrated CDSS provides personalized advice for each patient, providing the GP with a concise overview of treatment options and thereby helping them to effectively discuss all relevant options in an SDM conversation.

When assessing SDM as an outcome measure, the Observer OPTION-MCC (Pel-Littel et al., 2019) was used as a coding scheme to observe the level of SDM in each consultation. This assessment tool was chosen as it was developed specifically for an older population based on the dynamic model for shared decision-making in frail older patients (Pel-Littel et al., 2019; van de Pol et al., 2016). Furthermore, it provided the opportunity to assess both the GP's and the patient's level of SDM individually with separate coding schemes. Lastly, an important asset of this assessment tool is that it assesses all key elements of SDM. A systematic review showed that this is often not the case for SDM scoring sheets, as they found only 5 out of 12 assessed assessment tools covered all key elements (i.e. fostering choice awareness, informing about options, discussing patient's preferences, and making the decision; Kunneman et al., 2019). Other assessment tools that did cover all key elements according to this review, such as the Decision Support Analysis Tool (DSAT; Guimond et al., 2003) and the Decision Analysis System for Oncology (DAS-O; Brown et al., 2011), were less comprehensive or not as suitable for medication optimization in the context of fall prevention.

The Observer OPTION-MCC was a useful tool to assess SDM levels, but a deeper understanding of the content of the consultations that goes beyond the level of involvement would require further qualitative analyses. This could provide a more elaborate insight into the content of the consultations, for instance, which goals and priorities held by the patient play an important role in the decision-making process when deciding whether certain types of medication should be changed. It should also be noted that the scores of GPs and patients are often related to each other. If the GP does not ask questions and does not leave room for the patient to speak, the patient is also likely to score lower on SDM. This works in both directions; a very active, well-prepared patient makes it easier for the GP to engage in SDM and score higher on the assessment tool. Additional qualitative analyses could also help to gain insight in this regard, as this mechanism could also have contributed to the effectiveness of the SNOWDROP intervention. The intervention empowers patients, who will show up to the consultation prepared and with a proactive attitude, and it assists GPs by providing a comprehensive overview of advice that they can use to structure the conversation. This might lead to an interplay between GPs and patients, where they both contribute to each other's level of engagement. In addition to this, the Observer OPTION-MCC coding scheme for healthcare professionals is rather elaborate, while the scheme for patients is more superficial (e.g., score of 0 means no or minimal participation, such as only yes or no; Pel-Littel et al., 2019). It could be valuable to further elaborate the scoring sheet for patients. In this dissertation, the scoring sheet was already somewhat elaborated by assessing patients' participation on a 5-point scale (similar to the healthcare professionals), as opposed to the original 3-point scale. This allowed for more nuance, and easier comparison between patients' scores and GPs' scores. Altering the scoring sheet from a 3-point to a 5-point scale was considered a feasible and useful approach by another study (van Lent, 2024), and this dissertation further substantiates that consideration.

Apart from SDM as the primary outcome, this dissertation also described the effects of the intervention on other relevant variables. First, the intervention significantly decreased the level of decisional conflict experienced by patients after the consultation. Decisional conflict concerns uncertainty, stress, difficulty in deciding, and worries about undesired outcomes surrounding a medical decision-making process (Garvelink et al., 2019). Research has shown that high levels of experienced decisional conflict after a consultation are often a consequence of insufficient SDM during the consultation (Elwyn et al., 2016; Thompson-Leduc et al., 2016). The findings presented in this dissertation, where we see enhanced SDM and diminished decisional conflict, are in line with this. It is important to note, though, that the exact reason for the diminished decisional conflict is not completely evident. The effect could be caused by the SNOWDROP intervention, but it is also possible that the diminished decisional conflict is a consequence of the enhanced SDM, instead of a direct effect of the intervention itself. The RCT presented in this dissertation was not powered to test more complex models and mediated relationships, making it difficult to disentangle the exact origin of the effect.

Furthermore, the intervention did not seem to influence patients' beliefs about medication. The lack of variation in patients' beliefs about medication could be attributed to the fact that the intervention did not influence the content of the consultations; these always covered a medication review focused on falls. We saw that the communication process was influenced by the intervention, but content-wise, they might have been too similar to find an effect on these beliefs. Furthermore, beliefs about medication are very deeply rooted beliefs that often depend on, for instance, a patient's medication use patterns and are difficult to influence in a single consultation (Sundell & Jönsson, 2016).

The effect of the intervention on medication changes is inconclusive. This dissertation cannot provide a fully conclusive answer as to whether the intervention influences these medication changes or not. Initially, there were no detectable significant effects. However, the study was underpowered for detecting effects on changes in medication, and one of the participating GPs seemed to form an outlier in the dataset, displaying a vastly different pattern of deprescribing compared to all other participating GPs. Removing the outlier did result in a significant effect on the number of patients for whom a medication change was made (56.1% of intervention patients vs. 25.9% of control patients). However, when removing the outlier, the sample became even smaller, losing more power to detect effects. It is, therefore, not possible to provide a definitive conclusion based on this dissertation, and a bigger sample is needed to gather additional evidence in the future.

The intervention may not necessarily have influenced the decisions that were made during the consultations, but it did influence *how* those decisions were made. We expected that the intervention would make it easier for GPs to identify potentially useful medication changes for each patient, resulting in a larger number of changes. Healthcare professionals struggle with medication management in light of older patients' fall risk, for instance, because of a lack of knowledge, time, and skills (Drickamer et al., 2006). The SNOWDROP intervention aimed to assist them in this process by providing tailored advice for each patient, aggregating available knowledge, and making the review process less time-consuming. It is necessary to reflect on the ambiguity surrounding the effect of medication changes and on its potential relatedness to the SDM process. As mentioned, the SNOWDROP intervention successfully improved the level of SDM between GPs and older patients. This enhanced SDM process means the patient's goals, priorities, and concerns in relation to potential medication changes were explored (van de Pol et al., 2016). It is important to realize that enhanced SDM should result in decisions that fit the patient's individual priorities (Elwyn & Vermunt, 2020). In the context of the SNOWDROP intervention, this can also mean nothing is changed in a person's medication, for instance because they expressed concerns about possible destabilization of established effects or because they already tried to withdraw their medication and were unhappy with the results. Therefore, enhanced SDM can also result in not changing anything simply because the GP took the patient's personal priorities into account, even though the CDSS did suggest one or more changes. Optimizing the communication process may or may not have influenced the amount of medication changes made, but it certainly did result in more satisfied patients who experienced less decisional conflict after engaging in effective SDM.

Technology in Healthcare

This dissertation does not only contribute to knowledge on how to facilitate SDM between patients and healthcare professionals, but also to the knowledge base on how to effectively develop and make use of technology in a healthcare setting. Implementing technology such as computerized clinical decision support has revolutionized healthcare by assisting clinicians in the decision-making process. Technology in healthcare, such as a CDSS, has the potential to improve patient safety and healthcare quality (Nanji et al., 2018; Tolley et al., 2018; Trivedi et al., 2002), but it is often not used as intended (Van Der Sijs et al., 2006). Several theories and models of technology acceptance have been developed over the years. However, these often lack nuance or are very generic in terms of context. In this dissertation, the HOT-fit model (Yusof et al., 2008) was used for the categorization of barriers and facilitators pertaining to medication-related CDSS acceptance by clinicians (**chapter 3**). The identification of a vast number of barriers and facilitators, and the categorization of these barriers and facilitators within the HOT-fit model provides valuable insight into the most important factors contributing to the (lack of) acceptance of CDSSs by clinicians. The HOT-fit model was chosen over more generic models of technology acceptance, such as the technology acceptance model (TAM; Davis, 1989) or unified theory of acceptance and use of technology (UTAUT; Venkatesh et al., 2003), as it was developed specifically for health information systems and encompasses a broader range of relevant factors than the TAM or UTAUT. Many barriers and facilitators that were now categorized within the HOT-fit model would have lost a significant amount of nuance or would not have fit at all when placed within the TAM or UTAUT, as HOT-fit allowed for more detailed distinctions between factors to take into account during the development process. Later on in this dissertation, the TAM was used to evaluate the CDSS and patient portal, respectively (**chapter 5** and **chapter 6**). The TAM has been translated into a widely used and validated scale to measure technology acceptance (Nadal et al., 2020). In the context of this dissertation, the TAM was a useful model for the basic evaluation of the prototypes and final versions of the developed systems. However, it must be acknowledged that the model is not specific or complete enough to guide the development of interventions similar to the one presented in this dissertation. The limited scope of the TAM has been pointed out before as a shortcoming of the model (Holden & Karsh, 2010), and this dissertation reinforces this critique. The TAM lacks specificity for guiding the development of technological health interventions, while the HOT-fit model is not (yet) suitable for a validated user-reported evaluation. Using both the HOT-fit model and the TAM for the development and evaluation of the SNOWDROP intervention was useful. However, for a more elaborate user-reported evaluation measure, a more extensive scale encompassing more than just the broad TAM constructs is needed.

It is also important to reflect on the risks and opportunities that come with new technological advances in healthcare, such as the usage of prediction models to predict health risks. The intervention developed in this dissertation uses innovative technology and integrates a prediction model within a CDSS that is linked to the electronic medical record. The intervention results in positive effects on patient-provider communication and offers support to GPs in identifying at-risk patients and gaining advice on medication management. However, even though the rapid advancement of technology and artificial intelligence (AI) in healthcare has great potential to support healthcare providers (Panch et al., 2019), their implementation in practice should be done with great caution. In this dissertation, AI systems are defined as systems that use knowledge-based, statistical, or certain other data-driven approaches to generate predictions, recommendations, or decisions (EUR-Lex, 2021). It is important for healthcare professionals to remain involved, and to be aware of the pitfalls of working with technology. Research has also shown that AI literacy scores of healthcare professionals leave room for improvement (Kimiafar et al., 2023). Healthcare professionals need knowledge and skills to enjoy the benefits of using technology and AI in healthcare while also remaining aware of its pitfalls. For instance, when using a prediction model like ours to identify patients with a high fall risk, it is important for healthcare professionals to realize that these models are not causal and are also not perfect in the identification of every single at-risk patient. To be mindful of this we, for instance, added additional background information on the prediction model within the CDSS, to make sure GPs were informed users of the system.

In general, the SNOWDROP intervention requires an active role of the GP. The intervention offers decision support, but does not touch upon automated decision-making, where a system would make decisions on its own. Research shows a mix between optimism about the potential usefulness of automated decision-making and concerns about the risks that it creates (Araujo et al., 2018). A scenario-based survey experiment about perceptions of automated decision-making showed that, overall, people are concerned about the risks of automated decision-making (Araujo et al., 2020). However, in some cases, particularly for high-impact decisions in a health context, automated decisions made by AI were perceived to be fairer than decisions made by human experts (Araujo et al., 2020). It is important to take these hopes and concerns into consideration when developing technological interventions using, for instance, prediction models and decision support, especially when this field evolves even further in the future. Fully automated decision-making in complex healthcare contexts without any involvement of a human is unlikely to happen soon, but the extent to which technology and AI are used is expanding and will continue to expand. The intervention presented in this dissertation applies a balanced approach in this regard, by integrating a prediction model and a rule-based advisory system to assist the GP without taking the actual decision-making process out of their hands. The GP plays an active role in deciding which patients they invite for a medication review, and the advice given always needs human interpretation based on the nuanced situation of each individual patient. To add another layer to this, the patient's personal preferences are also taken into account, creating an active role for the patient as well. The system's advice is considered valuable input, but with an emphasis on SDM rather than it being fully directive.

Strengths and Limitations

The research presented in this dissertation comes with several core strengths, making it an innovative and highly valuable project. A first major strength is that the intervention was developed specifically for the SNOWDROP project, and that the development process itself was an important part of this dissertation. The intervention was developed in a systematic manner and involved its end users closely. Furthermore, collaborations with partners from the field were very valuable. This resulted in a CDSS that is fully integrated within the electronic medical record, which is unique in a research context and shows great promise for future implementation of the intervention into clinical practice. Lastly, the interdisciplinary nature of the project forms a core strength, combining data science, medical science, and communication science to address the complex nature of facilitating SDM in the context of medication-related falls.

Besides the abovementioned strengths, it is important to address the limitations encountered in this dissertation. First, the interdisciplinary nature of this project with both academic partners and partners from the field comes with challenges. Collaborating with external partners from the field is a core strength of this project, but also results in some lessons learned that can benefit future projects. External partners are often working on multiple projects simultaneously, and as a researcher, you need to take their timeline into account when creating your own. The agenda of developers and the potential setbacks they might experience will inevitably affect the timeline of the research project, and potential delays should be anticipated. Furthermore, technical setbacks can alter the course of the development process. In this project, for instance, not all features that were originally envisioned could realistically be implemented. This means flexibility is key, and researchers working on the development of similar interventions should take into account that the final product may likely deviate from their original plans. In that sense, every decision requires conscious deliberation. In this dissertation, certain design choices were made that were, for instance, not entirely in line with the UCD process, but that did make it possible to implement the intervention in real clinical practice during the evaluation phase.

The process of evaluating the intervention also led to valuable lessons learned. During this process, several challenges were encountered. First, establishing what is considered usual care in the context of medication-related fall prevention in primary care posed a challenge. We operationalized usual care as conducting a medication review focused on the fall risk. However, in practice, we know that not many GPs conduct these reviews focused specifically on the fall risk. Therefore, one could argue that GPs in the control condition were also asked to partake in a type of consultation that they usually do not conduct, even though they did not receive any additional support from the developed intervention. Still, the RCT yielded significant effects of the intervention on the communication process, meaning that despite the fact that the control group was also prompted to conduct a medication review they normally might not conduct (i.e. checklist effect; Lyons & Popejoy, 2014), the intervention still succeeded in improving the communication process surrounding this type of consultation. Second, conducting an RCT in clinical practice with real patients and real GPs inevitably results in imperfections. Recruiting GPs was difficult because of the time constraints and work pressure they experienced. This was also noticeable during data collection, where last-minute cancelations occurred, or the other way around, patients were recruited at the last minute, leaving little time for the T1 questionnaire. This requires flexibility from the research team in order to complete the evaluation phase of projects like this one successfully.

Lastly, the intervention described in this dissertation consists of multiple components. While this is considered a strength of the project, as multicomponent interventions are effective for facilitating SDM (Legar et al., 2012), it also results in a limitation. Because of the multicomponent nature of the intervention, it is impossible to tell which exact components did or did not contribute to the positive effects on the communication process. It might also be the case that the interactions resulting from multiple components contribute to the effects on the communication process, and not so much individual components of the intervention. Of course, the intervention is evidence-based and takes end users' needs and wishes into account, but to really disentangle which elements of the intervention contributed to which effects, a bigger RCT with more conditions would be necessary. This RCT could assess the effectiveness of the separate components of the intervention to see if using only the patient portal or the CDSS would yield similar effects.

Implications and Directions for Future Research

The most important practical implication that can be drawn from this dissertation is the fact that the SNOWDROP intervention shows great promise in clinical practice. It is, therefore, important to think about how to realistically implement the intervention into practice in the future. Therefore, we are currently working on an implementation study that will result in a blueprint for future implementation. For this study, we conduct interviews with relevant stakeholders such as GPs, health insurance companies, technical partners, and medical ethics experts. When working on the implementation of this intervention, it is important to take all relevant factors into account. The technical, economic, legal, organizational, scheduling (TELOS) framework provides a useful basis to do so (Hall & Singleton, 2005). The TELOS framework forms the foundation for the interview study, making sure all relevant feasibility angles are covered. The blueprint resulting from these interviews will outline all steps that still have to be taken to realize implementation into clinical practice. This can be used to guide future implementation of the SNOWDROP intervention and can also serve as a guide for other, similar interventions.

Based on the findings and implications outlined in this chapter, I propose several avenues for future research. First, the intervention should be tested with a bigger sample for two reasons: to be able to test the intervention with more conditions, and to generate more power to find out definitively whether any significant differences in medication changes are caused by the intervention. Future studies could test the intervention in another RCT with more conditions to establish which components of the intervention contribute to which effects.

It would also be valuable to add a more long-term follow-up questionnaire to this RCT, as the long-term effects of SDM are not often studied (Elwyn et al., 2016). In this dissertation, SDM was only assessed as an outcome measure, while it can also be a predictor of other (health) outcomes, such as cognitive-affective and behavioral outcomes (Shay & Lafata, 2015). This dissertation did assess the level of decisional conflict experienced by the patient afterward (a cognitive-affective outcome), but did not dive into behavioral outcomes. It would be valuable to assess the relation between the increased level of SDM and behavioral outcomes, such as adherence to the treatment plan, in the future. Research shows that increased SDM can contribute to adherence to the treatment plan (Joosten et al., 2008), and it would be interesting to see what happens in terms of adherence in the longer term.

Future research should consider the ethical aspects of using technology and AI in healthcare. As discussed earlier in this chapter, technology and AI hold great potential but should be implemented and used with caution. When deploying AI-based techniques, such as prediction models, it is important to consider their fairness. This means we need to strive for unbiased data in order to provide accurate diagnoses and treatment for all patient populations regardless of factors such as sex, social status, or ethnic differences (Ueda et al., 2023). Potential biases can emerge from bias in the data (e.g. the dataset used is not always representative of the entire patient population), from the algorithm itself, or from the complex human interactions that occur during the decision-making process (Chen et al., 2023). It is of the essence for future research to keep examining the ethical considerations underlying AI-based technologies, to ensure their safe and fair usage in healthcare.

Lastly, future research could explore to what extent the intervention structure presented in this dissertation is also applicable to other health issues. The development and evaluation process of the SNOWDROP intervention can serve as an example to create similar interventions for other health problems. The concept of using a prediction model to identify at-risk patients, providing personalized advice in a CDSS, and using a patient portal to empower and inform patients could be effective in multiple contexts.

Conclusion

This dissertation applied rigorous qualitative and quantitative methods to develop and evaluate an innovative, evidence-based intervention. By harnessing the power of technology and AI, the SNOWDROP intervention has reformed SDM in a fall prevention context. This innovative approach combines a patient portal with a CDSS that contains a prediction model and rule-based advisory system fully integrated into the electronic medical record, offering unique personalized decision-support opportunities. The results are compelling: the intervention enhanced the communication process between GPs and older patients. Both patients and GPs engaged in SDM better during the consultations. Patients were more satisfied with the communication and experienced less decisional conflict after the consultation. The effects on medication changes seem promising, although they remain somewhat inconclusive. However, even though the decisions themselves may not have changed, the way in which they were made and the way patients experienced them did. Continuously evolving and improving the communication process in complex doctor-patient interactions, such as medication reviews in a fall prevention context, is crucial. This will enhance SDM and reduce experienced decisional conflict. This dissertation has showcased the great potential of innovative technology-driven interventions to empower patients and guide healthcare providers to engage in effective SDM.