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Original Paper

Internet-of-Things Skills Among the General Population: Task-Based Performance Test Using Activity Trackers

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Abstract

Background: The health internet-of-things (IoT) can potentially provide insights into the present health condition, potential pitfalls, and support of a healthier lifestyle. However, to enjoy these benefits, people need skills to use the IoT. These *IoT skills* are expected to differ across the general population, thereby causing a new digital divide.

Objective: This study aims to assess whether a sample of the general Dutch population can use health IoT by focusing on data and strategic IoT skills. Furthermore, we determine the role of gender, age, and education, and *traditional* internet skills.

Methods: From April 1, 2019, to December 12, 2019, 100 individuals participated in this study. Participants were recruited via digital flyers and door-to-door canvassing. A selective quota sample was divided into equal subsamples of gender, age, and education. Additional inclusion criteria were smartphone possession and no previous experience of using activity trackers. This study was conducted in 3 waves over a period of 2 weeks. In wave 1, a questionnaire was administered to measure the operational, mobile, and information internet skills of the participants, and the participants were introduced to the activity tracker. After 1 week of getting acquainted with the activity tracker, a task-based performance test was conducted in wave 2 to measure the levels of data IoT skills and the strategic IoT skill component—*action plan construction*. A week after the participants were asked to use the activity tracker more deliberately, a performance test was then conducted in wave 3 to measure the level of the strategic IoT skill component—*action plan execution*.

Results: The participants successfully completed 54% (13.5/25) of the data IoT skill tasks. Regarding strategic IoT tasks, the completion rates were 56% (10.1/18) for action plan construction and 43% (3.9/9) for action plan execution. None of the participants were able to complete all the data IoT skill tasks, and none of the participants were able to complete all the strategic IoT skill tasks regarding action plan construction or its execution. Age and education were important determinants of the IoT skill levels of the participants, except for the ability to execute an action plan strategically. Furthermore, the level of information internet skills of the participants contributed to their level of data IoT skills.

Conclusions: This study found that data and strategic IoT skills of Dutch citizens are underdeveloped with regard to health purposes. In particular, those who could benefit the most from health IoT were those who had the most trouble using it, that is, the older and lower-educated individuals.

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KEYWORDS

internet of things; activity tracker; mobile phone; skills; digital divide; performance test

Introduction

Background

The internet has undergone numerous changes over the years. It went from a medium restricted to reading content (web 1.0) to a web-based environment where users can create, store, and share content themselves (web 2.0). These functions were further developed by introducing semantics to smoothen the interaction with the internet (web 3.0). In the most recent iteration (web 4.0), objects are added to the network of interconnected people [1]. This development, known as the internet-of-things (IoT), uses the internet to form a network of ubiquitous everyday objects that can sense and analyze their environments, communicate this information to both people and other objects, and use this information to make autonomous decisions [2]. Some of the most common consumer IoT appliances can be found in the health domain [3]. Applications of the IoT include, for example, telemedicine and wearables collecting physiological data. Health IoT has the potential to provide insights into the present health condition, potential pitfalls, and support a healthier lifestyle [2]. Additional (future) benefits include lifestyle management when undergoing treatment, support for health-related decisions, and cost savings on matters such as health insurance [4]. However, to benefit from health IoT appliances, people must be able to cope with the continuous data stream, make decisions based on these data, and evaluate and act upon data-driven decisions made by the IoT [2].

In 2018, 31% of the Dutch population used at least one health IoT device [5]. Almost half of these users were highly educated and aged between 18 and 35 years (44% and 45%, respectively). The most commonly used IoT device was the activity tracker (11%), a wearable device that continuously gathers data on physical activities (eg, number of steps taken, distance covered, and stairs climbed), intensity of activities (eg, by heart rate and calories), and recovery from intense activities (eg, through sleep). Users have to make sense of the collected data, that is, recognize what they were doing when certain data were collected, understand how data are presented, extract meaning from the data, and assess the reliability of the data (eg, was a heart rate peak because of intense exercise or a device malfunction?). In addition to understanding the data, users must know how to make informed decisions based on these data and act accordingly. For instance, to improve stamina, users can decide to use the activity tracker to adapt their training to their heart rate instead of sticking to a predetermined training scheme. In sum, the activity tracker allows users to train more effectively but requires advanced skills to fully capitalize on its potential benefits [2].

In line with this observation, previous research in the realm of the digital divide has indicated that internet skills are a primary determinant of eHealth use and outcomes [6-8]. As these internet skills proved to be relevant throughout web developments, including that of the IoT [9], we expect to see similar patterns of skill inequality regarding the use of health IoT. Accordingly, the older population, people from a lower socioeconomic status, and those with disabilities or health issues are expected to have lower levels of skills necessary to operate the IoT [2]. This suggests that the people who could potentially benefit most from the health IoT are least likely to get the most out of these IoT devices. In this study, we aim to answer the following questions: (1) what are the levels of IoT skills of Dutch citizens? and (2) what personal characteristics (gender, age, and level of educational attainment) and what internet skills determine the levels of IoT skills of individuals? The questions are addressed by a 3-wave study wherein the participants—initially nonusers of health IoT—are provided with an activity tracker for 2 consecutive weeks.

IoT Skills

From previous research on digital inequality, we know that internet skills are a key factor for beneficial internet use [6-8,10-13]. At first, this need for skills seems less relevant for using the IoT, as a primary characteristic of the IoT system is that it operates rather autonomously. However, Van Deursen and Mossberger [2] argue that skills remain relevant for beneficial IoT use, as users must be able to cope with the ambiguity of the IoT system, the vast amount of data, the decisions made for them, and the increased privacy and security risks IoT use brings. The complexity of the IoT system questions the possibility of a fair distribution of costs and benefits and equal opportunities for benefiting from the IoT [14]. To study skill inequality regarding the IoT, the skills of previous web developments serve as a starting point [2,9].

The skills necessary to use the internet can be divided into operational, information, communication, creative, and strategic internet skills [8]. In a previous survey research, internet skills were found to contribute to IoT skills (when considered as a unidimensional construct; [9]). The distinction between different internet skills, however, can also be applied to IoT skills. In this study, we focus on 2 types of IoT skills that are apparent through the entire process of using the IoT: data IoT skills and strategic IoT skills (corresponding to information and strategic internet skills, respectively).

Data IoT Skills

Data IoT skills are required to make sense of the data that are continuously gathered by the IoT without user interference. As IoT devices gather data autonomously, data IoT skills focus on deducting where the data are coming from, interpreting the data, and assessing their reliability and relevance to the context in which they are used [15,16]. By introducing objects to the network, we have moved away from the ability to use a search engine and are headed toward internet skills wherein data literacy—"the component of information literacy that enables individuals to access, interpret, critically assess, manage, handle and ethically use data" [17]—becomes more important. The main difference between information internet skills and data IoT skills lies in the greater complexity of handling (big) data compared with other information types [18]. Users must be able to find specific data in a continuously increasing data set, combine and present the data in a clear overview (eg, graph or summary), and connect the data to events in the (offline) environment. Textbox 1 provides a more detailed overview of data IoT skills (based on internet skills described by Iordache et al [19] and 21st century digital skills described by Van Laar et al [20]).

Textbox 1. Data and strategic internet-of-things skills definitions.

Data internet-of-things (IoT) skills is the ability to:

- determine when data are needed [17]
- set out a plan for how data are gathered [19,20]
- recognize the available data sources [17,19]
- critically assess data and their sources [17,19,20]
- select relevant data [17,20,21]
- present quantitative data [17]
- extract meaning from data [17,19,20]
- identify the context in which data are produced and used of reused [17,22]

Strategic IoT skills is the ability to:

- set a realistic goal [20,23]
- recognize how IoT can help to reach the goal [20,23]
- combine data with previous measurements, prior knowledge, and other information sources to draw conclusions [17,19,20,24]
- evaluate proposed actions and autonomous decisions of IoT devices [19-21]
- make data-based decisions regarding the goal [19-21,23]
- reflect on progress made toward the goal [23]

Strategic IoT Skills

Strategic IoT skills are necessary to use the data to benefit from the IoT system. Strategic IoT skills broadly follow the 4 steps of decision making that are considered in studies about internet skills: goal orientation, taking required actions, making decisions, and implementing those decisions and gaining benefits from those decisions [25]. As such, strategic IoT skills enable users to recognize how the IoT can help them reach a personal goal; combine data, previous knowledge, and other information sources to make informed decisions toward the goal; implement these decisions by performing goal-oriented actions; and reflect on the progress made toward the goal. In addition to the implementation and reflection on their own decisions, IoT users must be able to evaluate actions proposed or autonomously undertaken by the IoT and act upon these propositions. Textbox 1 provides an overview of the strategic IoT skills.

IoT Skill Determinants

Skills enable users to understand, interpret, and act upon the data and actions generated by the IoT. However, the possession of these skills is likely to differ among people. Research on internet skills has, for instance, long shown that education is an important resource for internet skills and that the older population has more problems using the internet [26,27]. These differences in skill levels are expected to be even more pronounced for the IoT because of its complexity and potential impact [28]. This is troublesome because people who rely the most on health-related services are likely to possess the lowest skill levels to use the health IoT for health support [2]. In addition, the big data generated by the IoT reinforce existing biases, as not every group (eg, racial and ethnic groups, disabled individuals, older individuals, and poor individuals) is represented, that is, present data only include people using the IoT and using it correctly [29].

For the internet, many determinants have been found to influence skills [30]. Most commonly studied determinants are sociodemographic and socioeconomic determinants, followed by motivational determinants. As this study is the first inventory of IoT skills, we start with the roles of gender, age, and education to answer the second research question, that is, what personal characteristics determine the levels of IoT skills of individuals? Furthermore, we study the role played by the levels of internet skills in possessing IoT skills.

Regarding gender and internet skills, the findings are inconsistent. Most self-evaluations in surveys found that men possess more internet skills than women, which has often been linked to earlier adoption and more extensive use of the internet [13,31-33]. However, other research found that men and women do not differ in their abilities but that women tend to underestimate their skills when compared with men [34,35]. In line with this argument, no differences were found between men and women in actual performance tests [7,26]. Furthermore, as education plays an important role when considering internet skills, a lack of gender differences can be expected, as in the Netherlands, gender differences within education have, to a large extent, disappeared [36]. Therefore, the following was hypothesized for IoT skill levels:

- *H1: There are no differences in data and strategic IoT skill levels between men and women.*

In general, older individuals experience more problems in using the internet, as they did not have the opportunity to acquaint themselves with the internet at an early age [37], have less access to support [8], and are hindered by mental and physical conditions [38]. These lower skill levels are also expected when using the health IoT, as usability research has shown that older individuals do not operate activity trackers beyond basic functions and that they have difficulty integrating the wearable device in their exercise planning, including goal setting [39]. Therefore, we hypothesize the following:

- *H2: Age contributes negatively to data and strategic IoT skills.*

Regarding educational attainment, those with higher levels possess more advanced internet skills [8,30] and are better able to keep up with technological advancements, resulting in greater inequality between themselves and lower-educated individuals who are unable to keep up [40]. We expect these differences in an IoT environment to become even larger, as a complex system requires even more cognitive capabilities [30,41]. We hypothesize the following:

- *H3: Education contributes positively to data and strategic IoT skills.*

Internet skills are expected to remain relevant for the possession of IoT skills, the same way as traditional literacy (eg, reading, writing, and understanding texts) has remained important for internet skills [9]. Operational and mobile internet skills are still needed for operating the IoT platform (website or app) and changing settings. In addition, information internet skills remain relevant as finding and selecting the correct web page and interpreting information remain relevant skills for selecting and interpreting the correct data in the IoT system. Furthermore, using the IoT is a matter of interpreting the data to act strategically. Therefore, operational, mobile, and information internet skills are hypothesized to be predictors of IoT skills:

- *H4: (a) Operational, (b) mobile, and (c) information internet skills contribute positively to data and strategic IoT skills.*

Methods

Recruitment

In this study, participants were recruited via the distribution of a (digital) flyer on social media and by door-to-door canvassing. Via the flyer, individuals were referred to a website created for the purpose of this study. The website contained more information about the study and participation in the study. It also included an option to sign up for the study. After signing up, potential participants were selected (those who signed up first had priority) based on quota sampling for gender, age, and educational attainment (low-middle-high). Additional inclusion criteria were that the participants were in possession of a smartphone and had no previous experience of using activity trackers. Of the 314 signups, 100 individuals were invited via phone to participate, and appointments were planned. These participants received a confirmation email with the appointments and their home address as the agreed research location. The participants were promised Eur €50 (US $60) for their participation in 3 research sessions of approximately 1.5 hours each.

Table 1 contains the number of participants and their distribution in terms of gender, age, and education.

Table 1. Distribution of the participants by gender, age, and education.

Characteristics	Value, n (%)
Gender	
Male	48 (48.0)
Female	52 (52.0)
Age (years)	
18-29	24 (24.0)
30-39	26 (26.0)
40-54	24 (24.0)
55-80	26 (26.0)
Education	
Low	33 (33.0)
Middle	34 (34.0)
High	33 (33.0)

Measures and Procedure

To answer the research questions, a 3-wave study was (physically) conducted wherein the participants—initially nonusers of health IoT—were provided with an activity tracker (Fitbit Charge 3; Fitbit Inc) for 2 consecutive weeks. In wave 1, the participants were introduced to the activity tracker for the first time. Hence, all the participants started out with no previous experience in using activity trackers. After 1 week of getting acquainted with the activity tracker, a task-based performance test was conducted in wave 2 to measure IoT skills. A week after the participants were asked to use the activity tracker more deliberately, a second performance test was then conducted in wave 3. Performance testing yields a direct measure of IoT skills. Although highly labor intensive, these tests are most valid and provide a realistic view of people's actual IoT skills [25,42,43]. The activity tracker collected data on exercising (eg, steps, floors, distance, active minutes, calories, training, and heart rate) and sleeping habits (eg, sleep duration, sleep phases, and sleep schedule) of the participants. The participants had access to the data in the corresponding Fitbit app.

The study was conducted from April 1, 2019, to December 12, 2019, and took place at the homes of the participants. Before the first wave, a 5-min questionnaire was administered on the web to gather personal information. The participants were asked for their birth year, gender, level of educational attainment, and experience using an activity tracker.

Wave 1

The first wave started with a printed offline questionnaire to measure the levels of operational, mobile, and information internet skills of the participants using the corresponding items of the Internet Skills Scale [44]. To respond to the items, a 5-point Likert-type scale was used, ranging from “not at all true for me” to “very true for me,” with “neither true nor untrue for me” as the neutral response. When the participants did not understand the item, they could also respond with “I don’t understand this statement.” In Multimedia Appendix 1, an overview of all items can be found with the descriptive statistics. The internal reliability of each skill factor was assessed using Cronbach α: .73 for operational internet skills, .76 for mobile internet skills, and .67 for information internet skills.

After completing the questionnaire, the participants received the activity tracker and downloaded and installed in the corresponding app on their smartphones. The participants used their own smartphone to assure familiarity with the operating system (iOS, Android, or Windows). After installation, the experimenter explained the functions of the activity tracker by showing how to retrieve general data and start tracking sports activities on the device itself. This was followed by an explanation of the app by showing the dashboard: a general overview of the data per topic. The participants were encouraged to go through the dashboard themselves and click on the different data topics (eg, sleep) to check the more detailed data representations (eg, infographics of sleep duration, phases, and schedule). In addition, they were provided with instructions for the first week to get acquainted with the features and data regarding exercise and sleep and to integrate using the activity tracker and its app in their daily lives. Whether the participants followed this instruction was checked by analyzing data on its completeness (eg, the absence of substantive gaps in continuous measurements and regular data synchronization).

Wave 2

Wave 2 took place after 1 week of using the activity tracker. This part consisted of 25 tasks regarding data IoT skills, focusing on the retrieval and interpretation of data—gathered by the activity tracker of the participants—using the app. An example of such a data IoT skill task was, “Have you had enough deep sleep if you compare it to other (wo)men your age?” The tasks were distributed across 9 assignments, each covering a different topic (eg, sleep, heart rate, and training). For 2 of the assignments—*Sufficient exercise* and *Good night’s sleep*—the participants also had to compare their data with 9 general health guidelines on exercise and sleep [45,46]. The participants did this by answering questions such as, “Have you been active for at least 150 minutes since wearing the Fitbit?” These questions were answered by filling in yes or no and providing a specific number, in this case, the number of active minutes. Answers to the assignments could be found in the Fitbit app of the participants but were administered on hand-outs to avoid unnecessary switching between the Fitbit app and an administrative app. After finishing the data IoT skill assignments, the assignments *Sufficient exercise* and *Good night’s sleep* were discussed, as the participants could use these assignments for the strategic IoT skill assignment discussed in the following paragraph. An overview of all data IoT skill tasks can be found in Multimedia Appendix 2.

The data IoT skill assignments were followed by a written assignment consisting of 18 tasks measuring strategic IoT skills. This assignment required the construction of a personal action plan based on the (discussed) comparisons made during the data IoT skill assignments *Sufficient exercise* and *Good night’s sleep*. The construction of the action plans for the participants followed the instructions “Use all of the guidelines (9) to find your points of improvement regarding exercise and sleep” and “Explain for each point of improvement how you are planning on improving/executing it” (Multimedia Appendix 2). In other words, 9 tasks involved setting goals for all the guidelines the participants did not yet conform to (eg, not being active for 150 mins a week), and 9 tasks involved describing how they were planning on reaching these goals. After completing the action plan, the answers were discussed with the experimenter and supplemented when incomplete (eg, when a goal or its execution was missing).

All assignments were pilot tested with 6 participants of different ages and educational levels to ensure comprehensibility and applicability. The participants themselves decided when they had finished or wanted to give up on an assignment. However, for the data IoT skill assignments, a time limit was set, after which the participants were asked to pass on to the next assignment. All participants completed the assignments in the same order. The order and the maximum time allowed for the data IoT skill assignments can be found in Multimedia Appendix 2.

Wave 3

In wave 3, the execution of the (discussed and adjusted) personal action plan was evaluated. The participants had to evaluate whether they had met their personal goals. The setup of these tasks was similar to that of the data IoT skill tasks, which involved comparing personal data with general guidelines, but instead of comparing the data with the guidelines, the participants compared the data with their personal goals (Multimedia Appendix 2). No time limit was set, as this assignment was person specific.

Data Analysis

To determine the levels of IoT skills of the participants, we focused on successful task completion of the data IoT skill tasks and of the tasks regarding the strategic IoT skill components, namely, action plan construction and action plan execution. To identify the factors influencing the levels of IoT skills, linear regressions were conducted for data IoT skills and for the 2 strategic IoT skill components, with total task completion scores as the dependent variable. The independent variables in the regression models were gender; educational level attained (coded from low to high); age (years); and the participant's operational, mobile, and information internet skill levels.

Results

Levels of IoT Skills

The levels of IoT skills were determined by successful task completion. As shown in Table 2, on average, the participants completed 54% (13.5/25) of the data IoT skill tasks successfully. Regarding strategic IoT skill tasks, completion rates were slightly higher for action plan construction. On average, 56% (10.1/18) of the construction tasks were completed successfully. For action plan execution, this was 43% (3.9/9).

Table 2. Overview of successful task completion.

IoT[a] skills	Task completion		
	Mean (SD)	Percentage (%)	Minimum to maximum
Data IoT skills	13.5 (4.93)	54	3-22
Strategic IoT skills			
Action plan construction	10.1 (3.96)	56	0-18
Action plan execution	3.9 (1.46)	43	1-8

[a] IoT: internet-of-things.

None of the participants were able to successfully complete all the data IoT skill tasks. The task that proved to be most difficult was finding the heart rate (bpm) that belonged to the *fat burning* zone threshold, as presented in the activity tracker's app. Overall, 22.0% (22/100) of the participants were able to complete this task successfully. Regarding strategic IoT skill tasks, 5.0% (5/100) of the participants were able to construct an action plan that included all the guidelines applicable to the participant. They struggled the most with creating a plan to reach their goal regarding active hours—the number of hours they intended to take at least 250 steps. A total of 21.0% (21/100) of the participants recognized how they could reach this goal. In addition, none of the participants were able to execute the constructed action plan. An overview of the number of data and strategic tasks failed can be found in Multimedia Appendix 3.

IoT Skill Determinants

Table 3 contains the linear regression results of the number of data IoT skill tasks completed successfully (R^2=0.50, $F_{6,99}$=15.44; P<.001). Age is the strongest contributor, followed by education. This indicates that older people and people with lower levels of education had the most trouble accessing and interpreting data gathered by the activity tracker. In addition to age and educational level, the possession of information internet skills was found to contribute to data IoT skill task completion.

Table 3. Data internet-of-things skill task completion.

IoT[a] skills	Task completion	
	β	*P* value
Gender (male/female)	−.13	.10
Age	−.61	<.001
Education (low/middle/high)	.25	.002
Operational internet skills	−.17	.10
Mobile internet skills	.11	.26
Information internet skills	.17	.03

[a] IoT: internet-of-things.

Table 4 presents the linear regression results of the number of successfully completed strategic IoT skill tasks, both for action plan construction (R^2=0.31, $F_{6,99}$=6.95; P<.001) and execution (R^2=0.04, $F_{6,99}$=.71; P=.64). For action plan construction, age and education were significant contributors to task completion. Older and lower-educated people experienced the most difficulty in constructing their own action plans. They experienced the most difficulty with recognizing how they could reach their goal regarding the number of active hours. Unlike data IoT skill task completion, internet skills did not contribute to the successful construction of an action plan. For the strategic IoT skills component of action plan execution, none of the determinants contributed to task completion.

Table 4. Strategic internet-of-things skill task completion.

IoT[a] skills	Task completion			
	Action plan construction		Action plan execution	
	β	*P* value	β	*P* value
Gender (male/female)	−.06	.46	−.004	.97
Age (years)	−.43	<.001	−.11	.29
Education (low/middle/high)	.27	.004	−.02	.84
Operational internet skills	−.07	.58	−.03	.84
Mobile internet skills	−.08	.50	.05	.70
Information internet skills	.16	.09	−.17	.12

[a] IoT: internet-of-things.

Hypotheses

Table 5 provides an overview of the hypotheses. Hypothesis 1—that there are no differences in data and strategic IoT skill levels between men and women—is supported. Gender did not appear to contribute significantly to any of the IoT skills.

Hypothesis 2—that age contributes negatively to data and strategic IoT skills—is partly supported. The older participants performed poorly compared with the younger participants with regard to data IoT skills and strategic action plan construction. However, age did not appear to be a significant contributor to the level of strategic action plan execution.

Hypothesis 3—that education contributes positively to data and strategic IoT skills—is partly supported. It appears that the level of education affects the data IoT skills and strategic IoT skills regarding action plan construction.

Surprisingly, hypothesis 4a—that operational internet skills contribute positively to data and strategic IoT skills—and hypothesis 4b—that mobile internet skills contribute positively to data and strategic IoT skills—are rejected. It appears that possessing higher levels of operational or mobile internet skills does not contribute to the level of any of the IoT skills. However, hypothesis 4c—that information internet skills contribute positively to data and strategic IoT skills—is supported for data IoT skills. As expected, those in possession of higher levels of information internet skills also possess higher levels of data IoT skills.

Table 5. Overview of supported and rejected hypotheses regarding data and strategic internet-of-things skills.

Hypotheses	Validation		
	Data IoT[a] skills	Strategic IoT skills	
		Action plan construction	Action plan execution
H1[b]: There are no differences of data and strategic IoT skill levels between men and women.	Supported	Supported	Supported
H2: Age contributes negatively to data and strategic IoT skills.	Supported	Supported	Rejected
H3: Education contributes positively to data and strategic IoT skills.	Supported	Supported	Rejected
H4a: Operational internet skills contribute positively to data and strategic IoT skills.	Rejected	Rejected	Rejected
H4b: Mobile internet skills contribute positively to data and strategic IoT skills.	Rejected	Rejected	Rejected
H4c: Information internet skills contribute positively to data and strategic IoT skills.	Supported	Rejected	Rejected

[a] IoT: internet-of-things.

[b] H: hypothesis.

Discussion

Principal Findings

In this study, we used activity trackers to examine the levels of IoT skills of Dutch citizens. By using this smart health device, a valid and realistic perspective was provided on how people make sense of IoT data, make informed data-driven decisions, and act accordingly. To do this, people rely on 2 skill sets in particular: data and strategic IoT skills. For health IoT, these skills are necessary to monitor the present health condition and make decisions regarding health maintenance or improvement.

The potential benefits of using health IoT are promising, and they will probably become even more so as the IoT continues to develop. However, to what extent do Dutch citizens possess the skills that are needed to use the IoT beneficially? We addressed this question by measuring actual IoT skills using a performance test, a measure known for its high validity. In addition to the distinction made in this performance test between data and strategic IoT skills, strategic IoT skills were further divided into action plan construction and action plan execution to account for all competences of strategic IoT skills, ranging from setting realistic goals and making data-driven decisions to executing these decisions and reflecting on the progress made toward the goals. Overall, our results suggest that the Dutch population possesses insufficient data and strategic IoT skills. Citizens had significant problems retrieving and interpreting collected data, and they experienced even more difficulty in using the data to make and act upon decisions. However, the successful completion of half of the tasks suggests that the population is, at least to some extent, able to make sense of simple data and make decisions accordingly.

There is a sequential relationship between data and strategic IoT skills, as understanding the collected data are required to make the right decisions. To measure strategic IoT skills independently, in this study, we ensured that the construction of an action plan was discussed afterward and supplemented when incomplete. Only a few succeeded in constructing a complete action plan by themselves. This suggests that the actual number of participants who successfully completed the strategic IoT skills in regard to action plan execution was much lower when no support was provided.

Overall, our results underscore the need for skills development among Dutch citizens regarding the use of health IoT. When citizens possess sufficient IoT skills, certain health issues can be diagnosed and treated prematurely. However, with the present IoT skill levels, Dutch citizens miss out on these opportunities, with all the consequences this entails. In addition to health implications, possessing sufficient IoT skills also has financial implications. For instance, by incorporating insurance companies into the IoT network, citizens can save money on their health insurance [2]. In turn, insurance companies can use IoT-generated data to predict treatment costs across the Dutch population and change charges accordingly. However, at present, IoT data do not provide a fair representation of the Dutch population, as citizens lacking the skills to properly use the IoT are left out of the equation [29].

Both older individuals and lower-educated people appear to possess the least developed data and strategic IoT skill levels. This is problematic, as they could potentially benefit the most from using the health IoT. For instance, for older individuals and lower-educated people, an activity tracker could be a useful tool to track physical activity, as activity levels tend to decline with age [47], and lower-educated people are generally less active during their leisure time [48]. This physical inactivity poses a health risk and makes them prone to chronic diseases. When used correctly, activity trackers can promote healthy exercising behaviors, such as walking, cycling, and running. They can help with self-monitoring activities and general health condition and support goal setting and execution [47]. However, as older and lower-educated citizens lack the skills to use the IoT for these purposes, they miss out on the benefits the activity tracker has to offer.

The role of internet skills regarding the possession of IoT skills appeared to be smaller than expected. Only information internet skills contributed to the possession of IoT skills. These internet skills remain useful, as IoT users still have to retrieve and interpret information to act strategically. Skills such as revisiting a (web) page and understanding a website’s structure remain relevant for using the IoT. Furthermore, information internet skills can directly be used to browse the internet for information regarding where to find data in the IoT system and how to read it. Arguably, the lack of a contribution of operational and mobile internet skills to data and strategic IoT skills can be ascribed to the autonomous character of the IoT, a technology affordance that partly overcomes the lack of required individual skills. Despite the initial setup, fewer operational and mobile skills are needed as no interference by the user is needed to gather the data that can ultimately be used strategically.

Limitations and Future Research

This study provides an overview of general data and strategic IoT skill levels among Dutch citizens. However, only general levels of these skills were considered. Despite the distinction between action plan construction and execution when testing strategic IoT skills, further research is necessary to identify the participants’ possession of all different facets of data and strategic IoT skills that are needed to handle IoT data and use it strategically.

Furthermore, other skills should be considered in addition to data and strategic IoT skills. Although skills such as operational and communication IoT skills are not apparent during the entire process of using the IoT because of the autonomous character of the IoT, they remain relevant for the setup of IoT devices and actively sharing (autonomously constructed) content, respectively [2]. Moreover, future studies should pay attention to skills related to data privacy, as the IoT network has a significant impact on people’s privacy and potential exploitation by, for example, insurance companies. Using the IoT involves handling an enormous amount of personal information. Without the skills to protect personal data or mitigate potential risks, there is a serious threat from both people with malicious intentions and third parties looking for financial exploitation [2].

For a fair comparison of IoT skills, we began this study with participants with no previous experience with activity trackers. However, 1 week of practice might not have been sufficient for some of the included participants, for example, the older population and lower-educated participants. To counteract such effects, we provided comprehensive user support at the start of the study, including information on all the different functions of the activity tracker. For future research, we recommend using previous experience as a controlling variable.

Furthermore, in the realm of digital inequality, other determinants besides gender, age, and educational attainment should be studied, as previous research regarding digital inequality also found other factors that contribute to differences in skills possession (eg, social or personal factors: [30]). Particularly interesting would be the inclusion of information about the health lifestyles of the participants. Disparities in the ability to use IoT data and to act on propositions made by the

IoT are not only a matter of possessing skills but also of health attitudes and behaviors. Similar to skills, health lifestyle depends on social determinants that create differences in the ability to maintain or improve health and to use health services when falling ill [49]. Therefore, we suggest including questions to explore the health attitudes and behaviors of the participants. Furthermore, we recommend performing a longitudinal study to obtain a view of the role of IoT skills in incorporating the IoT in the health lifestyles of participants.

Finally, using an activity tracker as a means to measure general IoT skills should be treated with caution. Despite being one of the most popular IoT applications, they do not embody all the different functions and possibilities that other IoT devices offer. Hence, we cannot draw firm conclusions regarding the generalizability of our findings. In future studies, we recommend studying IoT skills using other health IoT devices or IoT devices from other domains (eg, smart homes). Furthermore, we recommend increasing the number of devices added to the network (eg, a smart scale, blood pressure monitor, and thermometer) when studying IoT skills. This is critical, as adding devices also adds complexity, which, in turn, can increase inequality, as people with lower levels of IoT skills are unable to cope with increasing levels of IoT complexity.

Conclusions

This study found that the data and strategic IoT skills of Dutch citizens are underdeveloped to benefit optimally from the health IoT and its potential. This is worrisome, as these skills are vital for searching and dealing with the continuous stream of personal health-related data and for making data-based decisions to maintain or improve the present health condition. Performing these actions appears most problematic for the people who could benefit the most from the health IoT: the older and lower-educated populations. These results indicate that policy makers that aim at reducing the digital health divide should aim at improving the level of data and strategic IoT skills, with special attention to older and lower-educated people. Attention for policy should come from both supply (eg, private sector suppliers that develop and use design guidelines for interface designs that are adapted to the abilities of the intended users) and demand (eg, governmental interventions that address educational curricula or forms of public support).

Conflicts of Interest

None declared.

Multimedia Appendix 1
Internet Skills Scale items.
[DOCX File , 16 KB - humanfactors_v7i4e22532_app1.docx]

Multimedia Appendix 2
Assignments.
[DOCX File , 18 KB - humanfactors_v7i4e22532_app2.docx]

Multimedia Appendix 3
Number of tasks failed per skill set.
[DOCX File , 14 KB - humanfactors_v7i4e22532_app3.docx]

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Abbreviations

IoT: internet-of-things

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Original Paper

Spanish Version of the System Usability Scale for the Assessment of Electronic Tools: Development and Validation

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Abstract

Background: The System Usability Scale (SUS) is a common metric used to assess the usability of a system, and it was initially developed in English. The implementation of electronic systems for clinical counseling (eHealth and mobile health) is increasing worldwide. Therefore, tools are needed to evaluate these applications in the languages and regional contexts in which the electronic tools are developed.

Objective: This study aims to translate, culturally adapt, and validate the original English version of the SUS into a Spanish version.

Methods: The translation process included forward and backward translation. Forward translations were made by 2 native Spanish speakers who spoke English as their second language, and a backward translation was made by a native English speaker. The Spanish SUS questionnaire was validated by 10 experts in mobile app development. The face validity of the questionnaire was tested with 10 mobile phone users, and the reliability testing was conducted among 88 electronic application users.

Results: The content validity index of the new Spanish SUS was good, as indicated by a rating of 0.92 for the relevance of the items. The questionnaire was easy to understand, based on a face validity index of 0.94. The Cronbach α was .812 (95% CI 0.748-0.866; P<.001).

Conclusions: The new Spanish SUS questionnaire is a valid and reliable tool to assess the usability of electronic tools among Spanish-speaking users.

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KEYWORDS

mHealth; usability; validation; System Usability Scale; Spanish

Introduction

The mobile health (mHealth) concept encompasses clinical and public health practices that incorporate mobile devices, such as smartphones, tablets, personal digital assistants, and patient monitoring devices [1]. According to estimates, there are more than 325,000 mHealth apps for the most popular mobile platforms, iOS and Android [2]. Categories of mHealth products encompass monitoring, treatment, diagnosis, health professional support, well-being, health surveillance support, and health care administration [3]. Although download indexes and apps in the market have increased in the last 5 years, clinicians, researchers, and patients remain skeptical about the reliability of the data generated [4]. These limitations have led to a lack of knowledge regarding the efficiency, efficacy, and safety associated with mobile app utilization in clinical practice. Furthermore, health organizations recommend making assessments before software implementation to ensure safety and accurate data quality [5].

Usability is an essential part of software development and is commonly evaluated through questionnaires [4,6]. Questionnaires reflect users' opinions and have the advantages of low cost, easy execution, and lack of necessary test equipment. Usability can be defined as the extent to which a product can be used by specific users to achieve specified goals effectively and efficiently while providing user satisfaction in a specific context of use (user technology interface) [7]. Due to the high demand for mHealth apps, usability evaluations are insufficient. Therefore, it is necessary to implement a usability metric that is context driven and standardized to efficiently assess clinically related software. There is no usability questionnaire specifically designed for mHealth apps. Previous studies have investigated usability models for mobile apps and have also modified existing usability questionnaires for use in mobile app usability studies [8].

The System Usability Scale (SUS) proposed by Brooke [9] in 1986 is a widely used questionnaire to assess the usability of a system, such as standard operating system–based software interfaces, webpages, and mobile apps. It has been implemented in several mHealth fields, including mental health (n=12), cancer (n=10), nutrition (n=10), pediatrics (n=9), diabetes (n=9), telemedicine (n=8), cardiovascular disease (n=6), HIV (n=4), sanitary information systems (n=4), and smoking (n=4) [2]. The SUS questionnaire has been translated into several languages, such as Portuguese [10], Indonesian [11], and more recently, Malay [12]. All translated versions have shown similar internal reliability compared with the original English version. Although there is a Spanish version [13], there is no evidence of the validity and reliability process. Therefore, it is necessary to have a Spanish version of the SUS that documents the validation process in order to guarantee the quality of the resulting questionnaire. The objective of this study is to develop and validate a Spanish version of the original English SUS, guaranteeing conceptual, semantic, and contextual equivalence between both questionnaires.

Methods

SUS Scale

The SUS scale is a 10-item questionnaire scored on a 5-point Likert-type scale from 1 (strongly disagree) to 5 (strongly agree). Its advantages include versatility, simplicity, low cost, accuracy, and validity. Its reliability (Cronbach α=.85) has been reported [11,12,14-16]. The questionnaire is designed to be answered after the user's interaction with the system. It is arranged to alternate between positive and negative statements to avoid habitual bias from the respondent. The score contribution for the odd items (the positive statements) is the scale position minus 1 and the contribution for the even items (the negative statements) is 5 minus the scale position. The overall score is calculated from the sum of all item scores multiplied by 2.5, with the overall score ranging from 0 to 100. A system with a score above 85 is considered to have excellent usability, whereas a system with a score between 68 and 84 is considered to have good usability.

Translation

The original SUS questionnaire was translated into a new Spanish version using the methodology described by Ortiz-Gutiérrez and Cruz-Avelar [17], following the international guidelines proposed by the World Health Organization [5] to ensure the semantic equivalence, quality, and consistency of meaning with the original version. The methodology included 9 steps: (1) preparation, (2) forward translation, (3) synthesis, (4) back translation, (5) review of the back translation, (6) revision of the target language phrasing, (7) harmonization, (8) piloting, and (9) completion.

First, for the preparation, we evaluated the measurement properties of the original tool, identifying differences and similarities among them. The author's permission was requested to work with the scale.

Second, to achieve the forward translation, the original version of the SUS was translated into Spanish by 2 independent translators with an adequate understanding of the source language: one individual had a master's degree in translation studies and the other was a professional certified in English language and linguistics whose native language was Spanish. Each of the 2 translators provided their own translated version in Spanish. The translators were blind regarding the usage of the tool. Both translations were compared by the working group to combine them into one preliminary version.

Third, the working group for the synthesis was composed of 5 health professionals who were native Spanish speakers. Two of them were research coordinators, another held a master's degree in clinical epidemiology, and 2 had PhD degrees in clinical epidemiology. The team had knowledge and experience in clinical and epidemiological research. They compared both translations and adjusted them, focusing on semantic equivalence and language reliability, to obtain the first consensual version.

Fourth, for the back translation, the first consensual version of the new Spanish version of the SUS was translated into English by a native English speaker whose second language was Spanish to ensure its compatibility with the original English version. The translator was blind to the final use of the translation. The output was an English version of the SUS translated from the preliminary SUS Spanish version (Table S1 in Multimedia Appendix 1).

Fifth, we conducted the review of the back translation. The working group compared the translation of the reconciled version to the original version to assess the conceptual equivalence between the 2 versions.

Sixth, to achieve a revision of the target language phrasing, we revised the semantic equivalence and worked to improve the phrasing of the new Spanish SUS version. In this step, we intentionally checked the presence of double-negative statements and the usage of words that are easily understandable by a population of different backgrounds and educational attainments.

Seventh, for the harmonization step, all the translations produced during the process were reviewed to detect possible discrepancies and to obtain the prefinal version.

Eighth, the pilot was planned following the methodology described by Ortiz-Gutiérrez and Cruz-Avelar [17], ensuring similar and appropriate conditions for answering the questionnaire. Target participants for the piloting were part of a clinical trial that aimed to measure environmental exposure using electronic tools that was taking place at the Unidad de Investigación de Enfermedades Metabólicas at the Instituto Nacional de Ciencias Médicas y Nutrición Salvador Zubirán in Mexico City. All participants provided written informed consent, and the study was approved by the institution's ethics committee. The study follows the principles of the Declaration of Helsinki.

Ninth, after the pilot data were collected, they were carefully analyzed to detect time spent, possible questions that emerged from the participants over the process, and semantic understanding during the usage.

Validation and Reliability Process

The SUS questionnaire was validated for content validity, face validity, and reliability. The method for quantifying content validity was the content validity index (CVI) [18], which is based on expert relevance ratings. The questionnaire (Table S2 in Multimedia Appendix 1) was given to 10 mobile app developer experts, or computer system engineers who had been working on mobile app development for at least 3 years. They were asked to give a score from 1 (question not relevant to assess usability's tool) to 4 (relevant question to assess usability's tool) for the relevance of each item of the SUS questionnaire to assess the usability of an electronic tool. According to the method, scores of 3 and 4 were recategorized as 1 (relevant) and scores of 1 and 2 were recategorized as 0 (not relevant). The CVI was calculated for each item on the SUS questionnaire, and then the CVI average across items was calculated.

The face validity index (FVI) aims to assess the clarity and comprehensibility of the translated items. This was performed by 10 users, who were asked to give a score from 1 (item not clear and not understandable) to 4 (item very clear and understandable) to assess the clarity and comprehensibility of the translated items of the SUS questionnaire. Scores of 3 and 4 were recategorized as 1 (clear and understandable) and scores of 1 and 2 were recategorized as 0 (not clear or understandable) [18]. The FVI was calculated for each item on the SUS questionnaire and then computed by calculating the scale average.

Reliability testing was conducted with 88 respondents, based on the minimum sample size estimation to assess internal consistency. The sample size was computed according to the Cronbach α estimation [19] by considering an α of .70 with a precision of 0.10 and a 2-tailed significance level of .05 for 10 items. The sample size required was 82 participants. For the reliability testing, we invited participants aged 18 to 75 years who had used Zoom (Zoom Video Communications) at least twice over the last month. We selected Zoom because it is a widely known application that can be used on different electronic devices, such as cell phones, laptops, and tablets, covering different modalities of a system. The respondents were asked to use the SUS to assess the usability of Zoom. All the surveys were conducted using Google Forms. The URL was sent through WhatsApp to each participant.

The reliability analysis was computed using Cronbach α, a measure of internal consistency. A coefficient of .70 or higher is considered acceptable for internal reliability [20]. Statistical analysis was performed using IBM SPSS Statistics version 21.0 for Macintosh (IBM Corp).

Results

After reviewing all translated versions, we re-evaluated the complete questionnaire to ensure the syntax and grammar had meaning as a whole. In the back translation, the most important differences from the original version were the terms "technical person" and "cumbersome," since the literal translations in Spanish are different from the conceptual meaning. We considered it appropriate for this translation to use "*personal experto*," and "*tedioso*," respectively. Likewise, the word "system" was changed to the Spanish words for "electronic tools," namely "*herramienta*," as this version attempts to determine the usability of mobile apps and websites. The output of this step was a preliminary version of the new Spanish SUS version.

The pilot study was conducted with 10 users who answered the questionnaire in person after using a website to record diet and exercise. The time spent to answer the questionnaire was 10 to 12 minutes. The pilot data were carefully analyzed by the working group. A total of 3 questions—numbers 2, 5, and 9—were difficult to understand for most users due to the use of complex words. The misunderstood words were changed for synonyms such as "*funciones*," "*compleja*," and "*confiado*," which made the questionnaire easier to understand.

The output of the translation process was a questionnaire of 10 items in Spanish, equivalent to the SUS version in English, that measures the usability of electronic tools (Multimedia Appendix 2).

The CVI (Table 1) and FVI (Table 2) of the new Spanish version of the SUS were calculated to be 0.92 and 0.94, respectively. CVI and FVI scores above 0.80 for both tests indicates that all items in the questionnaire are relevant to the domain, clear, and comprehensible to experts and users.

Table 1. Content validity index based on the rating of the relevancy of items by 10 experts. The content validity index average was 0.92.

Item No	E1[a]	E2	E3	E4	E5	E6	E7	E8	E9	E10	I-CVI[b]
1	3	3	4	2	3	3	3	4	3	3	0.9
2	2	3	4	4	4	4	4	1	4	4	0.8
3	4	3	4	4	4	4	4	4	4	4	1
4	4	3	4	3	3	4	3	4	4	3	1
5	3	3	4	4	3	4	3	4	2	4	0.9
6	3	3	4	3	3	2	2	4	3	3	0.8
7	3	4	4	2	4	3	3	4	4	4	0.9
8	4	4	4	3	2	3	3	4	4	4	0.9
9	4	4	4	4	3	3	4	4	4	4	1
10	3	4	4	4	4	3	4	4	3	4	1

[a] E: expert.

[b] I-CVI: item content validity index.

Table 2. Face validity index based on the rating of the items' clarity and comprehensibility by 10 target users. The face validity index average was 0.94.

Item No	U1[a]	U2	U3	U4	U5	U6	U7	U8	U9	U10	I-FVI[b]
1	4	4	4	4	4	4	3	4	3	2	0.9
2	3	3	4	4	3	2	4	4	3	4	0.9
3	4	4	4	4	4	4	4	4	4	3	1
4	4	3	4	4	4	4	3	4	4	4	1
5	3	2	4	4	4	3	3	3	4	3	0.9
6	3	3	4	4	4	2	4	3	4	3	0.9
7	3	4	4	4	4	4	4	3	2	3	0.9
8	3	4	4	4	4	4	4	3	4	3	1
9	4	4	4	4	4	4	4	4	4	3	1
10	4	4	4	4	4	4	2	3	4	4	0.9

[a] U: user.

[b] I-FVI: item face validity index.

The reliability testing was conducted using 88 users. Table S3 in Multimedia Appendix 1 shows the characteristics of the users. The average age was 32.5 years. Most of the users were of middle socioeconomic status and had a bachelor's degree.

The Cronbach α for the new Spanish version of the SUS was .812 (95% CI 0.748-0.866; $P<.001$). This α value indicates the high internal reliability of the new questionnaire (Table 3). The final version was shared with the authors.

Table 3. Internal consistency of the total item statistics.

Item No	Scale mean if item deleted	Scale variance if item deleted	Corrected item total correlation	Cronbach α if item deleted
1	17.42	36.98	0.403	.806
2	17.67	35.90	0.495	.795
3	17.98	35.11	0.660	.778
4	18.10	41.33	0.129	.831
5	17.57	37.07	0.492	.796
6	17.62	34.62	0.602	.783
7	17.97	37.67	0.487	.797
8	17.93	34.63	0.610	.782
9	17.71	35.07	0.528	.792
10	18.04	36.43	0.538	.791

Discussion

In this study, a Spanish version of the SUS questionnaire was developed and validated. The results of the validation process indicate that the elements were easy to understand and there were no semantic or content-related problems. The translated items were considered equivalent to the original version; therefore, the Spanish questionnaire is a reliable tool to assess the usability of tools for Spanish-speaking users.

Spanish is the native language of most countries in Latin America and the second most widely spoken native language in the world, with more than 400 million speakers. In addition, it is important to develop multilingual strategies to assess each new electronic tool for health research with a wide array of individuals. Although there is a Spanish version of the SUS scale in existence, to our knowledge the translation process is not documented and there is no information about its validity and reliability.

Similarly, some broad concepts of the first Spanish translation make adaptation difficult for current mobile software and websites. With the advent of mobile apps and websites for research proposes in Spanish-speaking countries and around the world, is necessary to develop tools with supporting local evidence to evaluate specifications of new devices to ensure the data collected are accurate to the user. However, the development of new tools requires additional cost and time. Therefore, adapting available questionnaires into other languages and ensuring their validity is the best alternative.

The new SUS scale in Spanish will allow researchers and clinicians to evaluate a Spanish tool’s usability in an accurate, practical, and low-cost manner. In our study, the questionnaire was proven to be easy to comprehend and apply.

For this study, we applied the methodology proposed by Ortiz-Gutiérrez and Cruz-Avelar [17], which is consistent with the guidelines of the World Health Organization [5]. This methodology was combined with the process reported by Mohamad Marzuki et al [13] in 2018, who translated the same tool to Malay. Among the strengths of this methodology, the planning of each of the steps of the process particularly enhanced the quality of the translation.

Only young adults were included in the study. Therefore, the applicability to other age ranges may be questioned. In addition, the representativeness of the sample in reflecting the rest of Latin America may need further studies, as results might vary by region. Although only individuals of Mexico City were included, Mexico City constitutes an important representation of several states and regions of the country, including the south, center, east, and west coast of Mexico. This characteristic makes it appropriate to carry out representative studies when the possibility to extend them to several regions across the country is limited.

In conclusion, the new Spanish version of the SUS is a valid and reliable version of the original English version, adapted to be used for electronic tools in clinical and health research settings.

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Authors' Contributions

MRSG conceived of the idea, determined the study design, and drafted the manuscript. LML drafted the manuscript. LSLC drafted the manuscript and collected data. BBR collected data. AVR drafted the manuscript. MLP reviewed the manuscript. PAV reviewed and drafted the manuscript.

Conflicts of Interest

None declared.

Multimedia Appendix 1
Supplementary tables.
[DOCX File , 30 KB - humanfactors_v7i4e21161_app1.docx]

Multimedia Appendix 2
Spanish version of the System Usability Scale.
[DOCX File , 16 KB - humanfactors_v7i4e21161_app2.docx]

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Abbreviations

CVI: content validity index
FVI: face validity index
mHealth: mobile health
SUS: System Usability Scale

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Original Paper

Exploring the Feasibility of Relapse Prevention Strategies in Interdisciplinary Multimodal Pain Therapy Programs: Qualitative Study

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Abstract

Background: Although interdisciplinary multimodal pain treatment (IMPT) programs are widely regarded as treatment of choice for patients with chronic pain, there are signs that many patients are unable to maintain their treatment gains in the long term. To facilitate the maintenance of positive treatment outcomes over time, we developed two relapse prevention strategies.

Objective: The main objective of this study was to explore the feasibility of these strategies within the context of IMPT programs.

Methods: We performed a feasibility study using 3 workbook prototypes containing either one or both strategies. For a period of 6 months, the workbooks were made available in two IMPT facilities. Qualitative data were collected through a focus group and semistructured interviews. We performed a thematic analysis using a deductive approach with (1) applicability to the treatment program, (2) acceptability of the workbook content, and (3) form, as predefined themes.

Results: The final dataset consisted of transcripts from a focus group with health care providers and 11 telephone interviews and 2 additional in-depth interviews with patients. In general, the intervention was perceived as useful, easy to use, and in line with the treatment program. The data also include suggestions to further improve the use of both strategies, including more specific implementation guidelines, revised goal-setting procedure, and development of a mobile health version. However, several factors, including a high dropout rate and small sample size, impact the external validity of our findings.

Conclusions: This study should be regarded as a first step in the process of transforming the prototype workbook into an effective intervention for clinical practice. Although these initial results indicate a favorable evaluation of both behavior regulation strategies within the workbook, this study encountered multiple barriers regarding implementation and data collection that limit the generalizability of these results. Future research efforts should specifically address the fidelity of HCPs and patients and should include clear procedures regarding recruitment and use of both relapse prevention strategies during treatment.

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KEYWORDS

chronic pain; interdisciplinary treatment; rehabilitation; relapse; behavior change; goal setting; pain; behavior; feasibility; strategy; treatment

Introduction

Interdisciplinary multimodal pain therapy (IMPT) programs have been developed to address the complex multifaceted nature of chronic pain. Instead of directly treating the pain itself, IMPT programs offer a comprehensive approach to target mutually interacting cognitive, behavioral, emotional, biological, and social factors to improve daily life functioning and quality of life, irrespective of pain [1-3]. Typically, these programs include an interdisciplinary team of at least three professionals from varying backgrounds that coordinate their therapeutic activities throughout the program in line with patient-centered goals and biopsychosocial treatment principles. Also, IMPT programs are generally provided within a single facility, and patients are actively engaged with their rehabilitation by means of exercises and tasks [2,4]. Although IMPT programs are often considered treatment of choice for patients with chronic pain [5], there are signs that a considerable proportion of patients are not able to maintain positive treatment outcomes over time [6-8]. This problem of relapse is not limited to IMPT; other behavioral treatments show similar trends for various patient groups, including patients following orthopedic rehabilitation [9] and patients with chronic diseases [10,11]. These results indicate that the problem of relapse may transcend disease-specific treatment.

One strategy that has been recommended to improve long-term effectiveness is to adjust the treatment program to specific individual patient characteristics, needs, and preferences [12,13]. This tailoring is specifically relevant in the domain of IMPT because these types of treatment programs seldom target one type of behavior but a complex and patient-specific cluster of health behaviors, each associated with patient-specific personal and contextual factors [14]. Moreover, in the context of IMPT, the options to realistically simulate a patient’s natural environment within the boundaries of a treatment facility are limited, which may threaten effective generalization of newly learned behaviors to patient-specific meaningful contexts [15].

To provide patients and health care providers (HCPs) with tools that could prevent relapse after successful treatment, we initiated a research project to develop a relapse prevention intervention. In iterations over a period of 18 months, patients, HCPs, pain researchers, experts on behavior change, and designers participated in co-design activities to develop two relapse prevention strategies [16]. These activities ranged from interviews with patients and HCPs to full-day cocreation sessions where ideas were developed into concrete prototypes. In the final phase of the project, the two most promising relapse prevention strategies were merged into a paper prototype intervention. This relapse prevention workbook was regarded as the optimal form to test both strategies within existing IMPT programs, given the available budget and development time. The strategies within the workbook were based on experience from practice (eg, patient interviews, stakeholder discussions, HCP feedback) and general self-regulation principles that relate to maintenance of newly learned behaviors (eg, habit formation and goal setting) [17-21]. The main goal of the workbook was to support and facilitate the transfer of individually meaningful insights and learned skills to the personal context of each patient. Treatment teams provided feedback on the workbook design to ensure that the form and content would fit existing treatment principles [22].

To determine if these strategies are eligible for further development and efficacy testing, it is important to investigate their potential in a real-world setting. According to Bowen and colleagues [23], feasibility studies are important to select promising interventions for further development and obtain specific feedback regarding factors such as usability and implementation.

To provide insight into patient and HCP evaluations regarding the relapse prevention strategies, our primary study objective was to examine the level of acceptability to stakeholders of the current workbook prototype within the context of IMPT programs. To explore how well the workbook fits within the existing treatment program, we additionally investigated the degree of applicability.

Methods

Study Design

To investigate the feasibility of the strategies, we conducted a qualitative study to assess patient and HCP evaluations related to acceptability and applicability of the prototype intervention within the existing treatment program. Ethical approval was granted by the local ethics committee (Medical Research Ethics Committee Zuyderland 16-N-46).

Participants

The study was performed in two locations of the Adelante Rehabilitation Centre: Hoensbroek and Maastricht. Patients with chronic musculoskeletal pain were referred to the program by general practitioners or specialists who determined that primary care treatment was insufficient to address all existing biopsychosocial factors. Patients were eligible for treatment when their pain and pain-related disability interfered with daily life functioning to a moderate or severe extent. Patients could not participate in the rehabilitation program if they had severe or dominant psychiatric conditions, were unable to speak Dutch, were involved in ongoing legal procedures, or insisted on obtaining additional somatic diagnostic procedures. An additional criterion for location Maastricht was that patients needed to experience pain-related fear of performing certain activities in daily life that could be challenged in an in vivo exposure procedure. In this study, all patients who participated in the IMPT were eligible for inclusion.

Treatment

The outpatient IMPT programs at both locations varied in dose and content but had a similar biopsychosocial perspective and included pain neuroscience education as well as cognitive behavioral approaches to improve physical functioning and health-related quality of life. At minimum, the treatment staff consisted of a physiatrist, physical therapist, and psychologist but could also include a social worker and occupational therapist. Both programs required active patient involvement and included regular interdisciplinary team meetings to discuss the patient’s progress. The treatment program in Hoensbroek contained multiple intervention components, including but not limited to graded activity, acceptance and commitment therapy, learning to pace (work-related activities) and set realistic goals under supervision of an occupational therapist, and functional exercise therapy such as swimming or walking under supervision of a physiotherapist. After an initial treatment phase of 3 weeks (5 days per week), a patient-specific program was created that matched dose and content with individual needs. On average, the total program was 12 weeks. The center provided accommodations for patients who were unable to commute to the center on a daily base. Location Maastricht primarily provided exposure in vivo treatment [15,24,25]. At minimum, the program was 2 weeks with 2 treatment sessions per week but could be extended up to 10 weeks depending on the complexity of the case. A typical treatment program contained 20 hours of treatment and consisted of medical education by a physiatrist (that no harm or additional injury could be inflicted by performing activities) and behavioral experiments led by a physical or occupational therapist and psychologist (half of the sessions were led by both HCPs).

Materials

We developed two strategies to prevent relapse after successful treatment: Insight Cards and Value-Based Goal Setting (VBG). Insight Cards consisted of a set of cards on which patients could write down their most meaningful rehabilitation experiences, ideas, and milestones (Multimedia Appendix 1). The upper half of the card provided space for the insights, and the bottom half was reserved for a related environmental cue such as a picture or a quote. The collection of these cards allowed HCPs to ensure the intervention was received as intended (ie, teach-back) and evaluate progress. For patients, the collection of Insight Cards provided lasting access to their most meaningful rehabilitation experiences in their personal environment.

VBG consisted of a worksheet that facilitated the formulation of meaningful goals. The first part of the worksheet prompted patients to identify important personal values. The second part consisted of a prespecified algorithm to formulate desirable and feasible goals that were related to one of the identified values and could be attained within 6 months. Patients were also encouraged to set up calendar reminders and organize social support. In the third part of the worksheet, patients could plan their goal-directed activities in multiple steps, which facilitated gradual progress toward the goal. For each step, patients indicated what, when, and where as they planned the activity. Next, patients were prompted to identify potential barriers and formulate adequate strategies to overcome these barriers. When the first step was completed, patients could plan consecutive steps until the goal was attained. By continuously using the same step-by-step sequence, patients learned to set desirable and feasible goals for themselves and progress toward attainment through achievable steps, while anticipating potential barriers (Multimedia Appendix 2). Multimedia Appendix 3 provides an overview of the prototype intervention components and behavior change techniques (BCTs), according to the BCT taxonomy V1 of Michie and colleagues [26]. The Dutch version of the full workbook is available in Multimedia Appendix 4.

Both strategies were presented in the prototype workbook. This end result of the co-design project was not only based on cocreation and user experience evaluations but also informed by behavior change theory [27,28]. To optimize the fit between the prototype intervention and the needs of each patient, we developed three workbook versions. Two workbook versions contained either VBG or Insight Cards. The third workbook version contained both strategies.

Procedure

We wanted to minimize the impact of this study on existing treatment procedures to resemble a real-world situation as much as possible. Therefore, we did not prescribe when, how, or how much the workbook should be used. Rather, treatment teams were free to select the appropriate patient and time point for introducing any of the workbook versions. For each participating treatment team, a 1-hour training session was provided in which the content of the workbook and suggestions for integrating the strategies into the treatment program were explained (eg, by encouraging patients to use an Insight Card to express a particular relevant treatment experience). Patient inclusion was permitted at any time during treatment, as long as the HCPs considered the workbook to be of potential additional value. We recommended HCPs discuss the workbook with patients on a weekly basis during treatment, but they were free to decide how and when to use it. For a period of 6 months, printed workbooks were made available to the teams.

When the treatment staff decided to introduce the workbook, patients were approached by their physician or therapist who explained the study purpose and provided an information letter that explained the purpose of the study. Patients who were willing to participate signed an informed consent form and were provided with instructions on how to use the workbook by a member of the treatment staff.

Data Collection

Patient Interviews

Approximately 1 month post-IMPT, participants were contacted for a semistructured telephone survey of approximately 20 minutes by SE (male, physical therapist psychologist and as researcher involved in the development of the prototype intervention). The researcher was not involved in the treatment program, and the telephone survey was the first contact with the participants. In the introduction, the researcher explained the study aim and his role in this project. He also encouraged patients to speak frankly and provide all information that could be relevant for future use or development. Patients were asked to describe (1) the frequency of using the workbook, (2) the effect of the workbook on treatment adherence, (3) their satisfaction with using the workbook, (4) the contribution of the workbook to positive behavior change, and (5) its overall usability. Each topic was introduced with an open question (eg, “To what extent does the workbook facilitate the maintenance of treatment goals at this moment?”) and followed up with one probing question (eg, “Could you give an example of how the workbook facilitated the maintenance of treatment goals?”). After each answer, the interviewer repeated the notes to check if they accurately reflected the meaning of the patient’s responses. In response to our request to participate in an in-depth follow-up interview of 60 to 90 minutes to provide information about using the workbook over a prolonged follow-up time (approximately 10 months posttreatment), two participants agreed. We used a general interview guide approach to ensure that each topic of interest would be covered while adopting a flexible and responsive attitude to the participant feedback [29]. The topic list queried experiences with the workbook during and after treatment, suggestions for improvement with respect to layout and content, and ideas for integrating the workbook in the treatment program. We developed interview guides for both interviews, each containing a topic list with guiding questions and a list of procedures (eg, testing the recorder). The topic lists contained introductory questions to build rapport and make participants comfortable with the topic, key questions that focused on obtaining the information of interest, and ending questions to check if anything of relevance was missed.

Focus Group

Four members of the rehabilitation team in Maastricht who were experienced with using the workbook participated in a 90 minute focus group session. This was held 12 weeks after the experimental phase and moderated by two researchers (AK/JP, both male, PhD, physical therapists and as researchers involved in the development of the workbook). Two analysts (SE/SB) were present to take notes and record the session. Similar to the interviews, we developed a focus group guide that included procedures, task assignments, and 9 open-ended questions [30] (Multimedia Appendix 5). During the session, the moderator ensured that all participants had sufficient opportunity to express their thoughts and ask clarifying questions when necessary. Each question concluded with a short summary before the group moved on to the next question.

Data Analysis

The dataset for the qualitative analysis consisted of verbatim transcripts of the focus groups and patient interviews and the notes that were taken during the telephone surveys. All files were imported into Atlas.ti version 8.4 (Scientific Software Development GmbH) for analysis. We adopted a deductive thematic approach to identify, analyze, organize, describe, and report the themes that we found within our data [31-33]. Importantly, thematic analysis enables researchers to summarize the most important topics of a dataset using a stepwise approach that involves coding all data segments relevant to the research question. We constructed a deductive framework a priori that consisted of 3 themes we believed to be essential for determining the feasibility of the prototype intervention. We considered a theme as a meaningful group of data segments representing a phenomenon of interest in relation to the study question [31,32,34]. Applicability (theme 1) refers to the extent and manner in which the workbook could be integrated in the existing treatment program [35]. Acceptability refers to the extent by which the workbook is evaluated as suitable, satisfying, or attractive [23,36]. We were not only interested in how participants judged the acceptability of the workbook content (theme 2), but also they evaluated the presentation form (theme 3). We added this latter theme because the current presentation form was chosen for practical purposes and we remained interested in alternative ideas.

In the first step of the data analysis, researchers read the data several times. All potentially relevant segments were coded according to these broad themes, but we allowed the possibility of adding extra themes if that would lead to a more accurate insight into the feasibility of this prototype intervention. In the second step, we inductively organized the data segments into subthemes to accurately describe the content [32].

SE and AK independently analyzed the patient data, and SE and JP independently analyzed the HCP focus group transcripts. Each step contained several iterations where researchers discussed the meaning of the data as well as how to accurately describe the data in terms of themes and subthemes with respect to the study aims. At the end of this process, the researchers held a final consensus meeting that involved summarizing the data in themes, subthemes, related quotes, and interim conclusions.

Although the answers on key questions during the interviews and focus groups were summarized by the interviewer to confirm they sufficiently captured their experience or opinion, participants were not involved in checking the results of the data analysis.

Results

Demographics

During the course of the study, a workbook was offered to 19 patients; 8 patients did not respond to our requests to participate in the telephone survey. Therefore, our final dataset came from a focus group with 4 HCPs, telephone interviews with 11 patients, and in-depth interviews with 2 of these patients. The HCPs were a behavior therapist (male, 19 years' experience), physiotherapist (male, 5 years' experience), behavior therapist (female, 14 years' experience), and occupational therapist (female, 11 years' experience). Table 1 provides an overview of the patient participant characteristics.

The majority of codes could be clustered within our predefined framework, but we added the theme adaptation for a better fit. This theme covered the extent to which the prototype intervention could be adapted to each patient or whether personal characteristics were required for effective use. Table 2 provides an overview of our final coding scheme.

Table 1. Overview of patient participant characteristics (n=11).

Characteristics	Value
Female, n (%)	6 (55)
Age in years, mean (SD)	55.20 (12.21)
Pretreatment level of disability (PDI[a]), mean (SD)	35.29 (9.48)
Pretreatment level of anxiety (HADS[b]), mean (SD)	8.83 (3.55)
Pretreatment level of depression (HADS), mean (SD)	8.00 (4.52)

[a] PDI: Pain Disability Index.

[b] HADS: Hospital Anxiety and Depression Scale.

Table 2. Coding scheme, including themes, subthemes, and representative quotations.

Themes and subthemes	Representative quotations
1. Applicability of the workbook in the existing treatment programs	
1.1 Introduction of the intervention (48 quotations)	I would have preferred the assistance of a therapist with the formulation of my first value-based goal. Without help, it took me some time to understand the logic behind the procedure. [P8[a]]
1.2 Interaction with the treatment program (35 quotations)	The workbook fits the treatment program well. [P11]
1.3 Final phase of treatment (7 quotations)	I liked to review the Insight Cards during the follow-up session. One patient even attached photos to his cards. It was nice to browse through and to gain insights in his experiences. [T2[b]]
1.4 Role of health care provider (28 quotations)	I liked the support of the therapists. During the sessions, we went through the workbook and discussed everything. They also reminded me sometimes to write down experiences. [P3]
2. Acceptability of the workbook content	
2.1 Usage (33 quotations)	I did not actively use the workbook posttreatment, but it is nice to have it as a work of reference. [P17]
2.2 Action mechanisms (47 quotations)	The workbook was an essential element in the process of learning to understand my condition. [P2]
2.3 Reported outcomes (30 quotations)	For me, the workbook functioned as an extension of the treatment. I could see the program evolve, and patterns change. I could read back my personal development. [P8]
2.4 New components (27 quotations)	Specific information on triggers that could cause a relapse is not provided in the current prototype. [T3]
3. Acceptability of the workbook form	
3.1 Type of delivery (mobile health vs paper and pencil; 32 quotations)	A negative point for both is that the intervention content would better fit an eHealth intervention in the current time. [T2]
3.2 Written instructions (18 quotations)	Related to Value-Based Goal Setting: I believe the concept [of values] is difficult. For example, one patient did not understand the idea behind “source of inspiration.” People that you needed to look up to...she found that a scary idea. [T4]
3.3 Appearance (13 quotations)	I had difficulty with the initial structure of the layout. How does that work? [P8]
4. Adaptability	
4.1 Personal characteristics (45 quotations)	To use the workbook appropriately, patients will need some sort of self-reflecting skills, as well as intrinsic motivation. [T1]

[a] P: patient.

[b] T: health care provider.

Applicability of the Workbook in Existing Treatment Programs

Based on their own experiences, patients and HCPs discussed how the workbook could be optimally implemented and adopted throughout the treatment program. Regarding the introduction of the workbook, there was no consensus among HCPs about when to introduce the workbook during treatment. An early introduction of VBG was believed to facilitate the formulation of treatment goals at the start of the program, and Insight Cards were considered useful to immediately capture important experiences at the start of the program (eg, the initial experiment of exposure in vivo). On the other hand, HCPs were hesitant to add more instruction time to an already information-dense start of the program.

> *If you provide patients with the workbook at the start of the program, you will also have to educate them*

> *on how it should be used. ... Yes, this will add to an already long queue of things that require explanation.* [T2]

From the patients' perspective, an early introduction did not seem crucial: patients who received the workbook in later stages still evaluated its use as relevant.

Although patients reported substantial variation on time spent on the workbook during treatment sessions ranging from discussing the workbook during each contact to no integration at all, HCPs found Insight Cards easy to integrate into their therapy sessions. The interaction with the treatment program was more difficult for VBG.

> *Sometimes, value-based goals relate to higher order goals than the goals we can work with. If you start discussing patients' values, you can fill plenty of sessions. However, this will be a different type of treatment than we are currently providing.* [T1]

In general, HCPs commented that regular checks of the content were preferable within treatment contact time but that the total time spent should be limited. Both patients and HCPs specifically considered these checks important during the final phase of treatment. For example, a patient commented on whether it would be relevant to evaluate the workbook during the final phase of treatment.

> *Yes, absolutely. That makes sense to me. It is not necessary to discuss the workbook every week, but it would help to ask at certain moments how things are going. Then, patients can show how they are using the workbook. They might be using it improperly. That sometimes by evaluating and also discuss this during the final evaluation: what's the status? How far did you come?* [P2]

Patients reported mixed experiences relating to the role of the health care provider regarding the workbook. Active involvement was considered useful as it facilitated the transition from the workbook to treatment and vice versa. Patients who did not actively discuss the workbook with their HCPs believed that more involvement would have led to better outcomes. As a minimum, they recommended an HCP-led introduction where the use of the workbook would be explained.

Acceptability of the Workbook Content

Patients and HCPs reflected on what potential action mechanisms were involved and which behavioral outcomes were targeted. Participants reported that the use of Insight Cards helped to create a moment of reflection on important experiences. Also, rereading the experiences provided a better understanding of important treatment concepts. For VBG, patients indicated that it contributed to pacing of activities, planning meaningful goals, and anticipating the effort needed to attain the goals. One patient who used the VBG strategy to plan a long journey in advance commented.

> *A positive experience is ... Normally it is just persisting, no matter what. I will do this now. But here, if you aim for greater things, you will need to work towards it. I have seen that clearly now.* [P8]

Patients reported a shift from active use during treatment to passive use (as a work of reference) posttreatment.

> *I have not actively used the workbook after treatment, but I am glad that it is available as a reference book.* [P17]

During active use, VBG especially was considered time-consuming, which hindered regular use for some patients. In the posttreatment phase, one patient reported that reading the workbook content helped him counter an impending relapse. Participants made multiple suggestions for new components to the prototype intervention such as additional reading material on pain education, a specific section that describes the possibility of relapse, and the option of prioritizing the most important Insight Cards. Participants further suggested discussing the workbook with peers during group meetings and made specific suggestions should the workbook be developed into a digital app, such as adding informative video clips and a digital avatar that could interact with the patient.

Participants reported that the workbook contributed to facilitating the pursuit of meaningful goals, providing a structure to the treatment process, pacing activities, monitoring progress, and revealing the most important milestones during the program.

> *A patient started with the Insight Cards at the final treatment phase. Nevertheless, during the refresher day his workbook was an exemplar of how they [the Insight Cards] should be used. Completely filled out and illustrated with photographs. He also mentioned that, in case of potential relapse, he could imagine himself using the workbook and browsing through his experiences.* [T2]

These positive outcomes were not shared by all participants. Some patients reported that the intention of the prototype intervention was not clear or questioned its efficacy.

> *I wonder whether a workbook would be sufficient to ensure the transfer to the home situation.* [P13]

Also, HCPs were cautious that too much emphasis on personal values could cause patients to focus on topics and goals that were beyond the scope of the treatment.

Acceptability of the Workbook Form

The general appearance and structure was appealing to most participants, but some patients provided suggestions for reordering the workbook and moving all instructions to the beginning. For VBG, the written instructions were considered too elaborate and complex, which caused confusion and problems in understanding.

> *It [the workbook instructions] should be easier to read. It may be due to my short attention span or because I am not a good reader, but I did like the underlying idea.* [P9]

The instruction text for the Insight Cards was shorter and easier to understand. Participants indicated that the included examples were helpful for both relapse prevention strategies.

Overall, participants would prefer a mobile health (mHealth) app over a printed workbook as type of delivery. In particular, the possibility of combining the strategies with smartphone functionalities such as a calendar and camera could lead to more personalized experiences and goals. Moreover, a digital app would be accessible throughout the day, allowing patients to directly record experiences, browse through insights, or plan new goals.

> *I would prefer an app. An app can provide feedback and is able to alert you. For example, I will plan a 3k walk for tomorrow. Then I will receive a reminder that I should go for a 3k walk. If think "no! not tomorrow," then—it is quite simple—I will modify the calendar...this is the future.... I have not grown up with this thing [mobile phone]. But nowadays people only look on their phones throughout the day. They will benefit more from this [the app] than from this paper [the workbook]. So I would think that is very important.* [P8]

Adaptability

The theme adaptability was added in response to multiple comments relating to individual personal characteristics that were believed to either facilitate or hinder optimal use of the workbook. In particular, participants reported that the current version of the prototype intervention required a high level of commitment and an active mindset to autonomously explore the features of the workbook.

> *Because of my work, I am used to discover things on my own, but I expect that this method will not work for everyone if it is not clearly instructed.* [P8]

Patients with low health literacy were expected to encounter problems with the current amount of instruction texts, reading level, writing down their own input, and analyzing which values would underlie their most important treatment goals. Characteristics that were reported to facilitate the use of the workbook included being organized, being able to reflect on experiences, and possessing adequate reading and writing skills.

Discussion

Principal Findings

This study was conducted to assess the feasibility of two relapse prevention strategies specifically designed to enhance IMPT programs. Overall, the workbook was perceived by participants as useful, easy to use, and in line with the treatment program. However, there was a difference in how the individual relapse prevention strategies were perceived. Insight Cards were expected to benefit all patients and were relatively easy to learn and apply. VBG helped patients to plan meaningful goals, but these were more difficult to understand and did not always fit into the treatment program. However, it is important to note that the focus group consisted solely of HCPs who provided exposure in vivo treatment and were not experienced with VBG. Participants indicated a preference for a digital app over a paper-and-pencil workbook as a future delivery mode. Other suggestions for improvement included more specific implementation guidelines for the treatment staff, group sessions among patients to discuss their input, and more attention to the workbook during the final phase of the treatment. Overall, these findings indicate that the workbook is feasible within the context of IMPT and acceptable to both patients and HCPs.

Importantly, these initial results contain detailed feedback on how the strategies can be refined. First, the study protocol allowed for substantial variation in when and how the workbook was applied. This flexible approach maximized HCP autonomy with respect to dose and content but at times resulted in limited or even no interaction at all once the workbook was introduced. As a consequence, not all intervention components were used effectively by all participating patients. For example, HCPs could use the Insight Cards to check if the patient understood important treatment principles as intended, but the dataset includes no mention of such a teach-back occurrence. Therefore, we believe that, in line with other study findings, an extensive onboarding procedure with additional guidelines, examples, and training sessions would improve overall implementation and optimize the potential of the workbook [37-39]. Based on the evaluations in this study regarding patient characteristics and requirements for optimal use, this onboarding procedure could also contain a deliberate consideration whether either or both interventions may benefit a patient. Second, the VBG sequence needs revision to improve clarity for patients and ensure that the goal-setting procedure matches the treatment program. The sequence was based on the insight that value-based goal-setting procedures outperformed specific, measurable, achievable, relevant and time bound (ie, SMART) goal setting [40,41]. However, patients reported difficulties in understanding the concept of values through written instructions in the workbook, particularly when the treatment program did not structurally include a values assessment. Altering the VBG procedure to shift the initial emphasis from values to goals may increase clarity; patients could begin formulating specific goals related to improved physical functioning instead of starting with personal values. Subsequently, assessing why this particular goal is relevant to the patient could direct attention toward associated values. Third, HCP responses concerning the amount of time spent with the prototype intervention suggests that they experienced a trade-off between focusing on the treatment program or preventing relapse with the workbook. This indicates that relapse prevention with the current version of the workbook is not yet perceived as an integral aspect of the treatment. Given that the workbook was introduced as an addition to the existing IMPT, this finding is not surprising. Nevertheless, future development should take time efficiency into account and focus on increased integration of the relapse prevention strategies into the existing treatment protocols. One possibility is to relate the identification of problems in daily life functioning during the assessment phase (eg, by using instruments such as the Canadian Occupational Performance Measure) to the goal-setting procedure of VBG. Furthermore, integration of Insight Cards into clinical practice could be enhanced by routinely relating this to specific communication strategies, such as a teach-back approach [42,43]. Reflecting on Insight Cards during patient-therapist conversations could facilitate both shared decision making and teach-back and empower patients to actively participate.

One promising direction for the development of the prototype is to embed these strategies in an mHealth app (ie, software apps designed for mobile devices to provide or support health care services) [44]. This domain is becoming increasingly important in the assessment and treatment of chronic pain and is particularly suited for tailoring specific strategies to individual needs and preferences [45]. With machine learning approaches, it is even possible to automate the process of personalizing the strategies based on user-generated data [46]. Another advantage of mHealth is the opportunity of letting both strategies interact. For example, if a patient used an Insight Card to highlight an effective strategy to overcome barriers to physical activity, this card could also be used as a future solution to anticipated problems within the planning procedure of VBG. Although the idea of a digital intervention had already been suggested by stakeholders in earlier development stages, we did not make any decisions on its final form prior to this feasibility study. Because our study findings are in accordance with these earlier suggestions, we believe there is potential in transferring this prototype workbook into an mHealth app.

Limitations

Limitations of this study include a small sample size and relatively high dropout rate. Because the study was designed, conducted, and analyzed by the same three researchers, who were also involved in the development of the workbook, confirmation bias and socially desirable responses may have resulted. Furthermore, due to organizational reasons at location Hoensbroek directly after the inclusion period, we were only able to collect evaluations from HCPs from location Maastricht, where regular reflections on patients' values are beyond the scope of their treatment program. With these limitations in mind, it is important to reflect on the validity of the conclusions of this study. Concerning the adequacy of the sample, Malterud and colleagues [47] have introduced the concept of information power, which is determined by five factors: narrow or broad study aim, sample specificity, established underlying theory, quality of dialogue, and type of analysis strategy. We believe that the specific focus in our study objective on 3 key factors for feasibility positively contributed to the information power of this dataset. Furthermore, all participants that we interviewed received instructions to use the workbook, participated in an IMPT program, and had—at minimum—made an effort to use the workbook in this setting, which not only resulted in high specificity but also to a high quality of dialogue. In addition, we included several established procedures to enhance the credibility of our findings and minimize bias, including member checks, triangulation of researchers and data sources, and including questions regarding negative experiences with the workbook to search for disconfirming evidence [32,48,49]. However, we conducted a cross-case analysis and the low sample size resulted in limited variation on personal characteristics and a low likelihood that potential problems in use did occur within the sample [47,50], which limits the generalizability of our findings.

Although multiple reasons could have contributed to these limitations, an important factor may have been our real-world approach toward the use of the prototype intervention within the inclusion period. We expected that the active participation of the treatment teams during previous development phases would contribute to high patient inclusion rates. However, it is likely that the limited guidance on when or how to explain the workbook and absence of fixed procedures regarding patient recruitment increased the required effort for HCPs to integrate this study into their treatment routine. Although this means that the extent to which this workbook can work in IMPT programs is inconclusive, we did obtain important insights for further developing the prototype intervention. From an intervention design perspective, the feedback from actual use within the intended environment is crucial to further refine the strategies and adapt them to that specific context [51]. Regarding the low response rate on the in-depth interviews, some patients indicated that they already provided a full evaluation of the workbook in the telephone interview. Other patients mentioned the traveling distance as main reason. In addition, we believe that a moment of direct contact with the researchers prior to the telephone interview could have helped to better explain the importance of the interview and establish a good rapport in advance. For these reasons, this study should be regarded as the first iteration in the overall process of transforming a prototype into an effective intervention for clinical practice. Czajkowski et al [52] emphasize the need for initial prototyping before conducting more stringent tests in order to first align the behavioral strategies to the clinical context in which they will be implemented. In addition, experimental medicine highlights the need for a stepwise approach toward intervention development. This framework consists of multiple subsequent steps that should be undertaken to examine the relationships between the intervention and its effect on physical functioning and the modifiable behavioral factors that mediate this relationship [53]. Consequently, further development and testing are required and should indicate whether these strategies lead to a change in specific health behaviors such as goal setting and problem-solving and to what extent this change causes clinically relevant long-term improvements for patients with chronic pain. In addition, these limitations provide valuable information in preparation of future trials, including more emphasis on training HCPs in how to use the strategies, more integration of study procedures within clinical practice, and improved patient fidelity procedures to decrease dropout.

Conclusion

This first test of the relapse prevention workbook in a real-world setting of IMPT programs resulted in important insights regarding form, content, and use, as well as its interaction with the treatment program and study design. Although these initial results indicate a favorable evaluation of behavior regulation strategies within the workbook, this study encountered multiple barriers regarding implementation and data collection that limit the generalizability of these results. Future studies should address the fidelity of HCPs and patients and should include clear procedures regarding recruitment and use of both relapse prevention strategies during treatment. Future development efforts should consider eHealth or mHealth options, extensive onboarding, and a modified value-based goal-setting procedure for the VBG strategy.

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Conflicts of Interest

None declared.

Multimedia Appendix 1
Insight Card examples with a blank card (translated from workbook).
[PDF File (Adobe PDF File), 154 KB - humanfactors_v7i4e21545_app1.pdf]

Multimedia Appendix 2
Value-Based Goal-Setting blank form with example (translated from workbook).
[PDF File (Adobe PDF File), 82 KB - humanfactors_v7i4e21545_app2.pdf]

Multimedia Appendix 3
Overview of intervention components of Value-Based Goal Setting and Insight Cards with corresponding behavior change techniques.
[PDF File (Adobe PDF File), 150 KB - humanfactors_v7i4e21545_app3.pdf]

Multimedia Appendix 4
SOLACE workbook in Dutch.
[PDF File (Adobe PDF File), 8 MB - humanfactors_v7i4e21545_app4.pdf]

Multimedia Appendix 5
Focus group guide with procedures, task assignments, and questions (translated from workbook).
[PDF File (Adobe PDF File), 155 KB - humanfactors_v7i4e21545_app5.pdf]

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Abbreviations

BCT: behavior change technique
HCP: health care provider
IMPT: Interdisciplinary multimodal pain therapy
mHealth: mobile health
SMART: specific, measurable, achievable, relevant and time bound
VBG: Value-Based Goal Setting

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Original Paper

Characterizing and Visualizing Display and Task Fragmentation in the Electronic Health Record: Mixed Methods Design

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Abstract

Background: The complexity of health care data and workflow presents challenges to the study of usability in electronic health records (EHRs). Display fragmentation refers to the distribution of relevant data across different screens or otherwise far apart, requiring complex navigation for the user's workflow. Task and information fragmentation also contribute to cognitive burden.

Objective: This study aims to define and analyze some of the main sources of fragmentation in EHR user interfaces (UIs); discuss relevant theoretical, historical, and practical considerations; and use granular microanalytic methods and visualization techniques to help us understand the nature of fragmentation and opportunities for EHR optimization or redesign.

Methods: Sunburst visualizations capture the EHR navigation structure, showing levels and sublevels of the navigation tree, allowing calculation of a new measure, the Display Fragmentation Index. Time belt visualizations present the sequences of subtasks and allow calculation of proportion per instance, a measure that quantifies task fragmentation. These measures can be used separately or in conjunction to compare EHRs as well as tasks and subtasks in workflows and identify opportunities for reductions in steps and fragmentation. We present an example use of the methods for comparison of 2 different EHR interfaces (commercial and composable) in which subjects apprehend the same patient case.

Results: Screen transitions were substantially reduced for the composable interface (from 43 to 14), whereas clicks (including scrolling) remained similar.

Conclusions: These methods can aid in our understanding of UI needs under complex conditions and tasks to optimize EHR workflows and redesign.

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KEYWORDS

electronic health record; electronic medical record; medical informatics; information technology; data visualization; user computer interface

Introduction

Background

The ubiquity of electronic health record (EHR) systems has transformed the health care landscape over the past several decades. Yet, even as improved patient care and cost savings have begun to emerge, significant usability impediments have been well documented [1]. One such usability issue for EHRs is display fragmentation, which can be defined as the location of clinical elements or other care-related information on different screens or in different parts of the EHR, or in ways that require searching, scrolling, or other navigation actions to access [2]. Display fragmentation can affect EHR-mediated workflow and the clinician's ability to analyze patient health information and provide optimal patient care [3].

Research on EHR system usability, including display fragmentation, has often characterized problems at a rather high level of abstraction (eg, violations of usability principles) or in terms of the user's expression of dissatisfaction. Researchers are beginning to develop new approaches to documenting problems with increasing granularity and specificity as an extension of usability studies [4]. However, few granular methods have been applied to display fragmentation. Thus, the researcher's ability to understand the impact of display fragmentation on usability, develop potential solutions, and evaluate these solutions is limited.

The work presented in this paper addresses this gap and problem by describing the theoretical background behind display fragmentation and its impact on a clinician's ability to provide safe and high-quality patient care. It also introduces 2 methods for granularly assessing display fragmentation in health information technology (HIT) systems so that this challenge can be diagnosed, and system redesigns can be proposed.

Display Fragmentation and Task Fragmentation

Display fragmentation occurs in EHR systems when a user must click through and view many different screens or parts of screens to view all relevant clinical information [2]. This requires sequential viewing and calls for retaining information in memory while other information is sought. This sort of fragmentation may also occur in a densely populated or cluttered screen requiring much in the way of cognitive resources to locate information. Display fragmentation is closely related to and overlaps with 2 other types of fragmentation involved in clinical care. One is *information fragmentation*—the location of important information sources in forms outside the EHR, often in several different modalities such as paper records, faxes that have been scanned to a repository, messages from staff, and even Post-it notes [5]. This type of fragmentation is extremely common in health care, as it is often not possible or desirable for all patient information to be contained merely within the EHR [5]. Processes that predate EHRs and remain operative can determine information location and health professional use of patient information. Information fragmentation can contribute to the deleterious effects of display fragmentation, as information may not be available at the point of care and, as a result, may impair information seeking, clinical reasoning, and the subsequent quality of decision making by health professionals [6,7]. Information and display fragmentation share a core problem that makes it difficult for the health care provider to access needed patient data or pertinent EHR functions.

Although both display fragmentation and information fragmentation involve challenges accessing needed information, their point of emphasis is different. Display fragmentation emphasizes how features of an interface result in a user devoting cognitive resources to interacting with system complexity (eg, unnecessary actions) rather than thoughtful completion of the patient care task. The construct of information fragmentation emphasizes the difficulty of assembling needed information, some of which may be available outside of the system or application, and some of it may rely on the robustness of clinical communication as in patient handoff.

Another form of fragmentation is *task fragmentation*, in which there is a separation of the parts of a task in undesirable ways [6]. For example, the task may be broken into too many steps, or the steps are redundant. This usually slows the overall process of performing tasks using a system, such as an EHR, while at the same time increasing the cognitive load for the user (eg, physician or nurse) performing the task. Undesirable task fragmentation is often a result of display fragmentation and information fragmentation forcing the user to take additional actions to view related material to support their information seeking and decision making. It also fragments the user's optimal workflow and can lead to workarounds for completing tasks [8]. This is especially the case when new systems introduce new ways of performing cognitive and physical work (eg, to support a therapeutic decision) [9]. This may also be due to other circumstances, including interruptions and the need to reprioritize clinical activities.

HIT systems such as EHRs often create new workflows or can be disruptive to existing workflows, leading to increases in cognitive and physical burdens [3,8,10]. For example, researchers found that the use of a computerized physician order entry system introduces additional steps to view the *patient overview* as compared with the work practices before the implementation [11]. Systems that are not coextensive with clinical workflow may increase the frequency of task switching and multitasking, thereby contributing to a fragmented experience [10]. A recent review of EHR usability and safety literature concluded that navigation is a crucial component of usability [12]. The authors of this paper argue that further usability research is necessary to identify and categorize navigation actions with greater precision [12]. These mapping efforts can provide a uniform approach to EHR usability research and enable systematic comparison between different systems [13].

Research has also shown that reasoning and decision making by clinicians can be highly sensitive to and influenced by the structure and organization of information and information categories in menus and lists, as it is displayed in an EHR system itself [14,15]. The fragmentation of clinical information can create inefficiencies and lead to suboptimal diagnostic reasoning [14,15]. This suggests a need to more closely scrutinize the impact of display fragmentation on clinical cognition. We do this by developing a new method for characterizing fragmentation guided by a cognitive engineering framework. Our approach is interdisciplinary and focuses on the development of methods and tools to assess and guide the design of computerized systems to support human performance [16,17].

Cognitive Engineering: Characterizing and Visualizing Fragmentation

User interaction can be analyzed as a combination of elementary cognitive, perceptual, and motoric behaviors [18]. All 3 elements are necessary for any task, and specific task-system combinations may be of a more memory-intensive nature or require more in the way of perceptual and motor behavior [19]. Users divide their cognitive resources between navigating through the system interface and performing specific tasks at hand (eg, documenting vital signs) [20]. Seamless navigation is characterized by a fluid interaction in which the effort expended while interacting with the system interface is minimal. Systems of greater navigational complexity necessitate that more effort be devoted to interacting with the system and less to thoughtful task completion [21].

Specific interface elements such as screen layout, pull-down menus, and dialog boxes can affect the levels of optimality or complexity in system interaction [22]. Optimizing the form in which information is displayed, accessed, and documented is dependent on identifying and understanding the flow of specific tasks [21]. Understanding the levels of fragmentation and navigational architecture by mapping specific vendor EHRs can have many applications, including the creation of new navigation tools and streamlining workflows, improving the usability of systems, and decision making. The navigational complexity can be operationalized and measured in terms of the flow or level of interactivity for a given task [21].

This paper describes the methodology behind 2 new approaches for visualizing and quantifying display fragmentation and task fragmentation as they apply to clinician use of EHRs. In the Methods section, we will describe the approaches in detail, including their methodology and examples of their application (titled Illustrations). In the Results section, we will present the results of the illustrations to gain insights into display fragmentation and task fragmentation. The short-term goal of this research, as reflected in this paper, is to show how these methods can provide valuable insight into HIT interface challenges related to display, information, and task fragmentation. The long-term goal is to improve the design of HIT interfaces, such as EHRs, so that they have better fit-to-task, lower cognitive burden, and can enhance clinical decision making, thus improving patient quality of care and safety.

Methods

Overview

Two methods used to visualize and characterize display fragmentation and task fragmentation were sunburst diagrams and time belt visualizations, respectively. We first present each of these methods in detail and 3 illustrations that exemplify how each of these methods can be applied to analyze display fragmentation and task fragmentation.

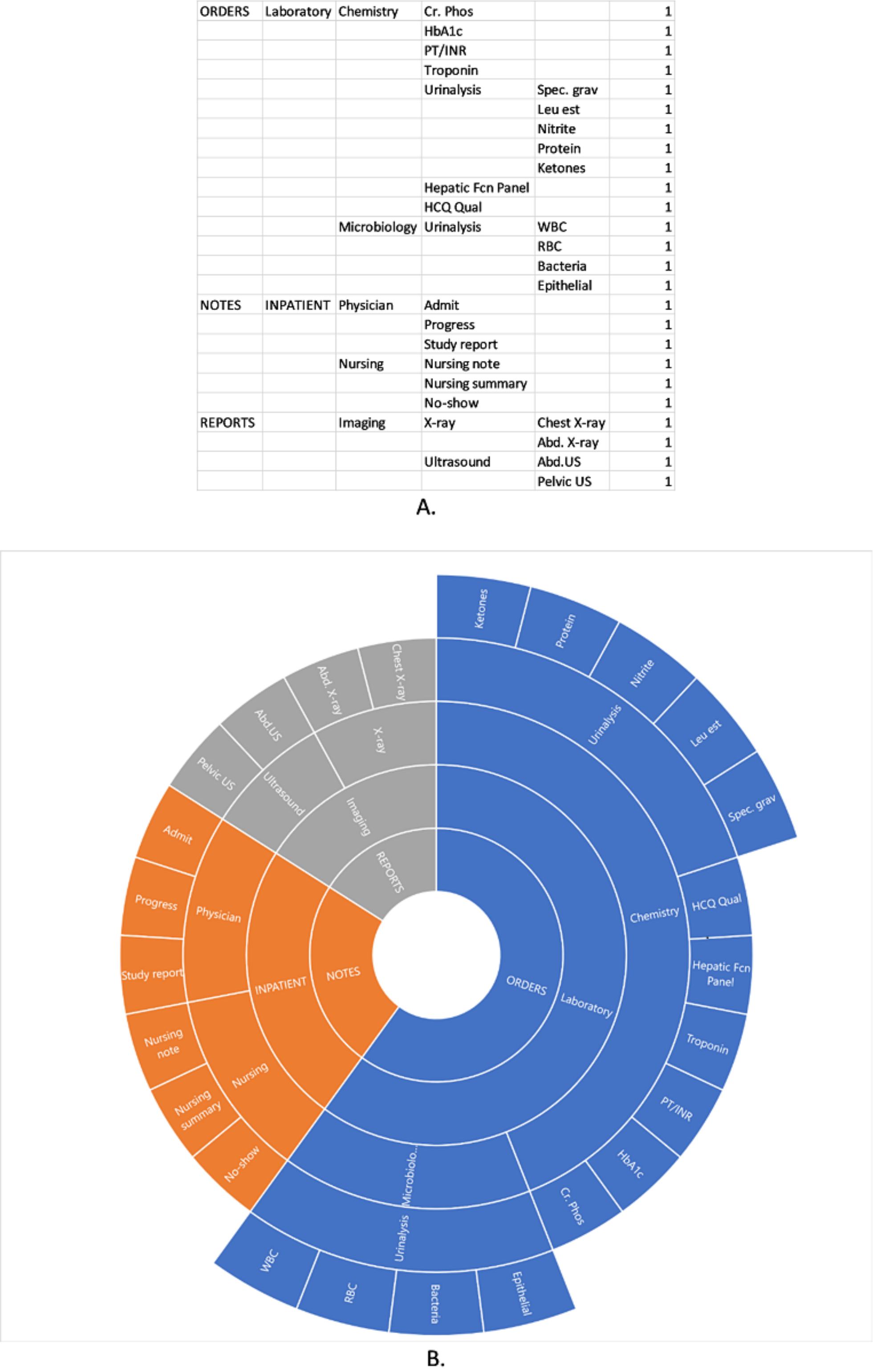
Method One: Sunburst Diagrams for Describing Display Fragmentation

To understand display fragmentation, we developed *sunburst diagrams* as a method for visualizing system navigation and, subsequently, display fragmentation. Using these diagrams, we developed a measure to quantify display fragmentation and allow easy comparison between systems.

Navigation in menu-based systems is typically represented in the form of a tree arrangement; on the top-level screen, menus are usually displayed in a left-hand column or as tabs across the top or both. The *root* of the tree represents the highest-level screen, and each level of the tree and its *leaves* represent subsequent menu and submenu choices and varying levels of branching downward. The sunburst diagram presents an alternative, more concise representation of system navigation. The visualization shows the highest level of the system or tree as the first, innermost wrapped circle, and successive levels in the system or tree as successive concentric circles (Figure 1). Screens or levels of navigation that are in the same hierarchical level appear as segments within the same circle. The screens at different hierarchical levels appear as different circles. Therefore, a diagram with a greater number of circles indicates more system levels and screen transitions.

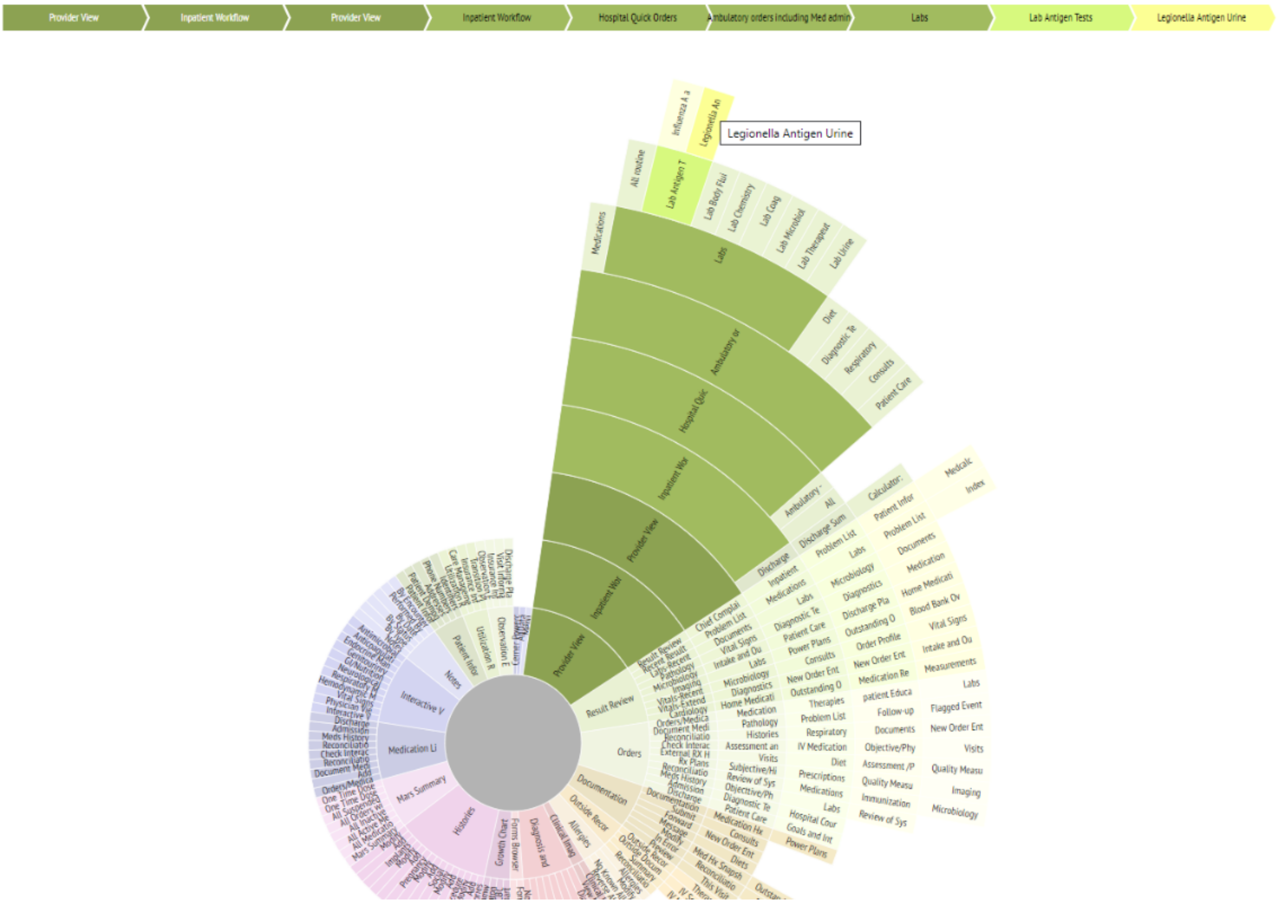
To begin building a sunburst diagram, a modified cognitive walkthrough is performed, in which the researcher steps through all levels of the system’s navigation systematically, recording the menu structures and substructures and how they lead to different clinical data elements or other affordances [15]. This differs from usual cognitive walkthrough methods in that the aim is to create a map of the navigation structure of the EHR, rather than to elucidate the steps needed in the performance of specific tasks. We term this a *modified cognitive walkthrough* to make this distinction. After the modified walkthrough, the recorded information serves as the *data* that populate the sunburst diagram (Figure 1). Excel (Microsoft), for example, has a built-in sunburst diagram function that automatically creates the diagram based on the data. Figure 2 provides another example of a sunburst diagram that highlights a specific pathway.

Figure 1. An example of sunburst chart data in Excel describing the system architecture (A) and the resulting sunburst diagram (B).



ORDERS	Laboratory	Chemistry	Cr. Phos		1
			HbA1c		1
			PT/INR		1
			Troponin		1
			Urinalysis	Spec. grav	1
				Leu est	1
				Nitrite	1
				Protein	1
				Ketones	1
			Hepatic Fcn Panel		1
			HCQ Qual		1
		Microbiology	Urinalysis	WBC	1
				RBC	1
				Bacteria	1
				Epithelial	1
NOTES	INPATIENT	Physician	Admit		1
			Progress		1
			Study report		1
		Nursing	Nursing note		1
			Nursing summary		1
			No-show		1
REPORTS		Imaging	X-ray	Chest X-ray	1
				Abd. X-ray	1
			Ultrasound	Abd.US	1
				Pelvic US	1

Figure 2. Interactive sunburst highlighting one pathway (in green) from a root screen (Provider View) to a specific element (Legionella Antigen Urine lab results). The traced pathway is also described in the linear flow above the sunburst diagram. This diagram shows how 9 different screens must be navigated to access the desired element from the main screen.



Sunburst diagrams are advantageous in that, in addition to visualizing the structure and tracing pathways, we are also able to calculate the number of clicks, screen transitions, and other navigation actions needed, such as scrolling or filtering. For example, we can first shade the segments of the diagram that represent target information or screens a specific color (as in Figure 2). Knowing that the transition from one circle in the diagram to another represents a change in screens, and the transition from one segment in a circle to another segment in the same circle represents a click or perhaps screen scroll to view, we can use the sunburst diagram to systematically calculate the number of transitions and navigational actions needed to navigate from one target piece of information to another. We used this benefit of the sunburst diagram to create a measure to quantify display fragmentation and navigational complexity, which provides a basis for comparison between systems or between tasks. We termed this measure Display Fragmentation Index (DFI).

The DFI captures (as in Figure 3): the overall number of different content categories into which the required information is split; the different levels of the tree structure, with each level requiring additional clicks; navigation to elements at the same level, which also requires at least one click or scroll action (with multiple scroll actions counted as 2, as an average owing to the variability of such screens across cases); and the menu length (parallel items, which appear adjacently) at each stage, as this reflects the complexity of choice (and hence a taxing cognitive task) among menu items and results in greater visual search. Menu length is also highly indicative of the navigation time [23].

Thus, we can calculate DFI using the following equation:

$$DFI = E + IS(X_{IS}) + C(X_c) + SS(X_{ss}) + ML$$

where E refers to the number of data elements, IS the number of intermediate screens (transitions), C clicks (navigation action), SS scrolling screens (navigation action), ML menu length, and X a multiplier applied to each variable based on the number of levels traversed.

E does not have a multiplier because it simply represents the number of information elements that need to be accessed, regardless of their location.

To calculate this measure, we focus on the main obvious navigation paths as the measured pathway. As many EHRs may have several routes to get to an item, the fragmentation measure is a reasonable maximum; for some tasks, one may not have to go up all levels to get to the next item, as just the lower levels may be involved. The actual trajectory may vary depending on the user’s goals and preferences; the one presented is the longest reasonable pathway.

In this illustration, we show how sunburst diagrams allow easy comparison of fragmentation and navigational complexity between systems and can be used to calculate DFI.

Figure 3. Display Fragmentation Index element calculations. DFI: Display Fragmentation Index.

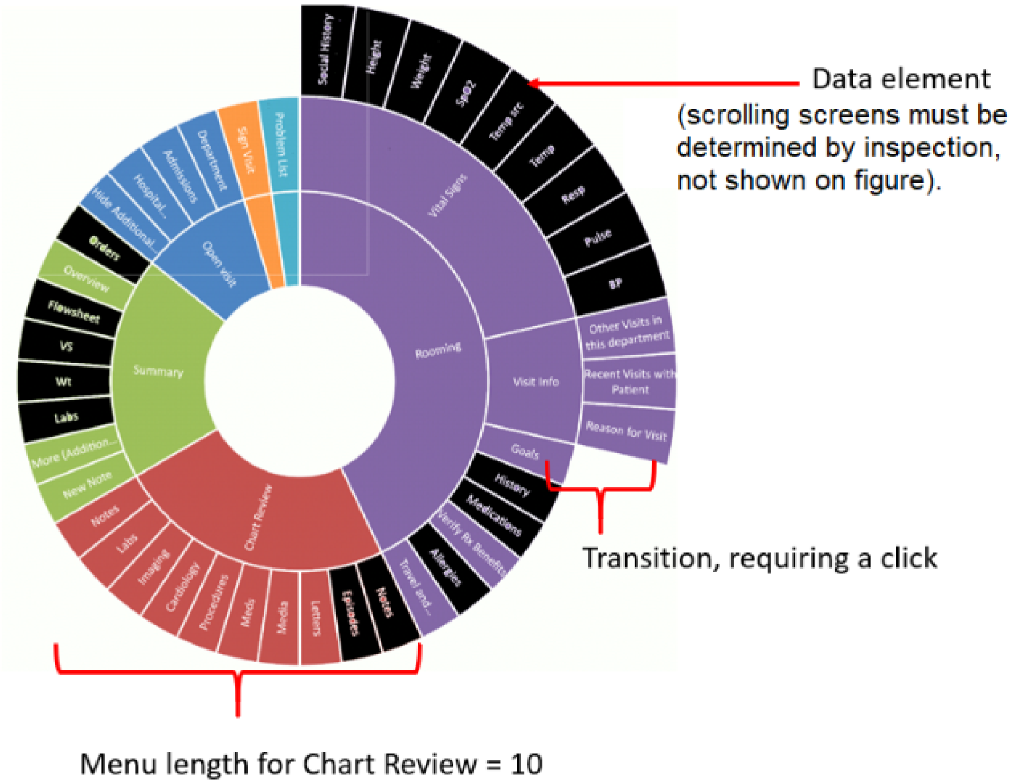


Illustration Overview: Using Sunburst Diagrams to Describe Display Fragmentation in EHRs and Developing a Measure to Quantify Display Fragmentation

To show how sunburst diagrams can be used to describe and quantify display fragmentation, we illustrate how we used sunburst diagrams to visualize display fragmentation for 2 different, widely used, commercial EHRs. The context of this illustration is that the research team sought to understand the extent of display fragmentation in commercial EHRs, including differences in navigational architecture. Thus, the team conducted a modified cognitive walkthrough and used the sunburst diagram to display the results.

The team then conducted a more traditional, task-oriented cognitive walkthrough emulating the process of clinicians conducting general case reviews. This is a second step in the method, after creating the general navigation map described in the Method One section above. Data and information types for this task included admission notes, laboratory results, orders, medications, allergies, study reports (eg, of imaging or other studies), images (if available), discharge summaries, primary care and specialist provider notes, medications, demographic and insurance data, and nursing notes (if available), and automated data from devices or mobile apps, if applicable. Most current EHRs house similar data types together, necessitating complex navigation to see all relevant types while evaluating a patient case.

Once the diagram was created, the number of screen transitions and levels of navigation were counted using the visualization, and DFI was calculated.

Method Two: Time Belts for Mapping User Workflow and Task Fragmentation

We also developed a method for visually characterizing user workflow and task fragmentation. Visualization methods provide a systematic way of graphically representing information in a way that allows for understanding work and cognitive processes. Cognitive visualization methods allow for the use of visual metaphors for gaining insights into user mental steps and mapping of user workflow. Many of these methods are linear, but there are nonlinear metaphors as well, such as the desktop, tree, or swimlane metaphors. Understanding how EHR navigational structure affects workflow can be aided by additional mapping of the user's actions while performing a task.

Time belt visualizations involve the linear depiction of the different phases and actions of a user (Figure 4). The different information types viewed, durations, and repetitious navigation to the same elements or element types can all be conveyed succinctly to understand a user's work patterns. In the diagrams, the percentage of time shown in each section of the system is easily identified by a key, and the time sequence of the user is clearly shown from the start of interaction with a system to the completion of a task. Such an approach can be used to graphically depict an individual user's patterns in accessing components of an EHR over time for comparison purposes (eg, comparing residents vs attending physician interactions with cases of differing complexity). Zheng et al [24] investigated the variation in preoperative workflow findings in 2 hospitals. Suboptimal patterns were identified, and the reasons for the variation were explored. Although both settings used the same EHR system, they observed marked differences in patterns of workflow with consequences for patient care. Figure 4 shows an example of a time belt that represents workflow as a series of discrete tasks representing their sequence (color-coded) and their duration (width of the colored segment). A simple representation can be used to compare clinicians, EHRs, patient conditions, and visit types. The time belt reflects the overall flow across the patient's encounter. We can also drill down to examine the navigational complexity for specific tasks, such as medication reconciliation.

Time belts can be used to compare time on tasks across different systems, as well as the time spent on different tasks. This representation enables us to scrutinize task performance at a granular level, including time spent on different tasks, fragmentation in terms of repeated tasks, and sequential ordering of tasks. We can also examine each segment and determine the degree of interactivity. Importantly, we can break down a task and characterize clinicians' clinical reasoning and, specifically, how diagnostic and therapeutic reasoning evolves over the course of time.

We also calculated the proportion per instance. Zheng et al [24] derived a measure of task fragmentation that relates the time on task for subtasks, normalized for EHR time. Their measure, time proportion per instance can be used to compare EHR tasks in different settings:

Proportion per instance = Instance task time/Number of task instances × Total EHR time

This is based on average continuous time (ACT) in which increased task fragmentation results in decreased time for a subtask [3]. The longer the ACT, the lower the task fragmentation. The proportion per instance normalizes this to accommodate total EHR time so that longer sessions do not inflate the measure.

Figure 4. An example of time belt visualization for 5 patient cases in preoperative care at a large tertiary care hospital. One single horizontal belt or row represents 1 patient case. The length of the belt indicates the case duration in seconds. Each belt comprised a sequence of tasks performed by the nurse and represented as color-coded segments. For example, Allergies refers to the task of checking allergies.

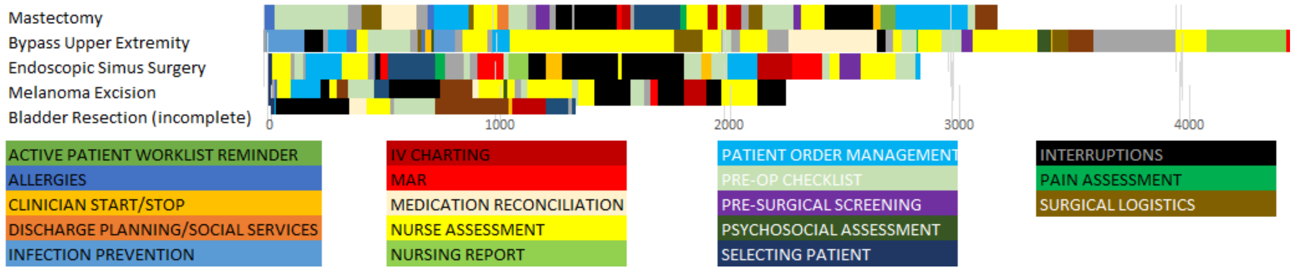


Illustration Overview: Using Time Belts to Compare Task Fragmentation and Workflow for a Conventional EHR and a Composable EHR

We developed an experimental EHR interface to address some of the issues of fragmentation and cognitive load [25-27]. The following illustration details how the described visualization techniques were used to compare a commercial EHR with the experimental system.

The context for this illustration was a larger study where medical residents were recruited and presented with a series of cases using real patient data in a conventional EHR or the experimental system. The patient data were collected at a large health care site as part of a larger study examining EHR-mediated nursing workflow. For each of the cases, the patients were *seen* by other clinicians previously, and the study participants were asked to review the documentation, determine the reason for the patient's problem, and present a therapeutic and management plan of action. The participants' interactions with the systems were captured by Morae (TechSmith) [28], a powerful video recording and analytics tool widely used in human-computer interaction research. Participants were also asked to think-aloud while completing the tasks, and their dialogue was recorded and transcribed.

After the study, the recordings were analyzed, and time belt visualizations were created to compare time on tasks across the conventional and experimental systems. Note that this illustration is meant to show how time belt visualizations can be used to surface different dimensions of clinical cognition. It is not intended to compare the efficacy of the conventional and experimental systems, but rather exemplify how their interfaces yielded different patterns of interaction.

For the purpose of this illustration, we present the results for one resident participant who used the conventional EHR system to examine a patient case, John Smith, and a second participant who used the experimental system to examine the same patient. In the scenario, John Smith had an extensive medical history and presented with an array of cardiac and other clinical problems. He is in the emergency department (ED) due to exertional chest pain starting 2 hours previously (severe, 10/10, sharp or stabbing, localized as substernal, radiating to the back). The clinician is an ED physician treating the patient and has some past EHR records, including 2 prior progress notes and medical or surgical history, laboratory values, allergies, social history, and medications.

Illustration Overview: Putting It All Together—Sunburst and Time Belt Visualizations

We present a third and final illustration in which we show the 2 visualization methods in tandem. The context for this illustration is similar to the one for the time belts: a larger study where medical residents were recruited and presented with a series of patient cases that used anonymized but real patient data in the conventional EHR or experimental system.

Participant interaction with the system was recorded and then used to create a time belt to show the time spent on each screen or element. Similarly, the EHR was mapped using the sunburst diagram, and the resulting Excel sheet was used to show how the user participant navigated across the system.

Results

Illustration Results: Using Sunburst Diagrams to Describe Display Fragmentation for an EHR System and Developing a Method to Quantify Display Fragmentation

The sunburst diagram for the cognitive walkthrough of the first conventional EHR is presented in Figure 5. The elements colored in black represent the information relevant to the clinical task used for the cognitive walkthrough—general case review. One can see how the relevant information elements are scattered across different paths, levels, and main sections.

Using the DFI measure described above, the DFI for the sunburst diagram presented in Figure 5 was calculated as follows:

DFI = 36 + 136 + 136 + 39 = 347

Note there are no scrolling screen terms incorporated into the above equation.

Thus, it is easy to conclude that the degree of fragmentation for this conventional commercial EHR is rather high and could likely lead clinicians to spend a large amount of time and cognitive resources while navigating, viewing, and retaining information.

The researchers also analyzed a second commercial EHR user interface (UI); the resulting sunburst diagram is presented in Figure 6. For this system, the DFI was calculated as follows:

DFI = 19 + 47 + 47 + 19 = 132 (again, with no scrolling screens term)

Thus, this system has a lower DFI (approximately one-third of the previous system), representing less fragmentation and fewer navigation levels.

Figure 5. Sunburst diagram representing display fragmentation of clinical data in a conventional, commercial electronic health record. Elements colored in black are those relevant for handling the clinical problem (general review of patient information). EHR: electronic health record; UI: user interface.

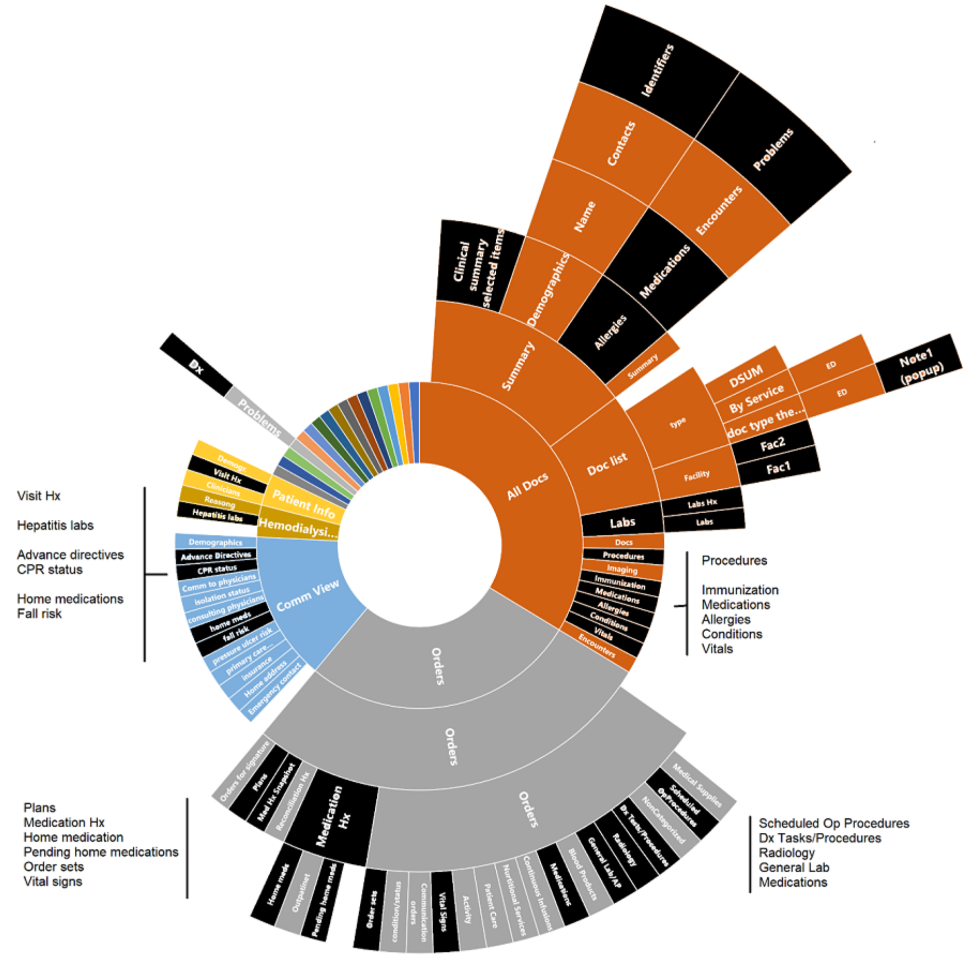


Figure 6. Sunburst diagram representing display fragmentation of clinical data in a second conventional, commercial electronic health record. Elements colored in black are those relevant for handling the clinical problem (general review of patient information). EHR: electronic health record.

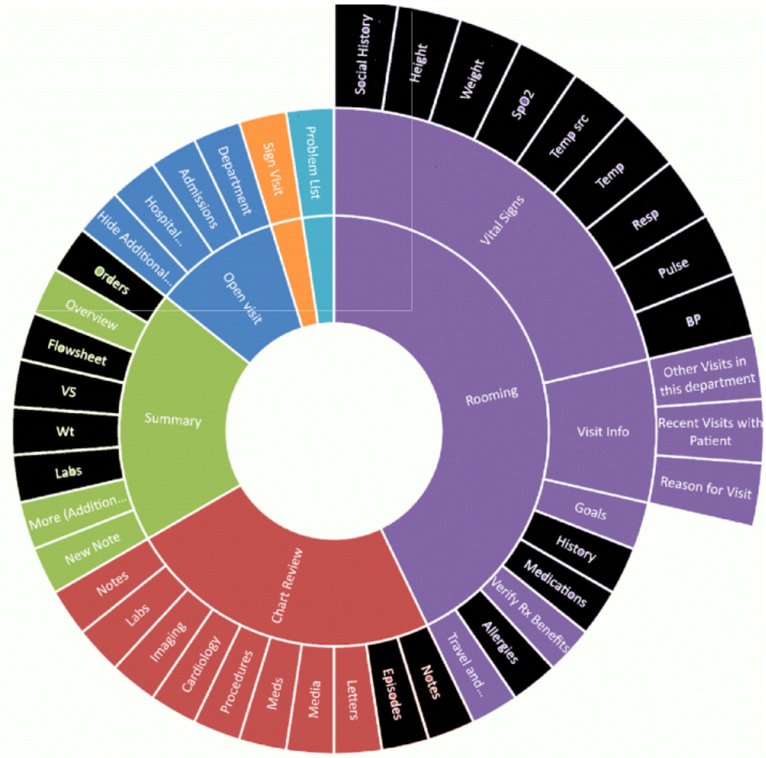


Illustration Results: Using Time Belts to Compare Task Fragmentation and Workflow for a Conventional EHR and a Composable EHR

Figure 7 presents a captured screen from the conventional EHR system presenting laboratory results for the patient case, John Smith. In the conventional EHR UI, information is accessible through a hierarchical set of tabs, menus, and side panels. To its credit, the conventional EHR UI is well segregated and organized. Much of the patient information can be accessed through the display. On the other hand, the interaction space is immensely complex, and there are multiple ways to access the same information.

The participant used 346 mouse clicks, including just under 200 left-mouse clicks. In that short span of time, the resident visited 43 display screens, including repeat visits to several displays (eg, blood gas arterial panel). She experienced some difficulty locating an appropriate index document, such as a progress note or discharge summary. As a consequence, the resident devoted considerable time to searching for information. She focused largely on laboratory values, some of which seemed anomalous or contradictory, and then toward the end of the session, came across 2 ambulatory care text documents (at the 200-second mark) that facilitated her development of a complete patient problem representation.

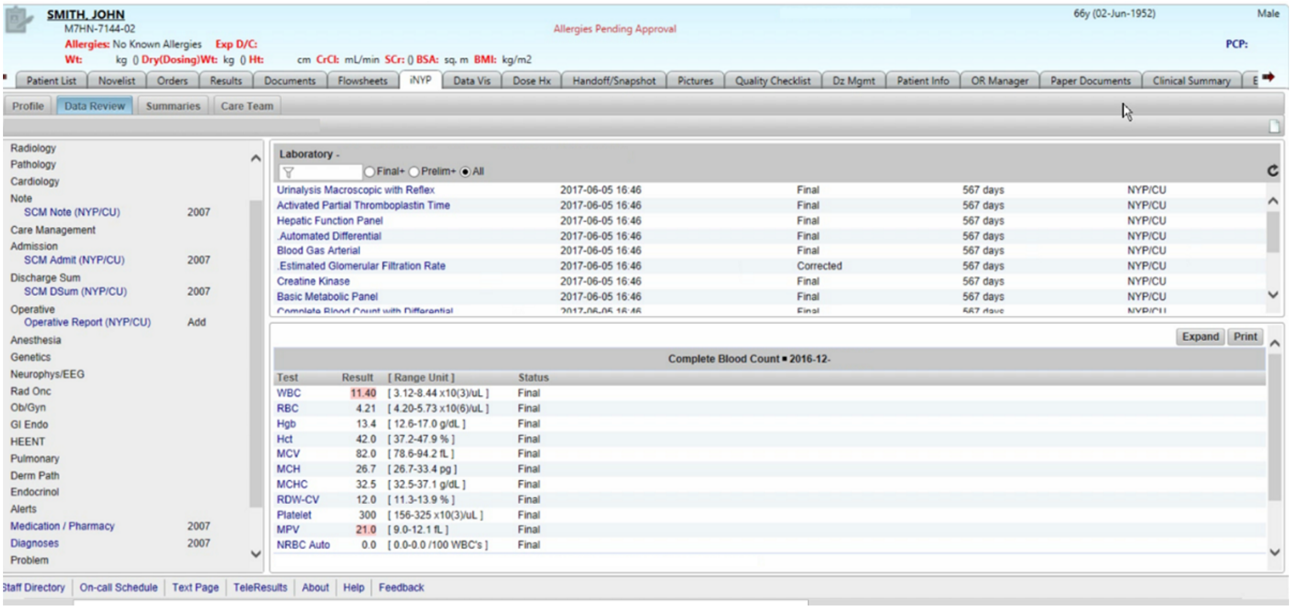
Figure 8 presents the time belt that illustrates the workflow or time on task for the single resident participant performing the task on the conventional EHR system. The participant required 6 min and 35 seconds to complete the task. The time belt is divided into task segments of variable durations.

Figure 9 presents the experimental system interface for the same case. The interface is entirely configurable. The left-hand panel contains a set of available documents relevant to the case. There are only 7 documents, including the contemporary (current) note, 2 older progress notes, a chest x-ray, labs, and Fishbones. Users can drag and drop documents and rearrange them accordingly. The screen below includes 2 rows of documents in the form of widgets. The first row contains 2 older progress notes and an x-ray. The bottom row includes the current document and all laboratory values.

Figure 10 illustrates the workflow or time on task for the resident performing the task using the experimental system. The task required 10 min and 48 seconds to complete. The user employed 389 mouse clicks, including only 20 left-mouse clicks. The remaining clicks reflect the extensive use of the scroll wheel. In that short span of time, the resident visited 14 display screens, including repeat visits to the current note and older progress notes. The current note acts as the index document to understand the patient's problem. As we can see, the time belt and other visualizations can be used to characterize a state of affairs—the current state of navigational complexity and fragmentation. They can also be used as guideposts for design at a granular level of interactive behavior.

As noted, participants' think-aloud statements were recorded. Multimedia Appendix 1 presents a summary of the participants' think-aloud statements as it relates to the time belt presented in Figure 10.

Figure 7. Conventional electronic health record (EHR) system user interface (UI).



SMITH, JOHN
M7HN-7144-02
Allergies: No Known Allergies Exp D/C:
Wt: kg () Dry(Dosing)Wt: kg () Ht: cm CrCl: mL/min SCr: () BSA: sq. m BMI: kg/m2
Allergies Pending Approval
66y (02-Jun-1952) Male
PCP:

Laboratory -
○ Final+ ○ Prelim+ ● All

Urinalysis Macroscopic with Reflex	2017-06-05 16:46	Final	567 days	NYP/CU
Activated Partial Thromboplastin Time	2017-06-05 16:46	Final	567 days	NYP/CU
Hepatic Function Panel	2017-06-05 16:46	Final	567 days	NYP/CU
.Automated Differential	2017-06-05 16:46	Final	567 days	NYP/CU
Blood Gas Arterial	2017-06-05 16:46	Final	567 days	NYP/CU
.Estimated Glomerular Filtration Rate	2017-06-05 16:46	Corrected	567 days	NYP/CU
Creatine Kinase	2017-06-05 16:46	Final	567 days	NYP/CU
Basic Metabolic Panel	2017-06-05 16:46	Final	567 days	NYP/CU
Complete Blood Count with Differential	2017-06-05 16:46	Final	567 days	NYP/CU

Complete Blood Count ▪ 2016-12-

Test	Result	[Range Unit]	Status
WBC	11.40	[3.12-8.44 x10(3)/uL]	Final
RBC	4.21	[4.20-5.73 x10(6)/uL]	Final
Hgb	13.4	[12.6-17.0 g/dL]	Final
Hct	42.0	[37.2-47.9 %]	Final
MCV	82.0	[78.6-94.2 fL]	Final
MCH	26.7	[26.7-33.4 pg]	Final
MCHC	32.5	[32.5-37.1 g/dL]	Final
RDW-CV	12.0	[11.3-13.9 %]	Final
Platelet	300	[156-325 x10(3)/uL]	Final
MPV	21.0	[9.0-12.1 fL]	Final
NRBC Auto	0.0	[0.0-0.0 /100 WBC's]	Final

Figure 8. Time belt visualization of clinical task using commercial electronic health record. Note that the labels for the tasks have been abbreviated for readability. Each item represents a task, primarily searching and reviewing tasks. For example, "X-Ray" is short for "Reviewing X-Ray," a task the clinician completed.

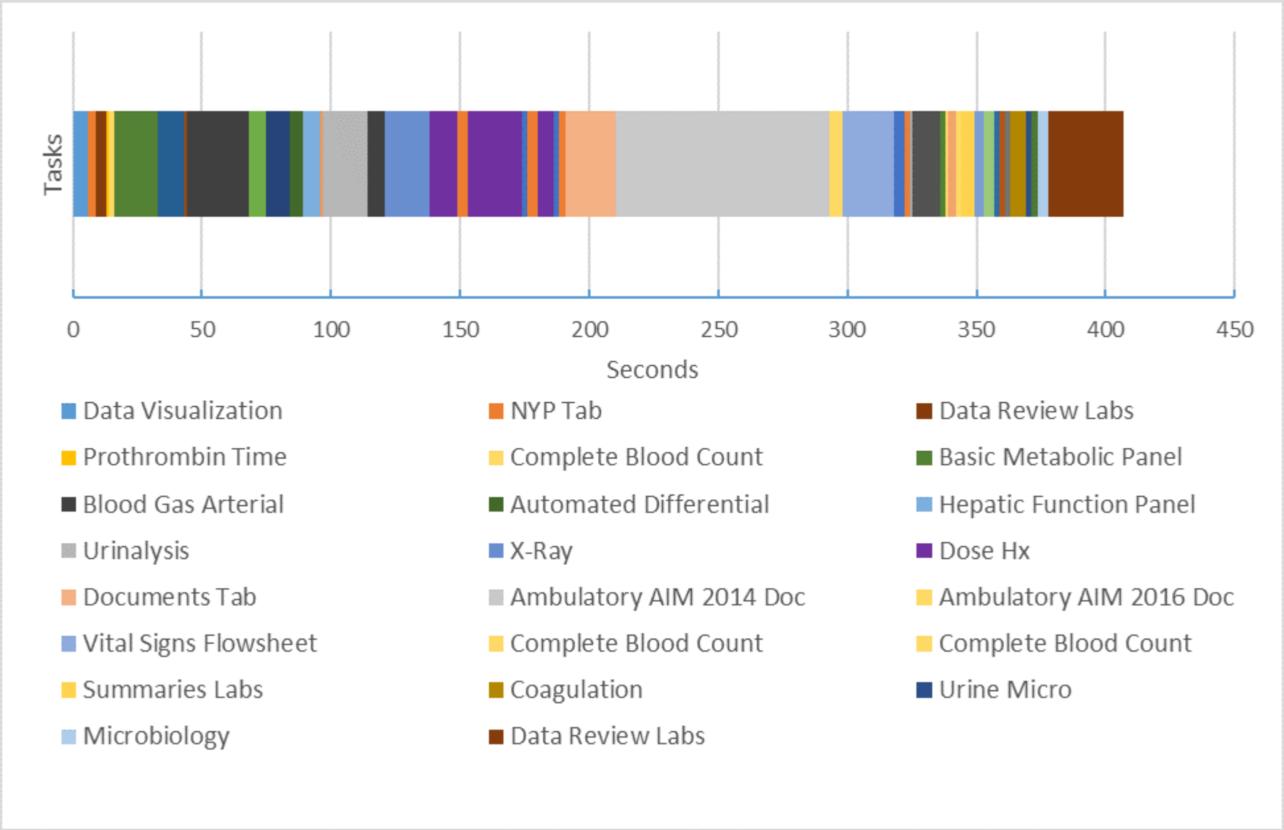
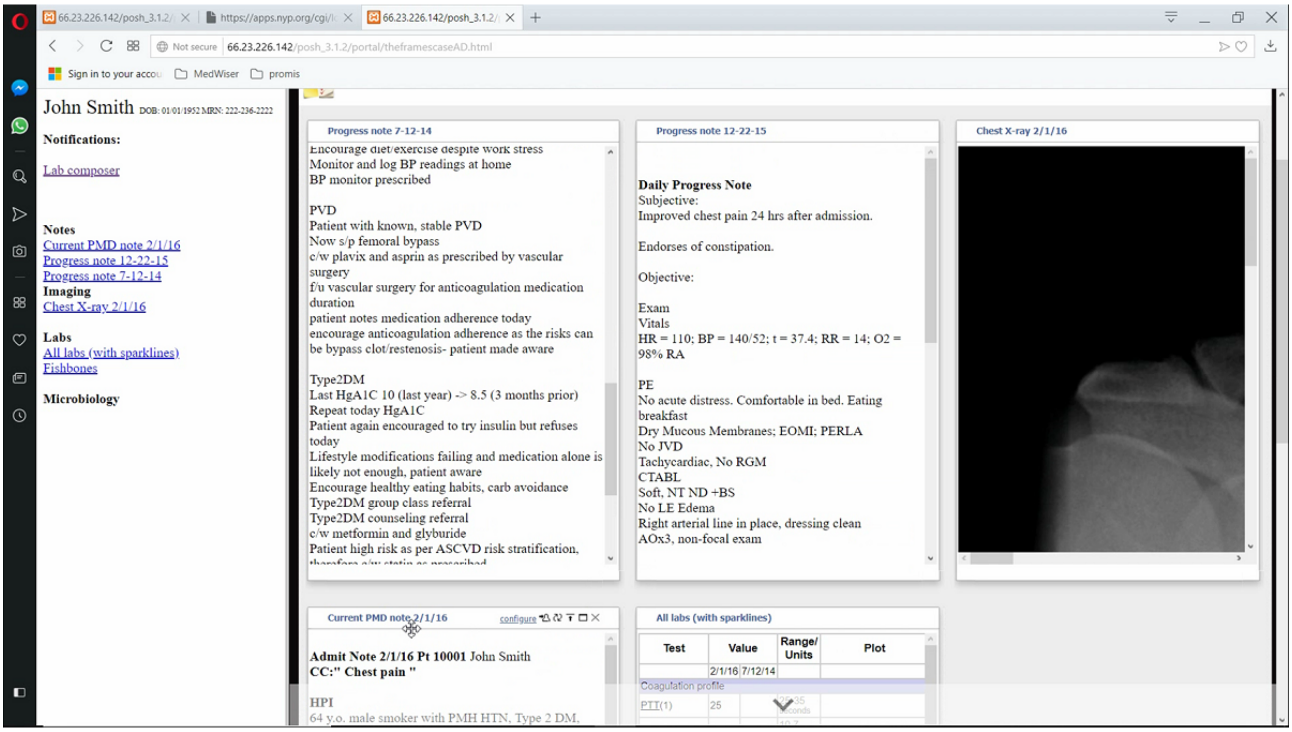


Figure 9. Experimental system screen with user placement of data elements for the same case as in Figure 8.



John Smith DOB: 01/01/1952 MRN: 222-236-2222

Notifications:

Lab composer

Notes
Current PMD note 2/1/16
Progress note 12-22-15
Progress note 7-12-14
Imaging
Chest X-ray 2/1/16

Labs
All labs (with sparklines)
Fishbones

Microbiology

Progress note 7-12-14

Encourage diet/exercise despite work stress
Monitor and log BP readings at home
BP monitor prescribed

PVD
Patient with known, stable PVD
Now s/p femoral bypass
c/w plavix and asprin as prescribed by vascular surgery
f/u vascular surgery for anticoagulation medication duration
patient notes medication adherence today
encourage anticoagulation adherence as the risks can be bypass clot/restenosis- patient made aware

Type2DM
Last HgA1C 10 (last year) -> 8.5 (3 months prior)
Repeat today HgA1C
Patient again encouraged to try insulin but refuses today
Lifestyle modifications failing and medication alone is likely not enough, patient aware
Encourage healthy eating habits, carb avoidance
Type2DM group class referral
Type2DM counseling referral
c/w metformin and glyburide
Patient high risk as per ASCVD risk stratification,

Progress note 12-22-15

Daily Progress Note
Subjective:
Improved chest pain 24 hrs after admission.

Endorses of constipation.

Objective:

Exam
Vitals
HR = 110; BP = 140/52; t = 37.4; RR = 14; O2 = 98% RA

PE
No acute distress. Comfortable in bed. Eating breakfast
Dry Mucous Membranes; EOMI; PERLA
No JVD
Tachycardiac, No RGM
CTABL
Soft, NT ND +BS
No LE Edema
Right arterial line in place, dressing clean
AOx3, non-focal exam

Chest X-ray 2/1/16

Current PMD note 2/1/16

Admit Note 2/1/16 Pt 10001 John Smith
CC:" Chest pain "

HPI
64 y.o. male smoker with PMH HTN, Type 2 DM,

All labs (with sparklines)

Test	Value		Range/ Units	Plot
	2/1/16	7/12/14		
Coagulation profile				
PTT(1)	25		25-35 seconds	

Figure 10. Time belt visualization of clinical tasks using experimental electronic health record (EHR) system.

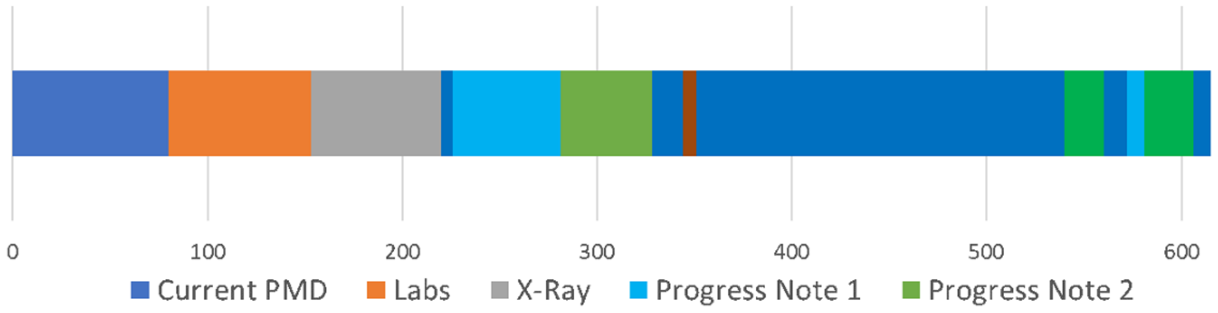


Illustration Results: Putting It All Together—Sunburst and Time Belt Visualizations

Figure 11 shows the time belt and sunburst diagram data for a user completing a patient review using a conventional, commercial EHR. The time belt shows the time spent on each task or screen. The Excel sheet shows the data for the sunburst diagram; however, in this instance, cells have been shaded to show the order and pathway the user took to navigate the system. For example, the user started on the *Data Visualization Screen* (light blue), then navigated to the *NYP Tab* (orange), then navigated to *Data Review Labs* (brown) within that tab, then *Complete Blood Count* (yellow), and so on and so forth.

From this combination of the time belt visualization and the sunburst diagram data scheme, we can see how task fragmentation corresponds with display fragmentation. Researchers can easily deduce how the user becomes *stuck* in several instances of back and forth navigation between 2 screens, and viewing sequences involving items far apart (see the number of orange-shaded cells indicating the user visited *NYP Tab*).

An example of proportion per instance is provided in Figure 11 time belt. Note that a lower proportion per instance value denotes more fragmented subtasks per unit time. In the time belt, this shows as a higher number of bands of the color corresponding to the task instances in a single patient encounter.

An example use of the measures can be seen to optimize displays by reducing fragmentation. In the time belt of Figure 12, the period from 140 to 200 seconds was spent in back and forth navigation looking at the same 2 elements 3 times each, with a navigation action screen between. Optimization could consist of juxtaposing these 2 elements, reducing the need for back and forth navigation. The proportion per instance would be improved for the same task.

Figure 11. Color of each cell or segment represents the task or screen the user was completing in sequential order. The time belt visualization shows the time taken for each task, whereas the Excel data scheme shows the different screen or part of the system needed for each task.

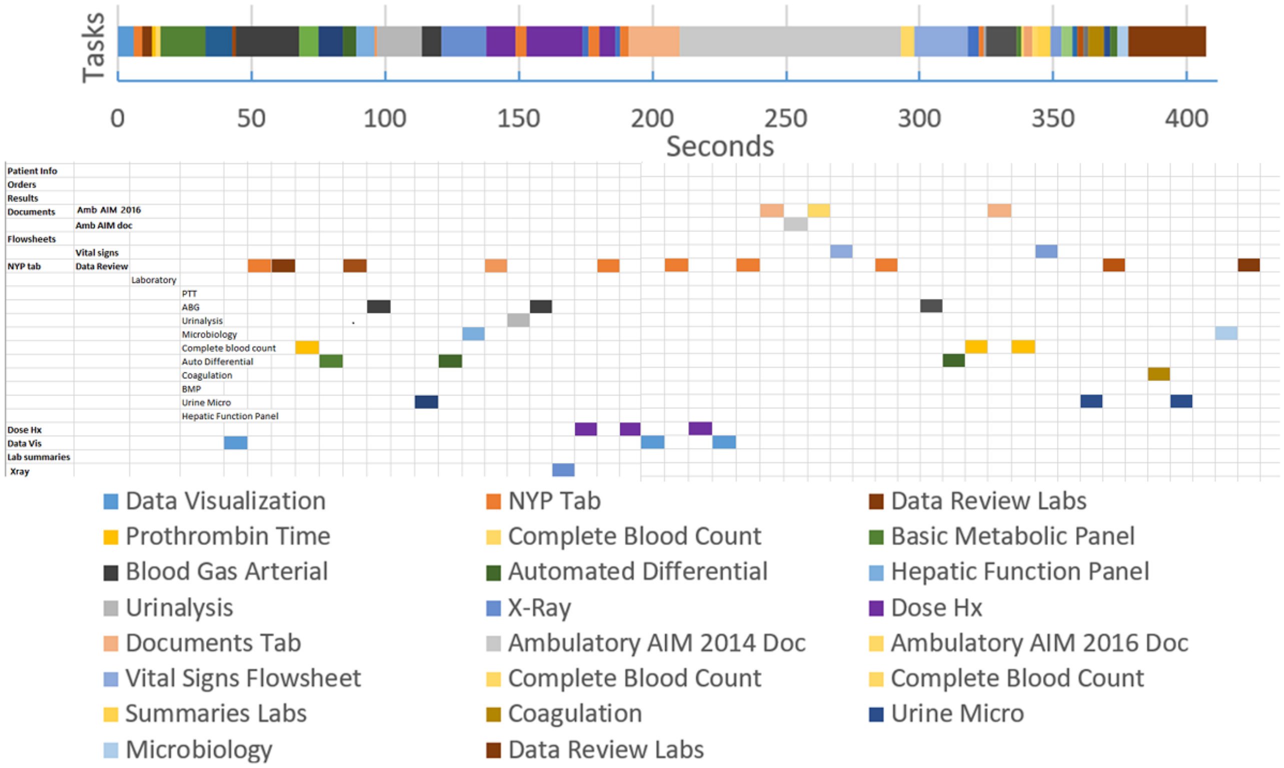
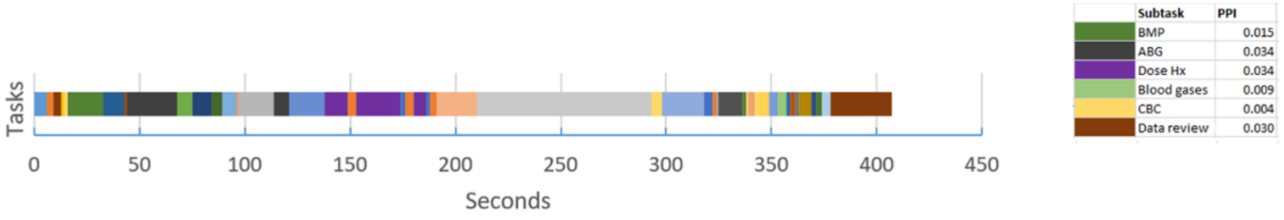


Figure 12. An example of proportion per instance calculated on the basis of the time belt from Figure 11. Proportion per instance for certain subtasks have been calculated in the small table to the right as examples. PPI: proportion per instance.



	Subtask	PPI
🟩	BMP	0.015
⬛	ABG	0.034
🟪	Dose Hx	0.034
🟩	Blood gases	0.009
🟨	CBC	0.004
🟫	Data review	0.030

Discussion

Principal Findings

This paper illustrates a set of methods and visualizations to characterize navigation complexity. It is based on the analytic work and video capture of users. There is a range of methodologies that can further inform our understanding of the problem. For example, eye movement studies have the potential to elucidate the relationship between the visual apprehension of information and clinical reasoning [4,29-31]. It should also be noted that EHR-mediated workflow extends beyond the confines of navigational complexity to a host of other issues necessitating convergent methodologies [32-36]. The work presented in this paper is formative and is part of a growing body of theoretically motivated research that seeks to expand the vision of usability and better situate it in the context of clinical workflow and quantifying complexity [20,21,24,37].

The sunburst diagram can serve many cognitive science, usability, and workflow analysis purposes. First, a static sunburst diagram is useful in simply providing a visual representation of the current system state regarding navigational complexity—it shows the structure of the system. The diagram can also be used dynamically and interactively to show the influence of redesign decisions on navigational complexity or screen fragmentation. Interactive versions permit clicking on a segment, which will then be shown as the top (the inner circle) of the resulting subtree, with subsections as concentric circles (Figure 2). This can then permit extensive drill-down and visualization of the entire tree even if it is very complex.

Second, the sunburst diagram permits viewing of the relationships between different parts of the system and facilitates the tracing of navigation pathways through the system (Figure 2). Once created, viewers can easily trace pathways for access to a certain system element or screen and thus further characterize display fragmentation. Pathway tracing and navigation map building are completed during a cognitive walkthrough [38], as described above. In web-based systems, there are web tools that can automate this process (eg, Powermapper [39] and edraw [40]), but many major vendor systems are not web-based. Furthermore, greater insight can be gained by differentially coloring the segments of the diagram, which can help to further visualize the degree of fragmentation.

For example, one color can denote the data of interest, and another color can denote irrelevant data for a task. Thus, someone can easily see the proportion of useful information to extraneous information and take action to redesign the system to remove the extraneous information.

The sunburst and time belt diagrams are complementary visualizations. The time belt is a succinct and clearly understood representation. One can view the distribution of tasks more readily. The time belt has a more explicit temporal dimension, which makes it easier to make inferences about the distribution of time.

Clinical care presents many pressures to the clinician; these are increased in emergency settings and where cases are complex. Current EHR systems interrupt clinical reasoning and workflow, increasing these pressures. The ideal system would rapidly present salient information and data critical to decision making and mitigate clinician cognitive load. We have found in studies of composed displays (where this is the case) that subjects find that the lack of the usual interruptions due to excessive navigation is cognitively supportive and helps their thought process. The methods described here can help to build such systems.

Ultimately, our aim is to make the arduous and already difficult work of clinical care smoother, more accurate, less cognitively demanding, and more pleasant. Ideally, information tools should be transparent, *fun to use*, enabling user control and freedom, and permitting focus on the tasks at hand rather than the tools themselves. Findings from our formative experiments suggest that composed displays that minimize the need for navigation can have this effect (prelim work, Y. Senathirajah et al, unpublished data, 2021). Some tool use in other domains approaches the level of artistic integration between users and tools to accomplish the most difficult of tasks. Although we are far from this in HIT, perhaps diligent further work can bring us close to the aim in the future. Consumer tools (such as some Apple products) have been studied for this quality of pleasure in use. Many clinicians view EHR use as unpleasant and unsatisfactory [41]. Reducing navigational complexity and facilitating task performance may free the clinician to be more creative, resulting in a more productive and pleasurable experience.

Although EHR usability has been much criticized, there is a very large installed base of the current EHR software. In conducting EHR mapping and task microanalysis, we aim to move beyond static conventional usability testing and bring together usability information with very particular guideposts, provide opportunities for EHR optimization, and more generally HIT redesign. A distinguishing feature of the composable EHR approach is its ability to juxtapose elements to decrease navigational complexity (thus increasing display integration). Understanding how the current EHR structure imposes fragmentation on both information access and task performance opens the way for specific focused redesign, which could shorten navigational pathways and thus time and effort taken. Decreasing screen fragmentation decreases the load on working memory. It could also permit specialized displays with low cognitive burden and machine delivery of UIs optimized for tasks.

We have derived useful measures addressing different needs for the comparison of EHR structure and its effect on navigation and task performance fragmentation. Having DFI and Zheng's proportion per instance permits making a distinction between different EHRs or their subsections for the same task, and different tasks carried in the same EHR as well as in different locations, by different clinician roles, and other factors. DFI can be used to distinguish EHR structure and navigation, subtasks for different EHRs, subtask time efficiency, and EHR interface redesign. Proportion per instance can be used to distinguish tasks, subtasks for different EHRs, subtasks for the same EHR but different clinician groups, and subtask time efficiency.

Subtask time efficiency is an important measure for finding areas in which EHRs can be optimized. Although DFI has no time elements, by identifying areas of fragmentation in navigation structure and therefore likely in task performance, it can aid in finding areas in which *pogo-sticking*, that is, navigating back and forth between elements or sections of the EHR occurs or is likely to occur. When this occurs repeatedly (eg, when a clinician reads a note and switches back and forth repeatedly from the note to a lab values section to check the current values of laboratory tests against those listed in the previous note), it is a subtask. The juxtaposition of the two elements (note and laboratory test results) would avoid this repetitious navigation, shortening the subtask time, and removing the excess navigation or clicks. The juxtaposition is known to foster reduced cognitive load (as data need not be retained in working memory as it is on screen together), reflection, the association of data elements, and the identification of patterns. In the note or labs example, the user will be able to see the change in laboratory values and the implications of such changes more easily. Providing both better cognitive support and shorter times or less navigation would aid in reducing the burden on clinicians, particularly in high-stress settings. EHRs are heavily implicated in contributing to physician burnout primarily because of the mismatch between task and system, leading to poor efficiency and frustrating navigational complexity.

Finally, we address the experimental system used in our illustrations. MedWISER is a system in which elements are easily arranged by drag or drop. Therefore, we can design novel UIs using MedWISER using the same elements used in conventional system tasks (eg, lab panels) to represent data and experiment with different configurations with the intent to simplify navigation. In the above subtask example, the clinician user can juxtapose the note and lab together by drag or drop without requiring programmer intervention; this is a normal way the system functions. Thus, the end user, or others such as researchers or system administrators, can easily rearrange data elements to foster shorter navigation paths, the juxtaposition of related elements, and the creation of screens that maximize support of clinical reasoning while minimizing excess navigation. The user's arrangements are stored, and patient-specific or specialty-specific displays can be shared (eg, with colleagues taking the next shift for that patient; they can also further modify the patient-specific display as new data comes in), further minimizing excess navigation and multiplying time savings. Thus, a set of displays could eventually be created with minimal fragmentation for the tasks being done (as can be calculated with new displays using our measures to evaluate degrees of optimization).

Limitations

There are several limitations to this study. Our presentation of cases is illustrative of the methods and is not representative of a larger set, which should perhaps be a next step in validating the work and formulae. Although the representations surface important dimensions of workflow, the comparative illustration of different systems cannot be used to infer that one system is better than another. There are many ways to represent data, and we have chosen ones that enable us to draw inferences about fragmentation based on a set of observations. The goal is also to convey the information visually and reliably so that readers can readily draw the same inferences or alternatively draw their own conclusions. However, there are other visualizations that may convey the same information. It is difficult to definitively prove that sunbursts or time belts are superior to other forms of representation. Expanding the space of potential visualizations can help advance the study of EHR-mediated workflow and, perhaps, its communication to stakeholders beyond academia.

Conclusions

In this paper, we described a methodological approach to addressing display fragmentation. Novel visualizations provide a suite of tools for communicating the exact nature of a navigation problem and creating the potential for precise and measurable design solutions. EHRs still present formidable usability challenges, but the potential for small tractable changes rather than large-scale prohibitively expensive ones is increasingly realizable. When combined with platforms such as MedWISER, which reduce the work involved in reconfiguration, they could provide pathways for rapid usability improvements and significantly improved the EHR-mediated workflow.

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Authors' Contributions

YS, DK, KC, EB, and AK contributed to the overall study design and manuscript writing. JF contributed to the overall manuscript writing.

Conflicts of Interest

AK is the Editor-in-Chief for the JMIR Human Factors. He had no influence on the decision to publish this article. The review and decision to publish were managed by a different editor at the journal.

Multimedia Appendix 1
Participant think-aloud process.
[DOCX File , 14 KB - humanfactors_v7i4e18484_app1.docx]

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Abbreviations

ACT: average continuous time
DFI: Display Fragmentation Index
ED: emergency department
EHR: electronic health record
HIT: health information technology
UI: user interface

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Original Paper

A Simulated Graphical Interface for Integrating Patient-Generated Health Data From Smartwatches With Electronic Health Records: Usability Study

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Abstract

Background: Wearable technology, such as smartwatches, can capture valuable patient-generated data and help inform patient care. Electronic health records provide logical and practical platforms for including such data, but it is necessary to evaluate the way the data are presented and visualized.

Objective: The aim of this study is to evaluate a graphical interface that displays patients’ health data from smartwatches, mimicking the integration within the environment of electronic health records.

Methods: A total of 12 health care professionals evaluated a simulated interface using a usability scale questionnaire, testing the clarity of the interface, colors, usefulness of information, navigation, and readability of text.

Results: The interface was positively received, with 14 out of the 16 questions generating a score of 5 or greater among at least 75% of participants (9/12). On an 8-point Likert scale, the highest rated features of the interface were quick turnaround times (mean score 7.1), readability of the text (mean score 6.8), and use of terminology/abbreviations (mean score 6.75).

Conclusions: Collaborating with health care professionals to develop and refine a graphical interface for visualizing patients’ health data from smartwatches revealed that the key elements of the interface were acceptable. The implementation of such data from smartwatches and other mobile devices within electronic health records should consider the opinions of key stakeholders as the development of this platform progresses.

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KEYWORDS

wearable; smartwatch; mobile; mHealth; user-centered design; electronic health records

Introduction

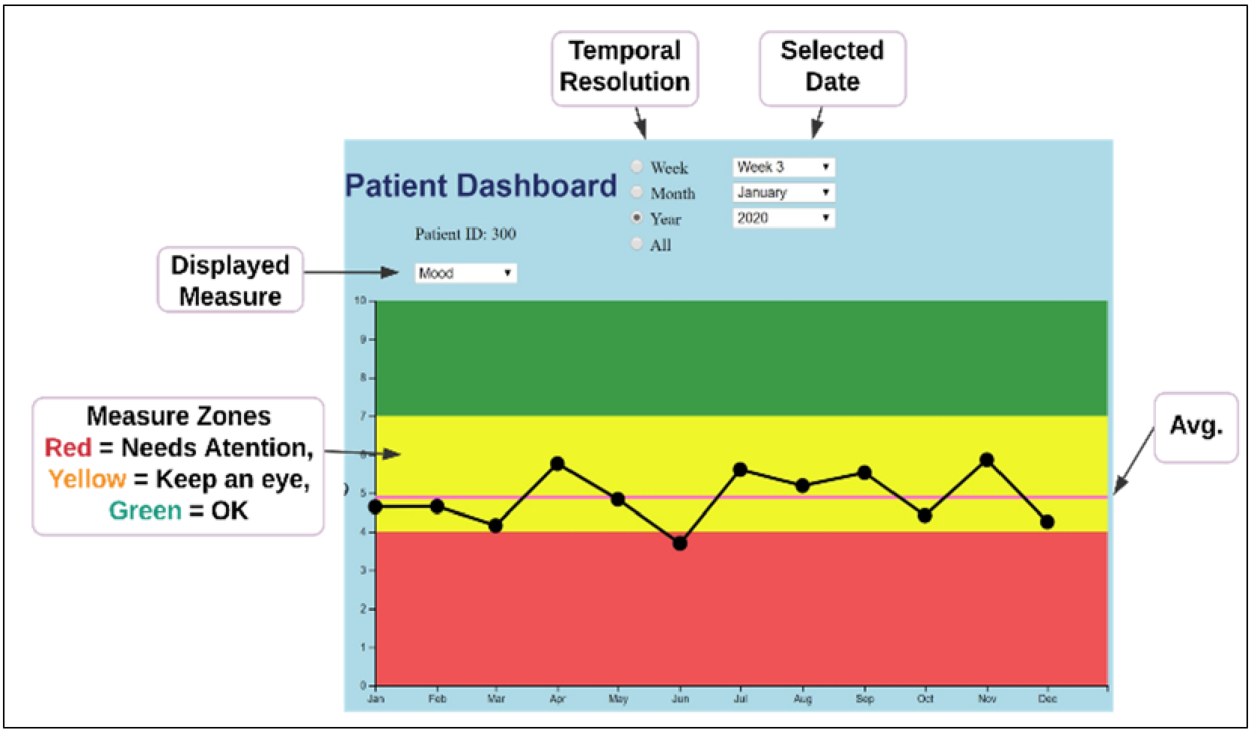
Wearable mobile technology enables long-term monitoring and capture of critical information about patients. Specifically, devices can be used to track physical activity, symptoms (eg, pain), and community mobility [1,2]. Health care professionals realize the value of receiving such data and have expressed the desire for those to be incorporated into electronic health record (EHR) systems [3]. However, simply adding data from wearable technology into EHRs can be problematic. Health care professionals were initially dissatisfied with the usability of EHRs when those systems were introduced [4,5], which led to difficulties in gaining proficiencies in EHR use [6] and slow adoption of the technology [7]. The best practices of implementation science indicate that involving stakeholders in the preimplementation and implementation phases to get their “buy-in” is necessary for success [8]. Involvement of stakeholders helps identifying user goals, which contributes to the acceptance and use of a system [9]. This study aims to test the usability of a graphical interface that displays patients’ health data from wearable devices (smartwatches) intended to be integrated within the EHR system by surveying health care professionals.

Methods

Setting and Study Design

Previously, a qualitative study was conducted with health care professionals about their perceptions and visual display preferences toward patient-generated data from smartwatches [3]. Based on the findings, a graphical EHR interface was developed to view measurements of attributes, such as pain, falls, hydration, and mobility patterns—the factors ranked high by health care providers in our previous study [3]. As part of the qualitative study, participants were aware that they would be recontacted to participate in the second phase. It is common for usability studies to repeat participants, as comparisons can be made to evaluate the efficacy of development [10-13]. All 12 participants from the qualitative study were recontacted via email to participate in this study, which focused on the usability of the interface. A link to an online survey with the sample interface was provided. First, participants were asked about the type of interface that would best suit their needs. Several figures were viewed, such as pie charts, bar graphs, and gauges; however, line graphs were most preferred due to their ability to display longitudinal data. Second, based on this information, a user interface was built using a web-based approach that would be suitable for an EHR interface (Figure 1). The interface mimicked what providers would see upon logging into an EHR system and allowed them to select the timeframe and specific variable. It was created on a separate server and was fully functional, which allowed users to toggle mock data as those would be received or summarized from smartwatches. The participants were queried again through an email that included 2 links. The first link directed participants to a simulated EHR interface with smartwatch data, and the second link led to the survey questionnaire (described in the next section). The survey instructions asked participants to respond to the questions after viewing and interacting with the simulated EHR interface for integration of health data from smartwatches.

Figure 1. Simulated EHR dashboard. Avg: average.



Patient Dashboard

Patient ID: 300

○ Week
○ Month
● Year
○ All

Week 3
January
2020

Mood

Usability and Data Analysis

The practice of usability testing is common with the presentation of graphical interfaces, and testing can enhance the efficiency of integrating EHR designs with existing workflow processes [14]. Thus, we evaluated the usability of the interactive elements and complex data presentation using a questionnaire developed by the International Organization for Standardization (ISO) to evaluate human-computer interactions (ISO 9241/110-S) [15,16]. This questionnaire contained 18 items. However, 2 items related to the ability to undo steps were not relevant to this interface and therefore were not evaluated. The remaining 16 items comprised 6 categories with the following principles: (1) suitability for the task, (2) conformity with user expectations, (3) self-descriptiveness, (4) controllability, (5) suitability for learning, and (6) error tolerance (Multimedia Appendix 1). Items focused on a variety of areas, including the clarity of the interface, colors, usefulness of information, navigation, and readability of text. An 8-point Likert scale ranging from 1 to 8 was used to gauge negative and positive sentiments toward each aspect of the interface. A score of 4 was considered neutral, consistent with another usability study that employed the same measurements as those used in this study [17]. The average scale scores and medians are presented in the next section along with the percent of responses above 5—the first green color code indicator, representing a positive score (as shown in Multimedia Appendix 1). In addition to evaluating individual categories, the ISO 9241/110-S evaluations also utilize aggregate scores, which range from 21 to 147 points [18].

Results

Participant Characteristics

There were 12 participants, representing different specialties, namely, geriatrics, orthopedic surgery, anesthesiology, nursing, and physical medicine and rehabilitation. The majority of participants were male (7/12, 58%) with an average age of 45 (SD 9.8) years. Health care professionals averaged 12 (SD 9.4) years of practice experience after residency. A detailed demographic summary is shown in Table 1.

Table 1. Demographic summary.

Characteristics	Values
Sex, n (%)	
Female	5 (42)
Male	7 (58)
Age (years)	
Mean	45.1
Range	33-64
Years in practice	
Mean	12.4
Range	4-35
Race, n (%)	
White	8 (67)
Indian	2 (17)
Latino	1 (8)
Asian	1 (8)
Specialty, n (%)	
Geriatric	4 (33)
Orthopedic surgery	4 (33)
Anesthesiology	2 (17)
Nursing	1 (8)
Physical medicine and rehabilitation	1 (8)
Patient setting, n (%)	
Outpatient	5 (42)
Inpatient	3 (25)
Both	4 (33)

Evaluation Outcomes

Scores from 1 to 3 were interpreted as negative; score of 4 was considered neutral or average; and scores from 5 to 8 were considered as positive responses to the interface elements. Overall, the interface was positively received, with 14 out of the 16 items generating a score of 5 or greater among at least 75% of participants (9/12). The highest and second highest scored items were turnaround times (item 7, mean score 7.1) and readability of the text (item 5, mean score 6.8). Terminology and abbreviations used in the interface (item 10) was the third highest scored item, with a mean score of 6.75. Other items with average scores above 6.0 were the interface's use of color (item 6, mean score 6.7), easily understood symbols and icons (item 11, mean score 6.6), appropriate number of elements for control (item 2, mean score 6.3), simple visualization (item 15, mean score 6.2), corresponds to expectations (item 8, mean score 6.1), and navigation (item 13, mean score 6.1).

Aspects of the interface that were scored between 5 and 6 were related to its design, such as straightforwardness of visualizations (item 1, mean score 5.8) and consistency of design (item 4, mean score 5.8). In addition, items related to the levels of information provided by the interface were scored similarly (ie, item 3 and item 9) along with that of customization (item 17).

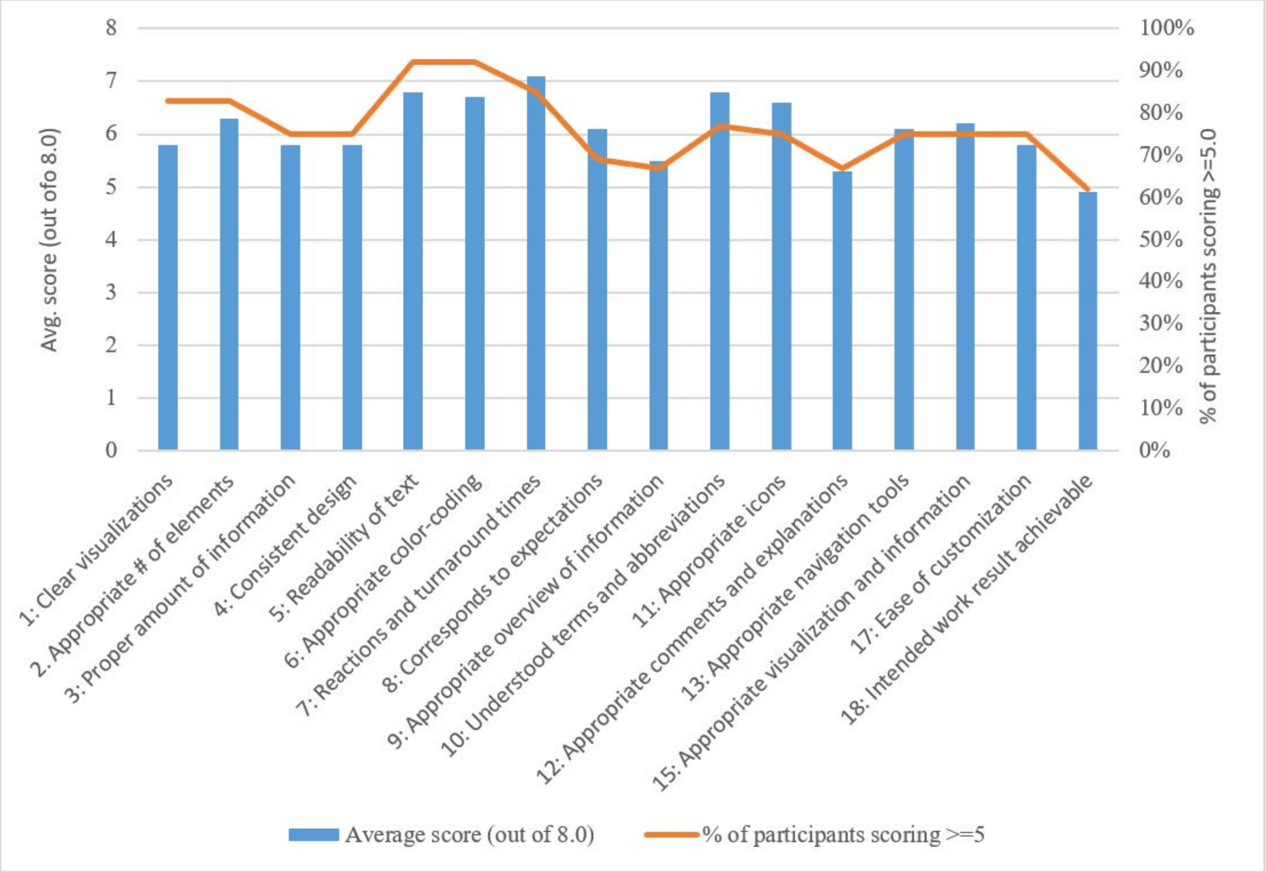
The lowest performing items pertained to the interface's output. Item 18 (effect of incorrect inputs on intended work results) and item 12 (comments and explanations) scored an average of 4.9 and 5.3, respectively. It is noteworthy that every item, including the aforementioned ones with the lowest scores, scored in the "positive" range. The results for all the items on the questionnaire are shown in Table 2 and Figure 2. The sums of scores from each participant were also calculated. The average score was 109; the median score was 111.5; and scores ranged from 57-142.

Table 2. Results by items in the usability questionnaire.

Items	Scores on 8-point Likert scale		Responses from participants (N=12) with scores ≥5 on Likert scale, n (%)
	Mean	Median	
Suitability for the task			
Clear visualizations (item 1)	5.8	6.0	10 (83)
Appropriate number of elements (item 2)	6.3	7.0	10 (83)
Proper amount of information (item 3)	5.8	6.0	9 (75)
Conformity with user expectations			
Consistent design (item 4)	5.8	7.0	9 (75)
Readability of text (item 5)	6.8	7.0	11 (92)
Appropriate color-coding (item 6)	6.7	7.0	11 (92)
Reactions and turnaround times (item 7)	7.1	8.0	11 (92)
Corresponds to expectations (item 8)	6.1	7.0	9 (75)
Self-descriptiveness			
Appropriate overview of information (item 9)	5.5	6.0	8 (67)
Understood terms and abbreviations (item 10)	6.8	7.5	10 (83)
Appropriate icons (item 11)	6.6	8.0	9 (75)
Appropriate comments and explanations (item 12)	5.3	5.0	8 (67)
Controllability			
Appropriate navigation tools (item 13)	6.1	7.0	9 (75)
Undo single steps (item 14)	N/A[a]	N/A	N/A
Appropriate visualization of information (item 15)	6.0	6.0	9 (75)
Suitability for individualization			
Undo single steps (item 16)	N/A	N/A	N/A
Ease of customization (item 17)	5.8	7.0	9 (75)
Error tolerance			
Intended work result achievable (item 18)	4.9	5.0	8 (62)

[a] N/A: not applicable.

Figure 2. Results by items in the usability questionnaire.



Discussion

Principal Results

This study tested the usability of a graphical interface in displaying health data from patients' smartwatches for integration with EHRs; we found that 14 of the 16 categories received above neutral/average scores from the majority of participants. Health care professionals were particularly satisfied with readability of the text and the interface's speedy response times. Improvements to the interface should prioritize allowing participants more control over data for better customization as per specific user needs. Results from this usability study support the findings from our qualitative interviews [3] as well as other studies in which health care professionals trusted health data from smartwatches and believed those would be helpful in clinical decision making [19]. Previous studies found that health care providers believed that wearable devices could improve health [20] and recommended health data from smartwatches to be incorporated into the convenient and secure environment of EHR systems [3]. Our qualitative study [3] also found that each medical specialty required different types of data and applied those data to different uses. This usability test demonstrated that the interface can satisfy a wide range of user needs. In regard to data visualization, the colors and charts recommended by health care professionals were chosen from differing layouts. The line graph depiction was proven to be the most effective, as it allowed participants to track longitudinal data easily.

Recommendations for Interface Integration

Although we received positive responses on the interface from participants in our sample, further testing is required to simulate the environment of health care professionals' typical workflow. We achieved an average aggregate score of 109 from the questionnaire (omitting 2 items). This score is higher than the one reported by another study evaluating a web-based platform (105.8) [18]. Considering these results, an iterative approach will be taken in which the interface will be improved incrementally until a satisfactory threshold for each item is achieved, and aggregate scores improve [21]. Once the interface is finalized, pilot tests will be conducted in clinical settings to ensure that health data from smartwatches are effectively integrated with EHRs, enhancing the way health care professionals utilize data. These pilot tests will determine the true utility of the interface and integrated data. This adoption process is similar to that of EHRs when they were introduced. Although cognitive task analysis was used to reveal how physicians used electronic medical records [14], successful integration of health information technology into the clinical workflow was only achieved when the benefits and barriers of implementation were considered [22]. The EHR system has become an essential vehicle for advancing quality of care [23]. Therefore, it is imperative to ensure that incorporating health data from smartwatches does not disrupt how EHRs are currently utilized but instead modernizes the technology by using the additional data to support clinical decisions and improve care.

Limitations

Our study had a small sample size and included health care professionals who volunteered to participate. Therefore, results cannot be generalized and may not reflect the opinions of other health care professionals. In addition, participants may have been primed by their exposure to preliminary versions of data charts in the prior qualitative study. Seeing visual elements for a second time that were included in the graphical interface may have positively influenced their perceptions. Although we used mock data, the evaluation was conducted in a test environment; therefore, results may differ if the interface was used during regular clinical workflows. Similarly, in clinical settings, providers may consider the issue of liability in which they may be assumed to be knowledgeable and responsible for the data, which may alter their evaluation of the graphical interface.

Conclusions

Incorporating health data from smartwatches into EHRs may benefit patient care, but it is important to consider the way in which data are presented to and visualized by health care professionals. Partnering with key stakeholders (health care professionals), who will be the main users of the interface is essential to developing a practical and valuable platform.

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Conflicts of Interest

None declared.

Multimedia Appendix 1
Usability study questionnaire along with the omitted questions.
[DOCX File , 18 KB - humanfactors_v7i4e19769_app1.docx]

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Abbreviations

EHR: electronic health record
ISO: International Organization for Standardization

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Original Paper

Health Care Staff's Experiences of Engagement When Introducing a Digital Decision Support System for Wound Management: Qualitative Study

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Abstract

Background: eHealth solutions such as digital decision support systems (DDSSs) have the potential to assist collaboration between health care staff to improve matters for specific patient groups. Patients with hard-to-heal ulcers have long healing times because of a lack of guidelines for structured diagnosis, treatment, and follow-up. Multidisciplinary collaboration in wound management teams is essential. A DDSS could offer a way of aiding improvement within wound management. The introduction of eHealth solutions into health care is complicated, and the engagement of the staff seems crucial. Factors influencing and affecting engagement need to be understood and considered for the introduction of a DDSS to succeed.

Objective: This study aims to describe health care staff's experiences of engagement and barriers to and influencers of engagement when introducing a DDSS for wound management.

Methods: This study uses a qualitative approach. Interviews were conducted with 11 health care staff within primary (n=4), community (n=6), and specialist (n=1) care during the start-up of the introduction of a DDSS for wound management. The interviews focused on the staff's experiences of engagement. Content analysis by Burnard was used in the data analysis process.

Results: A total of 4 categories emerged describing the participants' experiences of engagement: *a personal liaison*, *a professional commitment*, *an extended togetherness*, and *an awareness and understanding of the circumstances*.

Conclusions: This study identifies barriers to and influencers of engagement, reinforcing that staff experience engagement through feeling a personal liaison and a professional commitment to make things better for their patients. In addition, engagement is nourished by sharing with coworkers and by active support and understanding from leadership.

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KEYWORDS

decision support systems, clinical; eHealth; staff engagement; leg ulcer; telemedicine; mobile phone

Introduction

Background

Most patients with hard-to-heal ulcers, defined as ulcers that take more than 4 weeks to heal [1], are older adults and have multiple diseases [2]. Unfortunately, many patients with such ulcers are treated without diagnosis and receive suboptimal treatment, thus prolonging healing time [3]. The lack of national guidelines, decision support systems, and structural organization for this patient group is common in Sweden, making wound management difficult for patients and staff. Wound management is carried out by different caregivers within different medical specialties, and a multidisciplinary team of professionals is often necessary to establish the ulcer etiology and to provide diagnosis [4] and treatment. In Sweden, most patients with hard-to-heal ulcers have their continuous treatment in primary and community care [3], where nurses and physicians need to cooperate in wound management teams. The assigned nurse meets the patient approximately twice a week for ulcer treatment and dressing changes. The physician meets the patient for diagnosis and for the decision of referral to other clinical specialties such as vascular intervention. The assigned nurse is often responsible for the continuity of care and initiates contact with the physician when needed. Patients with hard-to-heal ulcers are generally diagnosed through in-person assessment, but a few studies have discussed the advantages of using eHealth solutions in wound management [5]. For this patient group, eHealth is expected to enable medical investigation and treatment for healing already in the home environment, to reduce transportations to different caregivers, and to minimize hospitalization [5,6].

eHealth solutions have been introduced in health care in recent years to increase accessibility and facilitate diagnosis and care [5,7]. eHealth is defined as the use of information and communication technologies for health [8] and includes various forms of digital transmission of imaging and clinical data. Digital decision support systems (DDSSs) are a type of eHealth solution designed for clinical decisions and medical education [9] and for facilitating a multidisciplinary working environment and quality-assured guidance [10,11]. Few studies have focused on health care staff's engagement and barriers to and influencers of engagement during the introduction of eHealth interventions such as DDSSs, although the aspects of engagement are often described as crucial for the introduction and implementation [12,13] of new ways of working.

Some of the existing literature defines engagement as a psychological process relating to user experiences and perceptions, whereas other literature defines engagement only as intervention usage [12-14]. This discrepancy can be explained by the different disciplines involved in the interventions: medical, social, psychological, or technological [15]. An expanded definition of engagement with eHealth interventions might include the extent of usage (eg, amount, frequency, duration, and depth) and the subjective experience characterized by attention, interest, and enjoyment [13]. More narrow descriptions of engagement involve active support for a project [16] or when an employee is enthusiastic about their work and takes a positive initiative to promote the organization's interests. To sum up, the process of engagement is a multidimensional experience characterized by cognitive, emotional, and behavioral dimensions [17]. In this context, engagement is conceptualized by health care staff's expressions of experience, not frequency of usage. Attempts to understand engagement in new ways of working within health care are also made more difficult, as engagement is often described only from the patient perspective [17,18]. Very few studies describe health care staff's engagement in eHealth interventions, and all these consider the perspective of one specific profession [19,20]. It is therefore of interest to take a broader perspective and investigate the engagement of several different types of health care staff: physicians, nurses, and assistant nurses, all of whom are part of a wound management team in primary, community, or specialist care. Methods to measure and evaluate engagement vary greatly but include interviews, self-report questionnaires, verbal reports, automatic recordings of use, and recordings of psychophysical manifestations [12,15].

There are indications that the introduction and implementation of new eHealth solutions into everyday work practice is complicated [21], and only a few such solutions have become useful in clinical practice. One explanation for this may be that eHealth solutions are not always harmonized with the specific context in which they are to be implemented, including the prevailing organizational cultures, values, and routines [6]. Nurses associate the introduction of eHealth in homecare with the risk of deprofessionalization [22], and studies have also described a fear that if the new technology lacks sufficient usability, mistakes might occur that endanger patient safety [23]. The importance of leadership [21,24] and a shared vision with coworkers [24,25] have been pointed out as influencing factors for successful implementation. Studies highlight that unless users are involved in the design process of an eHealth solution [7,26], the implementation process will be ineffective. Lack of time within daily clinical routines is also described as a barrier in the implementation process [21]. All the aforementioned barriers and influencers might also affect staff engagement and thereby complicate implementation further. To implement new working processes such as eHealth solutions, it is essential to gain knowledge concerning staff's experiences of engagement and to create conditions for long-term engagement.

Objectives

The aim of this study is to describe health care staff experiences of engagement and barriers to and influencers of engagement when introducing a DDSS for wound management.

Methods

Study Design

A qualitative interview design was selected to describe the health care staff's experiences of engagement. The study followed the guidelines presented in the COREQ (Consolidated Criteria for Reporting Qualitative Research) framework [27].

Setting

Launched in 2009, the Swedish National Quality Registry of Ulcer Treatment (RUT) is a tool for clinical assessment of hard-to-heal ulcers [28]. In collaboration with a technology company, it has developed a DDSS, known as Dermicus Wound (Multimedia Appendix 1), to help wound management teams in primary, community, and specialist care establish collaboration for ulcer diagnosis and treatment. The DDSS offers easily downloadable mobile apps for bedside automatic transmission of mandatory data to the RUT and to a platform for multidisciplinary consultation with the ability to share medical information and photographs in wound management teams. The DDSS is designed to be used when a nurse or assistant nurse meets a patient with a hard-to-heal ulcer for the first time. The standardized data for ulcer diagnosis, such as age, gender, smoking habits, ulcer duration, ulcer size, ulcer pain, ankle-brachial index, comorbidities, and photographs of the ulcer and dressing materials, are collected by the nurse or assistant nurse and transmitted from the app to a platform. An email is sent, as an alert, to a chosen connected participant within the nurse's wound management team that a new case has been received. The connected participant can then enter the platform to assess the data and photographs and recommend treatment strategies to the submitting staff. The wound management team can also invite external consultants to advise on especially complex patient cases. The DDSS is designed to delete all data and photographs from the app following transmission to the platform. The DDSS is Conformité Européenne certified according to medical devices class I (D3.0-112015) and compliant with health care regulations and the General Data Protection Regulation. It is compatible with the iPhone with the standard touch screen user interface and camera installed and with standard web browsers.

The DDSS was launched on RUT's website during an annual user meeting for registrars. In total, 65 health care staff from primary, community, and specialist care agreed to test the DDSS for 6 months. All participants were invited to participate in this interview study, and 11 agreed.

Participants

All the participants (n=11) frequently treated patients with hard-to-heal ulcers. Their workplaces had a wide geographical spread from southern to northern Sweden, including both urban and rural areas. Some of the participants had a managerial position or worked as coordinators for wound management. The participants working in primary care (n=4) were 2 general practitioners (1 female and 1 male) and 2 female nurses. The participants working in community care (n=6) were 3 female nurses, 2 male nurses, and 1 female assistant nurse. The final participant was a female assistant nurse who worked in a specialist clinic (n=1). Thus, 8 participants were females and 3 were males. The technology company demonstrated the DDSS to the participants before testing, but no further organized training was provided. All participants were given the same information and technical support, and the DDSS was free to use during the test period of 2018 to 2019. Before the interviews were conducted, the participants were informed orally and in writing about the study, confidentiality, and voluntary nature of participation. All participants provided signed consent. The Ethical Advisory Board in South East Sweden reviewed the project (ref: 506-2018).

Data Collection

The participants used the DDSS over a testing period of 6 months and underwent an individual semistructured telephone interview based on questions about their engagement in the introduction of the DDSS. The interviews were conducted within the first month of the introduction and were carried out between October 2018 and May 2019. An interview guide was used. The questions were open and started with a general question about the concept of engagement: "What do you think of when you hear the word 'engagement' in relation to changes in work processes?" The following questions were about the participants' individual engagement in relation to the DDSS, for example: "How do you experience your engagement in the DDSS?" with supporting questions, such as, "Can you elaborate?" and "Can you tell me more about this?" The interviews lasted between 29 and 48 min and were recorded and transcribed verbatim. The interviews were led by 1 of the 3 moderators: HW, HT, and CF. HW works as a physician at a wound healing center for patients with hard-to-heal ulcers, whereas HT and CF are conducting ongoing research within the engagement process, which constitutes their preunderstanding.

Data Analysis

The data were analyzed according to the Burnard method for qualitative content analysis [29,30]. The content analysis was performed in an inductive manner [31]. The recorded interviews were listened to at least four times each. The moderators read the transcribed interviews and field notes individually. With the aim of the study in mind, notes were written down in the margin of the interview text and field notes. These notes were distributed among the moderators. The text was divided into units of meaning comprising sentences and paragraphs and then condensed while preserving their core. Codes were identified in the condensed text; these were compared with the original transcribed texts and field notes to ascertain whether the context was maintained by the codes. The codes were put into a matrix and then compared and ordered into subcategories. Similar subcategories were combined into categories. To increase validity, the 3 moderators analyzed the text separately and then compared and discussed their listed units of meaning, codes, subcategories, and categories. The moderators re-read the transcribed interviews to ensure that the categories and subcategories reflected what had been said in the interviews [29].

Results

Overview

A total of 4 categories emerged from the analysis, reflecting these health care staff's experiences of engagement when introducing a DDSS for wound management: *a personal liaison*, *a professional commitment*, *an extended togetherness*, and *an awareness and understanding of the circumstances*. Each category had 2 subcategories (Textbox 1).

Textbox 1. Categories and subcategories based on the participants' experiences of engagement.

- A personal liaison:
  - Being vigorous and passionate
  - Seeking new knowledge and self-development
- A professional commitment:
  - Making things better for a neglected patient group and for society
  - Striving for safe and structured care
- An extended togetherness:
  - Anchoring with coworkers and patients
  - Connecting through support and inspiration
- An awareness and understanding of the circumstances:
  - Being directed by a supportive leadership
  - Considering time and timing

A Personal Liaison

The first category, *a personal liaison*, reflected how the participants expressed engagement as a constituent of their personality and their seeking for self-development via new knowledge. The basis for engagement came from themselves and their own personal attitudes, hopes, and driving forces. The personal liaison seemed to be essential for a successful implementation and relied on positive attitudes toward future improvements together with continuous seeking for improved skills. Feeling and having a personal liaison with the intervention was described as a positive influencer of staff engagement.

Being Vigorous and Passionate

When asked what engagement meant to them, the participants highlighted their underlying personalities and described themselves as vigorous, passionate, driven, and enthusiastic about future changes. This was affirmed in terms of a personal liaison. The participants described their strong capacity to initiate work changes and stated that a vigorous personality was a positive influencing factor for engagement:

> *If I think something is good, I don't think I'll let anything stop me.* [Participant 6]

The participants expressed engagement in positive terms, saying that they were excited about and looked forward to the challenge of staying up to date with technology and modern treatment methods. They experienced increased engagement when personally taking part in the development of a new eHealth solution and were excited to evaluate how it could be used within health care. The participants' engagement was also influenced by whether or not they were personally affected in the introduction of a new working method, for example, if the new work tool facilitated their work and gave them a direct personal gain or if they just used the DDSS in passing.

Seeking New Knowledge and Self-development

In addition to describing themselves as having a vigorous and passionate personality, the participants stated that they were engaged by the quest to acquire new knowledge, giving them a chance for enhanced competence and confidence within a specific area. Engaging in seeking new knowledge through life was a way of self-development for their own sake and for their own self-esteem. An interest in seeking new knowledge produced and nourished the personal liaison of engagement:

> *I saw it as a huge opportunity, both for myself and for the workplace, to ... to, like, develop in this, both for my own part, like, for myself, just because I think it's ... I think it's fun to gain new knowledge and to get better at things and so on.* [Participant 11]

The pursuit and wish for new knowledge were expressed as fundamental for engagement in work changes. The participants described a need for increased competence and education in wound management and believed that the DDSS would help with this. The participants described how responses from a coworker or consultant on the shared digital platform increased their own skills and knowledge of how to handle similar cases themselves. Evidence-based knowledge was mentioned as desirable and as a strong, engaging factor. The fact that a national quality registry was backing the DDSS gave confidence and an assurance of evidence-based and quality-based knowledge.

A Professional Commitment

The second category covered experiences of *a professional commitment* emerging as a positive influencing factor for the participants' engagement. The participants experienced that the reason and power to become engaged in the DDSS came from their professional commitment to do good for their patients, as the patients were the core value for doing anything. This, in turn, emanated from an obvious need for safe and structured medical care for this specific underprioritized patient group.

Making Things Better for a Neglected Patient Group and for Society

The participants described patients with hard-to-heal ulcers as being neglected and not prioritized in health care. They spoke about a lack of continuity and quality, and this obvious medical need positively influenced engagement in the introduction of the DDSS:

> *If you see an area where an improvement is needed, where there's developmental work that needs to be done. That's something that fosters engagement.* [Participant 1]

The participants felt that a prerequisite for engagement was the belief that the DDSS was directly beneficial to their patients. For them, the most important issue was to make things better for the patients, and this was why they would engage. The participants supposed that the DDSS could lead to reduced suffering, faster healing times, and fewer transportations for patients with hard-to-heal ulcers. The participants were engaged by the expectation of being able to provide better service and equal health care to the patients regardless of where they lived, that is, the patients could be treated at home, especially patients living in the countryside far from health care. Another factor positively affecting their engagement was the ability to use eHealth to avoid exposing patients to unnecessary examinations and surgeries, referring to the possibility of dismissing suspicions of malignancy in the ulcer by having a photograph assessed. The participants received encouraging responses from pleased patients and patients' relatives, which was interpreted as an acknowledgment of better care; this again positively affected engagement. Conversely, if patients were unwilling to use the DDSS, this would directly impose a barrier to continued engagement and then they would have to find other ways to aid improvement.

Additionally included in this subcategory were factors such as participants' engagement in doing good for society and in saving taxpayers' money by becoming more efficient in wound management. Nevertheless, in the first place, engagement was described as increasing due to the professional commitment to make things better for the individual patient and to make this patient group and its medical need more visible:

> *I'm not providing care to some financial system or a budget or something like that—it's supposed to benefit an individual person who is ill.* [Participant 8]

Striving for Safe and Structured Care

The participants described the current wound management as unstructured and unsafe. One part of the participants' professional commitment was to give patients with hard-to-heal ulcers a clear structure in their medical care; this target initiated their engagement. The participants were engaged by a belief that the DDSS could provide structure in the organization and secure new ways of communication to improve efficiency. They expressed that the DDSS could gather and organize a few involved nurses and physicians in local wound management teams for diagnosis and treatment with continuity, thereby increasing the quality of care:

> *Fundamentally, I guess it's about getting a structure and, like, building up a good wound healing clinic here at our primary health care centre.* [Participant 4]

The participants also mentioned technical safety and usability as influencing factors of engagement. They pointed out that the DDSS had an uncomplicated and well-known technology that created a safer structure in clinical praxis. The fact that clinically active staff were involved in designing the DDSS and adapting it to clinical reality created engagement and security. The participants experienced that their engagement was positively influenced by the possibility of using a technically secure way of communicating with other caregivers:

> *If we can find a system in which I can securely transfer information to a colleague in another organization, that would be fantastic.* [Participant 8]

Technical difficulties were mentioned, such as the lack of a spellchecker, sufficient space on the smartphones, immediate access to the patients' medical records, and compatibility with Android technology. Other technical problems included disruption and double documentation. These technical obstacles were described as risk factors for patient safety and hence as barriers to engagement, as protecting patients from risks was a part of the professional commitment.

An Extended Togetherness

The third category, *an extended togetherness*, described how the interaction between and within the wound management teams, with patients, other coworkers, external consultants, and the project team was essential for participants' engagement when introducing the DDSS. A feeling of togetherness around the patients increased and spread engagement, like a fabric for collaboration, and was a prerequisite for using the DDSS.

Anchoring With Coworkers and Patients

In order for the participants to maintain engagement with and enthusiasm for the DDSS, it was necessary for many coworkers and even patients to be engaged. Another prerequisite for engagement was a broad anchoring and encouragement within the participants' own group of coworkers. Support from coworkers was described in terms of positive traction, being grateful not to be alone, and having a feeling of togetherness. The participants expressed a wish that more coworkers felt the same engagement and said it was important to convince everyone that this new work process offered a chance for all of them to achieve progress in wound management. For example, the participants described how if a nurse did not have medical support from a physician, the nurse found it difficult to dare to try the DDSS. However, when there was medical support from a physician, the nurse felt safe in collaborating, and everything went well. In addition, participants who responded on the platform expressed great engagement in delivering answers promptly:

> *I feel a lot of engagement—it's like I want to respond if they write questions, because I see a great benefit there.* [Participant 3]

The participants expressed that they could support each other within the team; if one person's engagement decreased, someone else could bring up engagement again. If coworkers opposed and questioned continuously, that would be a barrier to engagement:

> *If you don't have the working team with you, if you feel like you're being obstructed, those can be the kinds of things that counteract your engagement.* [Participant 9]

Another engaging factor was the opportunity to make patients more involved and engaged in their own treatment because of the possibility of visually following the healing process in the DDSS. The participants highlighted that when introducing new tools, health care staff and patients must interact, creating togetherness.

Connecting Through Support and Inspiration

The participants experienced that support from external consultants and inspiration from the project team positively influenced engagement. They felt engaged by the opportunity to be connected to a specialist in wound management, to get feedback on their work, and to get support when assessing diagnoses and providing the best treatment. Stress and frustration were described to be reduced by knowing that there was someone to consult, who could give support and direct the participants toward the right clinical decision. Cooperation across the boundaries of different caregivers was described as an existing obstacle in Swedish health care, despite being a necessity for this patient group. The participants expressed hope that the DDSS would bridge this gap, create new connections, and extend engagement to other clinics. This expectation of extended interaction and togetherness around the patients fostered further engagement. A user meeting for health care staff registering in the RUT, conducted before the start of the DDSS introduction, was expressed to positively influence engagement and give inspiration, connecting participants into a network where engagement was shared. Meeting the project team face-to-face on this occasion facilitated efficient digital support during the introduction:

> *They gave a lot and in some way that increased the engagement that was already there, or, like, you felt that no, but ... that you ... that you were a bit more inspired to get going.* [Participant 4]

An Awareness and Understanding of the Circumstances

The final category covered considering factors for engagement, such as the leadership's *awareness and understanding* of what environmental and contextual resources were needed for a successful introduction of the DDSS. Lack of working time, lack of resources, and the timing of the introduction were potential barriers to participants' engagement.

Being Directed by a Supportive Leadership

Leadership awareness and understanding of the introduction colored and influenced the participants' engagement. The participants considered it important for the leadership in their own organization to be supportive, enthusiastic, and willing to arrange technical resources:

> *The manager, she's very positive about this as well, and of course that makes it easier when you're doing something that involves the entire team and so on.* [Participant 10]

One manager brought 3 smartphones to the wound management team at the beginning of the DDSS introduction; this made the participants feel that introducing this working tool was highly prioritized and important, which positively influenced engagement. Conversely, when the leadership showed no understanding of what resources were required to make the DDSS available, the participants' engagement was negatively influenced. The participants expressed that leadership should show confidence in the ability of engaged employees to plan and run the introduction of new eHealth solutions. The participants experienced a negative impact on engagement if the idea of introducing eHealth solutions was top to bottom:

> *It can come from the top, from the administration ... where we don't really, like, see the needs, and then it won't be something ... that also counteracts the engagement.* [Participant 2]

Considering Time and Timing

The lack of working time and timing were disadvantageous circumstances for participants' engagement when introducing the DDSS:

> *One thing that counteracts engagement, is the lack of time, that ... this compassion and participation ... can fail because you don't have the time to do things in the way that you would always like to.* [Participant 5]

Time was described as crucial for engagement. The lack of working time was experienced as a barrier to engagement and thus described as a source of stress and frustration. In addition, the DDSS itself could be time consuming, which negatively affected engagement. A stressful working environment meant that the participants could not always prioritize using the DDSS, although they recognized that a system like this would have been most valuable for the patients. The participants expressed hope that in the long run, the DDSS would generate faster and more effective consultation, thereby saving time. The timing of the introduction also influenced engagement. If the introduction took place during stressful circumstances, engagement decreased, but if the DDSS was introduced in a more structured and calmer period, engagement increased. During summertime or relocation, it was difficult and impracticable to introduce new working processes because of fewer employees and a heavier workload.

Discussion

Principal Findings

The participants in this study described barriers to and influencers of engagement in the introduction of a DDSS, resulting in 4 categories: *a personal liaison*, *a professional commitment*, *an extended togetherness*, and *an awareness and understanding of the circumstances*. The principal findings are that engagement arises when health care staff do something meaningful for themselves and their self-development, in combination with the professional commitment to improve things for this patient group. In addition, the staff need to feel togetherness with their surroundings (ie, the wound healing team, coworkers, and patients) and to have support and understanding from leadership regarding the resources needed, such as extra working time, timing, and equipment. These aspects of the staff's experiences of engagement in the introduction of a DDSS for wound management can provide guidance when building and introducing future eHealth solutions in health care.

The participants experienced engagement as a personal liaison, describing themselves as having a vigorous and passionate personality that formed the basis for engagement in new working processes. The influence of personal factors such as optimism and self-efficacy on engagement has been previously shown in a literature review of nurses' work engagement [20]. Furthermore, the participants experienced that the personal liaison was built upon their own interest in becoming better, striving for new knowledge and skills within a specific medical field. This is in line with a systematic review conceptualizing one part of engagement to be a subjective experience based on the individuals' attention, interest, and affect [13]. The same systematic review [13] described personal relevance and expectations as influencers of engagement, which could also be seen in this study. The participants perceived that the DDSS applied to their individual situation when treating patients with hard-to-heal ulcers, and this personal relevance positively influenced engagement. The expectation that the DDSS could make things better for their patients was emphasized as a prerequisite for engagement. Thus, what engaged the participants goes hand in hand with the aim of introducing DDSS into health care, that is, to promote medical education and improve clinical skills [6,9]. Hence, a DDSS needs to catch health care staff's personal interest and attention and contribute to improved skills and knowledge to make them engaged.

Patients with hard-to-heal ulcers constitute an older adult and fragile patient group. The present results clearly show that the benefits of introducing eHealth to this patient group were obvious and engaging for the participants. According to an earlier comprehensive Swedish government review, the staff strive for increased structure in wound management organizations [2], which seems to be in line with what made the health care staff in this study engaged in the DDSS. The participants expressed engagement by providing structured and patient-safe treatment in the patients' home environment, which was possible to do when using the DDSS. Studies have shown that older adults and chronically diseased patients themselves can see the potential of eHealth to help them continue living in their own homes [32,33], and this is in accordance with what made the health care staff in this study engaged in being able to offer. The participants experienced engagement and confidence in the DDSS if their patients were pleased; in contrast, they said that if patients expressed dissatisfaction with the DDSS, then this would negatively influence their engagement. One study found that physician engagement decreased because they believed that the use of a bedside DDSS was seen as unprofessional by patients [34]. The patients, on the other hand, perceived the use of a bedside DDSS as positive, signaling confidence and competence [34]. Patients' positive views of eHealth solutions derive from their feeling that these solutions allow the staff to gain knowledge and expertise [18,20], and, clearly, patients' opinions color staff engagement.

An earlier study described the importance of DDSS being adapted to both local and national guidelines, showing that this influenced engagement when physicians tried a DDSS in clinical praxis [34]. The participants in our study did not express any fears that the DDSS might be unsuitable or incompatible with any guidelines or the context; instead, they felt safe using it for the actual patient group. This is in contrast to previous findings where nurses felt afraid of losing context [6] or had feelings of deprofessionalization [22] when introducing eHealth tools.

Technical problems were reported as barriers to engagement. This is in accordance with findings from other studies on introducing eHealth solutions in health care [13,34]. The DDSS in this study used a well-known technical system that was easy to use, which seemed to balance this out to some extent, but there was still a risk of disengagement. The fact that clinically active staff and the quality registry were involved in designing the DDSS provided participants with assurances of safety, increasing engagement. This is in agreement with earlier findings that users' confidence increased if they had been involved in the development of the eHealth solution [7,26] and a study where staff described it as important for decision support systems to offer a sense of professional security [35]. Technical support by the project team was provided in an efficient way, which positively influenced participants' engagement. This is consistent with another study where the lack of technical support was described as a major barrier to engagement with technology solutions in health care [34].

The togetherness within the team, with other coworkers, and with patients seemed to be crucial for participants' engagement. It was essential to feel part of a supportive and encouraging environment where engagement could spread, bringing teams together, which, in turn, nourished further engagement. The participants strived for and desired to extend engagement to other clinics for broader collaboration. This togetherness decreased the feeling of loneliness and positively influenced participant engagement, as shown earlier in a systematic review of engagement in digital behavior change interventions [13]. Another literature review [20] also found that feeling part of a community and having social support increased nurses' engagement in work. Between the lines, there was a desire to feel affirmation, acceptance, and togetherness from others, that what they do is good. Hard-to-heal ulcers require the participation of physicians, nurses, and assistant nurses, and the inclusion of all these actors in the DDSS enables necessary collaboration and creates togetherness, which positively influences engagement. The importance of multidisciplinary collaboration has been described in a systematic literature review of treating chronic wounds by using decision support systems [36]. This review pointed out that most existing systems were built to meet the needs of nurses or physicians separately, which would be contrary to multidisciplinary collaboration [36]. There is a need for future studies focusing on the interaction between staff and its importance for engagement.

The staff in this study described how distinct and supportive leadership positively influenced engagement. Many previous studies have highlighted and confirmed the importance of leadership for successful eHealth implementation [20,21,24,37]. One key to the successful introduction of new working processes might be the leadership's ability to create conditions where staff engagement can thrive and persist. The participants expressed it as important for leadership to provide resources, especially working time, but also to plan the timing of the introduction and ensure that the necessary equipment was purchased. The fact that resources are required for engagement has been shown in studies of engagement in organizational improvements [38] and in digital behavior change interventions [13]. The most frequently described resource is working time, and many earlier studies have shown this to be important for engagement and implementation [6,21,34,37]. However, most important for the participants in this study was that the leadership showed an understanding of the new working process as well as confidence in allowing the engaged staff to lead the introduction. Many studies have highlighted time [6,21,34,37] and leadership [20,21,24,37], indicating that these 2 parameters are crucial for both engagement and introduction; they constitute basic premises that must be functioning and assured before the introduction. However, the apparent importance of this may also be because there are limited studies of other factors influencing engagement. The focus of studies on the successful introduction of eHealth in health care might need to be broadened, including personal and professional factors affecting staff engagement and their significance, in addition to resources, support, and understanding from the surroundings.

Methodological Considerations and Limitations

The data were presented objectively, as none of the moderators were involved in using or launching the DDSS, thus assuring confirmability. Concerning credibility, the moderators listened to and read all the interviews to ensure that no relevant data had been excluded. To ensure dependability, memos were used to track changes in the coding decisions and hence keep track of recoding and relabeling. The participants were representative of wound management, with all different disciplines involved, and with a vast geographical spread throughout Sweden, making the results transferable. The participants were both female and male. All participants received similar information about the interviews. The interviews were conducted in real time during the introduction, instead of afterward, which is another strength of the study. The fact that the participants volunteered to participate in the study is a limitation, as the staff who did not volunteer may have been those who were not engaged in the DDSS. Finally, the experiences of engagement belong to the participants themselves and hence can only to a certain extent be compared with other research.

Conclusions

This study contributes to the awareness of aspects that need to be considered in relation to engagement when introducing a DDSS for wound management. The findings indicated that staff experience engagement through feeling a personal liaison and a professional commitment to make things better for patients with hard-to-heal ulcers. In addition, their engagement needed nourishment by sharing with coworkers and by active support and understanding from leadership. Future research needs to explore potential obstacles to long-term engagement, as this study only included the time of introduction.

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Authors' Contributions

CF, HT, HW, and RÖ conceptualized and designed the study; HW, CF, and HT collected and analyzed the data; HW drafted the manuscript; and all authors (HW, HT, RÖ, PM, and CF) provided critical revisions of the text. All authors have read and approved the final submitted version.

Conflicts of Interest

None declared.

Multimedia Appendix 1
A photograph of the digital decision support system, the Dermicus Wound.
[PNG File , 2444 KB - humanfactors_v7i4e23188_app1.png]

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Abbreviations

COREQ: Consolidated Criteria for Reporting Qualitative Research
DDSS: digital decision support system
RUT: Registry of Ulcer Treatment

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Original Paper

Health Care Professionals' Experience of a Digital Tool for Patient Exchange, Anamnesis, and Triage in Primary Care: Qualitative Study

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Abstract

Background: Despite a growing body of knowledge about eHealth innovations, there is still limited understanding of the implementation of such tools in everyday primary care.

Objective: The objective of our study was to describe health care staff's experience with a digital communication system intended for patient-staff encounters via a digital route in primary care.

Methods: In this qualitative study we conducted 21 individual interviews with staff at 5 primary care centers in Sweden that had used a digital communication system for 6 months. The interviews were guided by narrative queries, transcribed verbatim, and subjected to content analysis.

Results: While the digital communication system was easy to grasp, it was nevertheless complex to use, affecting both staffing and routines for communicating with patients, and documenting contacts. Templates strengthened equivalent procedures for patients but dictated a certain level of health and digital literacy for accuracy. Although patients expected a chat to be synchronous, asynchronous communication was extended over time. The system for digital communication benefited assessments and enabled more efficient use of resources, such as staff. On the other hand, telephone contact was faster and better for certain purposes, especially when the patient's voice itself provided data. However, many primary care patients, particularly younger ones, expected digital routes for contact. To match preferences for communicating to a place and time that suited patients was significant; staff were willing to accept some nuisance from a suboptimal service—at least for a while—if it procured patient satisfaction. A team effort, including engaged managers, scaffolded the implementation process, whereas being subjected to a trial without likely success erected barriers.

Conclusions: A digital communication system introduced in regular primary care involved complexity beyond merely learning how to manage the tool. Rather, it affected routines and required that both the team and the context were addressed. Further knowledge is needed about what factors facilitate implementation, and how. This study suggested including ethical perspectives on eHealth tools, providing an important but novel aspect of implementation.

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KEYWORDS

communication; content analysis; eHealth; telemedicine; digital technology; interviews; primary health care; qualitative research

Introduction

Background

In many countries, primary care providers struggle to meet the needs and demands of increasing numbers of patients seeking their services [1]. In this case, primary care implies the entry point or opening contact with health care, provided by outpatient services located within the community but organized by the regional or a private health care organization. Lack of access to such care can have a negative impact on both individuals and populations; thus, there is a need for more effective routes to supply frontline health services to large and diverse populations [2].

During the last decade, several innovations for online communication with health care providers have emerged, such as video links, text messaging, email, and web-based portals. Despite progress, evidence for the benefits of introducing digital patient-professional communication within primary care is incomplete [3]. For example, although digital communication seems to enhance patient satisfaction, data about the impact on health outcomes are limited, and there is no consensus about the optimal design of digital communication services [3]. A systematic review of e-consultations in primary care identified 5 themes: patient access, patient outcomes, workforce issues, governance and safety, and willingness to adopt and sustain the service [4]. Nevertheless, the implementation process of eHealth innovations has attracted limited attention, despite its importance for progress [5]. Further attention should thus include end-user perspectives: a progression toward efficient services includes advancing technological innovations that facilitate patients, health care professionals, and organizations [6,7].

Within Swedish health care, the initial provision of digital primary care services by for-profit companies commenced a few years ago [8], although lately access to digital services through regular primary care providers has been increasing. Swedish health care is heavily decentralized, and thus mainly organized independently by the 21 regions of the nation. Currently, several regions are trialing digital services in primary care; one of these is Flow, a Swedish commercial digital communication service [9]. In 2019, a typical region tested the system, advertising it to patients through the general health care website or standard telephone service of their regular primary care provider as an alternative to applying for a consultation with the triage nurse via telephone. When choosing the pilot digital communication route, the patients received access via a link, identifying themselves via secure electronic personal identification.

Once patients had registered with the system, they were asked structured questions about the reason for the contact (equivalent to matter or issue), composing an anamnesis by means of extensive medically approved templates consisting of drop-down menu options tied to fit captions and free-text alternatives. While the patients could post their issues at any time, they were informed that the service was staffed only during the daytime (8:00-15:00), Monday through Friday. Submitted issues were posted as a case with the patients' primary care center, where a triage nurse responded within 2 hours, during office hours, initiating an asynchronous chat. The nurse could thus post further questions to patients (which they could respond to whenever appropriate) or refer the case to another staff member on the team (such as a secretary, for administrative issues, or a physician). Patients had the final say about when to close the chat, and the conversation was then manually inserted by the health care professional into patients' standard electronic health records.

Objective

This innovation, like equivalent digital tools, is promoted as an efficient use of resources in the often-burdened field of primary care. Yet the possibility of combining an online medical form with subsequent text messaging communication has been found to be suboptimally used [2]. Primary care, like all health care services, should optimize quality and efficiency, offering user-friendly options. Further understanding about what constitutes the ideal design, implementation, and use of digital services is needed [10,11]. In this study, we took an end-user perspective, aimed at conveying health care staff's experiences with a digital communication system used for patient-staff encounters via asynchronous chat in Swedish primary care.

Methods

Design and Setting

The study design was explorative and descriptive. We interviewed health care staff about halfway into the 1-year pilot period following a regional decision to test the digital communication system. We were independent of the project management but were assigned to investigate the implementation. A total of 5 primary care centers in a typical region of southeast Sweden had agreed to test the digital service, which was free of charge during the pilot period. The primary care centers were representative of Sweden and the region, including urban as well as larger and smaller community settings. The staff who were meant to use the system in their everyday practice and the primary care center managers from the start had received a concise training session (less than half a day) led by a project manager; staff who joined later were introduced to the system by their colleagues in each primary care center. The primary care centers then separately organized their use of the digital communication service; for instance, 1 of the 5 primary care centers included physicians in addition to the nurses and administrators who constituted the backbone of the service.

Sample

The project manager provided us with contact information for the health care staff who were using the digital communication system, collated by the primary care center managers. We identified a sample of 4 potential study participants from each primary center: (1) a manager, (2) at least one district nurse or registered nurse, or (3) a district or registered nurse and at least one physician, and (4) at least one secretary. We restricted the inclusion of managers, physicians, or district nurses—that is, nurse specialists—as not all primary care centers had these groups of professionals engaged in the test. We contacted the potential respondents via email with information about the study and a request to let us know whether they were willing to participate. We sent 1 reminder where necessary. If we received no response or a refusal, we identified a matching substitute in the primary care center and repeated the informed-consent process until we achieved the preferred sample. If several staff were available, we made a strategic selection to match the above roles, but also to consider a fair representation of gender in relation to roles across all respondents.

Procedure

Data Collection

All interviews were individual and conducted by telephone; a researcher called at an agreed-upon date and time, recapped the information about the study, and asked for consent. All participants provided verbal informed consent.

The interviews were performed by either of 2 researchers on the team: the first researcher (ACE) has extensive experience in qualitative methods and mentored a second researcher (EN), who is a well-rehearsed scholar. Besides data collection sessions, consistency was enhanced by an agreed-upon semistructured interview guide compiled for the study. This comprised 4 main areas related to the digital communication service: the primary care process, the implementation process, the digital communication system itself, and the patient-professional relationship. The guide had been developed for and tested in a previous study addressing patients’ experience; it was found to facilitate a narrative regarding the core issues of primary care interactions using the digital communication system, and we thus applied it after a minor linguistic adaptation to address staff experience. We used probes only if the participant did not freely elaborate on particulars, such as training, in his or her narrative. We asked 3 final demographic questions: age, gender, and how confident the respondent was about managing everyday issues with their computer or smartphone.

All interview recordings were transcribed verbatim by a skilled secretarial service (Literatim, Stockholm, Sweden) prior to the analysis. A total of 21 individuals participated in the study: 19 women, and 2 men, age range 25 to 67 years (median 44 years). Most (n=16) were “always or almost always” able to manage their computer and smartphone on their own (with 5 “usually” managing and none opting for the “seldom” or “never/almost never” alternatives). The interviews lasted between 14 and 41 minutes, mean 22 minutes. The transcripts constituted 126 pages of single-spaced text. We considered data saturation [12], and the interviewers maintained a dialogue during the data collection period, identifying that we obtained a rich set of illustrations across all interview queries from the interviews. We did not report any data back to the participants or the primary care centers.

Data Analysis

The analysis followed the trajectory of content analysis, as described by Elo and Kyngäs [13].

First, all 4 researchers separately read all transcribed interviews, forming an individual naïve understanding, then assembled and discussed them in the team.

Second, the subsequent structured analysis was informed by the identification of 8 main components of the mutual naïve understanding. We used these components to organize the analysis, meaning that we identified units from all the interviews and assembled them according to these codes, and we separated units encompassing meaning beyond 1 component or code into 2 (or more, as appropriate) [14]. Each interview text was thus once again read and reread separately, and all meaning units were assembled for each component. We further analyzed these texts by using an inductive approach to form categories and subcategories, thus procuring a shared human experience [15].

Third, we abstracted the categories and corresponding subcategories into a text that reflected a thorough understanding of the experience of using a digital communication system while working as a health care member of staff in primary care, also known as a comprehensive understanding [13].

We selected quotes to illuminate the findings and make it easier for others to grasp the main content, in terms of everyday language and experience. The quotes were translated into English by the researchers, preserving a unique meaning, and checked for grammatical accuracy by a proofreading service (Sprakservice, Malmö, Sweden).

Throughout both the structured analysis and the comprehensive understanding phases, we repeatedly discussed the evolving findings as a team [16].

Results

Comprehensive Understanding

The comprehensive understanding of the experience of the digital communication system in primary care incorporated 4 global themes: the innovation itself, the implementation process (addressing the device and context changes), the barriers (incorporating patient and staff needs and skills), and indicating a work in progress, where both the outcomes and, in particular, the benefits vary. The comprehensive understanding was scaffolded by the following structured analysis, with the categories marked in italics, and concluding with a summary. Refer to Multimedia Appendix 1 for an overview of the global elements, categories, and subcategories.

The Innovation

The digital communication system *required particular patient skills*, entailing working on an internet-connected computer, iPad, or smartphone and requiring a basic awareness of terms related to health and health care. In order to complete the templates, not skipping any mandatory details, the patient needed to follow the path designated for each trajectory, describing only symptoms that were related to the reason for contact, and specifying while not exaggerating. This also called for skills in expressing oneself in writing. Likewise, the ability of health care staff to phrase articulate and prompt responses and further queries in the chat dialogue affected the liability but also required more time than a phone conversation.

> *Many patients who seek advice for upper tract infections tick the box for having chest pain. For me as a professional, it [chest pain] indicates something*

> *severe. But then it turns out to be, like "it hurts a little when I cough."* [Interviewee no 7]

Besides skills, the digital communication system also required *patient access to devices* (an internet-connected computer, iPad, or smartphone), along with access to and the skills to use an e-ID. Thus, staff considered that the digital communication system was mainly beneficial to the young and to resourceful groups of patients, gaining a further route for contact and thus quicker communication. Empowering those in society who can navigate the system, the digital communication system may *buttress patient inequity*, professionals suggested.

The digital communication system offered what was advertised as the potential to chat with the primary care center, which some patients interpreted as a concurrent service, although it was actually asynchronous. The disparate limits on further dialogue, whereby staff are expected to respond within a couple of hours during daytime, while the patient is able to respond at any time for several days, caused lags in the *asynchronous chat*.

Implementation: The Device and the Change Process

The digital communication system was accompanied by *varying preimplementation training*; the staff claimed to have had either a common training by the company or by a particular assigned project instructor, or by a colleague who had been trained by the instructor. This was either in-house consecutive guidance or a joint event for the center's team. The training, much like the decision to join the project, varied between the primary care centers: either the entire team was engaged in the dialogue regarding the digital service pilot, or it was a sole management decision. Moreover, the attitude of the manager influenced whether and how innovations spread through the team, whereas a mere order impeded further discussion.

> *We've piloted before and are pretty eager to trial, particularly when it comes to eHealth and stuff. But we're used to more support.* [Interviewee no 3]

Although the digital communication system was simple to use, it was considered to have been *manufactured for a team*, requiring the routines it affects to be identified. This takes time, as does changing the routines to make best use of the innovation. Across the primary care centers, the nurses were in charge of triaging incoming cases; local routines were set up for how the nurses should use the chat function, allocating resources from the prevailing telephone service but with no corresponding increase in staffing. Rather, nurses took turns in managing the digital system, communicating with patients and surveying the errands, the latter including the follow-up on cases not resolved during each shift. Secretaries were invited to manage administrative issues and physicians managed the complex medical issues. While 1 of the 5 primary care centers included some physicians in *a team effort* at trialing the digital communication system, the nurses could direct the more complex medical issues straight to another professional within the system. Though physicians were portrayed as reluctant to engage, in all centers they were willing to confer about cases that the nurses brought up with them.

> *They [the nurses] chat with the patients and resolve the issues that they can, and if they need assistance from a doctor, they send on the thread.* [Interviewee no 1]

Settling the digital communication system into everyday practice meant more than getting it up and running: the implementation of the innovation drew attention to how complex patients' issues can be and how the digital communication system supported this complexity, or not. In response to patients who found ways around the mandatory features of the innovation, staff identified ways to uphold safe procedures. Furthermore, staff remodeled their routines along the way, identifying and agreeing upon new standards. Thus, *implementation took time* beyond the actual training and launching of the digital communication system. Yet it safeguarded a structure that was invented for and scaffolded the center, *inventing keys along the way*, in terms of both altering routines and learning how to take advantage of the digital communication system. At the point when the interviews were conducted, the primary care centers were pondering whether and how the innovation worked to their satisfaction.

> *The routines, they need to settle. Like, we became better at telling the patients that "now, this is another [health] issue that you're asking about, so you have to initiate a new thread."* [Interviewee no 19]

The Barriers: Patient and Staff Needs and Skills

The *lack of synchronicity between systems* resulted in a lack of connection between them, requiring that the staff manually register data from chat to the patient record system. Further, the patients were using several routes (eg, both telephone services and the digital communication service), thus occupying further resources for the same issue. As different staff members operated different services, the realization that multiple professionals were engaged with the same patient was purely coincidental. Furthermore, the *writing took time*, as there were no templates for replies and writing takes longer than talking over the phone. Additionally, once one was writing in the chat function, the lag made registration more time consuming.

Patient *matters derived from a wide range of aspects*, and although some issues were considered better managed due to the digital communication system, it was difficult to chat with patients about mental health issues. On the one hand, some patients preferred the more anonymous digital chat, which also offered an opportunity to write at any time of day, for sharing moods and feelings. On the other hand, it was harder to decipher details in text, but a verbal dialogue was more beneficial for such issues.

The extensive text bulk produced by a chat meant *the staff lacked an overview*. Staff operated the digital communication system for a shift at a time, and the patients did not have a set time limit within which to respond, extending the communication to weeks in some cases. Regardless of whether the nurses followed up their assigned chats or dispatched their ongoing chats after each shift, prolonged chats were considered risky, requiring either multitasking or cases being assessed differently, and thus muddling the response to the patient.

> *We need someone online who can respond in real time. But we don't have that kind of numbers [of*

> *incoming issues] to justify such resources.* [Interviewee no 17]

A primary uncertainty, however, originated from *missing data*; because of a lack of understanding of the necessity for a complete anamnesis, patients could skip mandatory items by means of alternative characters (eg, forcing the template by writing a period only). Furthermore, hearing a patient speak sometimes makes a big difference in achieving a correct assessment, covering a variety of aspects such as mood, confusion, a sore throat, or breathing problems.

> *It's hard enough to triage over the phone, but at least you have the voice to guide you, the tone, and additional sounds and such. Here, it's only the text.* [Interviewee no 5]

The Outcomes and Pros: A Work in Progress

The *prime advantages* of the digital system included the possibility for patients to upload photos, for example, on skin problems, such as rashes and eczema. Although none of the primary care centers used video chat, the triage was considered safer and more prompt with pictures, often saving patients a visit to the primary care center. This further sustained a safe environment because, for example, parents could be counselled over the chat when a photo had confirmed a child with chickenpox, rather than showing up at the center and risking contagion.

> *The photos, that's great. It's been all kinds of things: noses—are they broken or not? Is this foot swollen or not, and how to deal with it.* [Interviewee no 13]

The digital communication system also procured efficiency such as settling simple cases easily, relieving the telephone service of those minor issues that can be resolved by a single message turnaround. The opportunity for patients to raise several issues in 1 chat was considered good service, as was enabling patients to contact primary care at a time and place suiting them, with sufficient time to phrase their issues in a private setting.

> *You can see from the extent of the text, the way they write. It gives you a sense that this isn't simply a matter of that prescription really.* [Interviewee no 9]

The digital communication system facilitated an opportunity to read the anamnesis, to prepare the response or a further chat with the patient, and to sustain preliminary consultations before the response, thus *procuring a preliminary plan* and giving a more accurate reply to the patient. This required that the staff rendered a full anamnesis, where templates were further expanded by means of free text. The photos that patients (or if the patient was a minor, a parent) could upload onto the digital communication system provided supplementary data facilitating *safer assessments* that could be agreed upon by the health care team during the triage process. The same questions were asked of all patients with a similar issue or symptom, and (for those centers using this routine) the same staff followed up on the patient's chat.

> *You're likely to have quite an extensive history, which you can read, and you can read the previous records before making further contact [in the chat]. When you get them on the phone, you have no idea why they're calling and no chance to prepare prior to the dialogue.* [Interviewee no 15]

To some extent, the digital communication system thus *preserved resources*: although the innovation was time consuming, its implementation could lead to altered routines that provided the nurses with time to maintain communication. Although further engaging a particular professional group, having the patient anamnesis in place could procure a more accurate assessment, along with facilitating a nurse-physician interaction during triage.

Summary

For health care staff, providing good service is key. This implies balancing the workload that an additional contact route imposes on one's chores with patients' positive feelings; many patients today anticipate the opportunity to engage in digital communication, although for other patients it is not an option. Digital communication poses both benefits and drawbacks: while issues can be managed more easily and with greater accuracy because of digital transmission, it requires the patient to have a certain level of both digital literacy and health literacy, including a basic understanding of health care services.

Staff need to find the time and routines to work around the obstacles presented by the innovation, determining how best to manage both the communication and the transfer of information to the patient record system. A team effort is helpful, starting with a joint decision to trial and implement the service. On the other hand, a lack of engagement or a lack of resources hampers the potential benefits of the digital communication system, even though it aids a more convenient service for some patient issues. The implementation of a digital system is shaped by the balance, or lack thereof, between staff workload and patient needs, and the competence among both patients and staff.

Discussion

Principal Findings

Corresponding to previous research, our study illustrated a future form of primary care in which digital communication services function as valuable complements, even though certain elements need further attention for optimization.

A concern raised both in our study and by others is the potential misuse of the service as a way to ensure speedier contact or a visit to the general practitioner. The staff posed this as potentially jeopardizing the ethical principles of health care delivery, such as directing resources to those most in need or with the greatest benefits, rather than those with a strong voice [17]. A similar risk of inequity is the challenges faced by patients who are not able to express themselves in writing: the staff valued a summary of the patient's current health status and reason for contact before further communication, yet the anamnesis was sometimes incomplete. To aid safe assessments requires further guidance; additional instructions for patients would support not only their provision of details but also health literacy, of benefit to digital communication in primary care and beyond [18].

The notion that the inadequacies of digital communication are better settled by telephone [2,19] was addressed. While the chat was mainly based on text, face-to-face or telephone consultations have been found to provide additional information, enabling an appropriate assessment for patients who may not be able to express their problems adequately in writing [2]. The findings suggested that the digital communication service was best suited to less complex matters, but other digital solutions, such as video calls, have been found to be suitable in, for example, mental health issues [20]. Thus, online consultations may not be a replacement for, but rather a supplement to, traditional care [8] and should be part of an overall digital transformation of primary care, with more opportunities for self-administration [11].

Obtaining a further understanding of how to change and optimize both patient and staff behaviors regarding new digital forms of communication is warranted. Certain competencies required by the staff extend beyond their medical expertise to sustain a safe and person-centered approach to digital communication systems [21]. Voluntary testing of a digital communication system can derive from a joint or a management decision; staff readiness will lead to context variance, as will the engagement of either a few or all professionals [22]. In this study, implementation was facilitated primarily by means of training, a strategy known to transfer knowledge while having only potentially fair but often mixed effects on changing ways of doing things [23]. While in the last few decades understanding of the dynamics of implementation has increased, it is still fairly common for it to be mixed up with dissemination—that is, as primarily being the directed communication of information to increase knowledge and skills [24]. Rather, the complexity of how to support the satisfactory uptake of an innovation, to the extent that it actually becomes daily routine, requires further attention.

The Consolidated Framework for Implementation Research in particular echoes the professional end users' employment of the digital communication system in primary care, suggesting that any innovation will be adapted as a result of the implementation process, the context in which it is used, and the users involved [22]. Our findings recognize a further need to evaluate eHealth implementation in primary care, incorporating constructs of importance [25], and emphasizing the significance of continuing to facilitate the implementation after the initial training when the eHealth intervention is launched. However, with little or no support for the implementation per se, the staff had settled upon routines themselves, although they lacked the resources needed to benefit from the innovation as teams or individual health professionals. Further enterprises engaging implementation champions would be likely to facilitate a more comprehensive process [25], including the mapping of needs and resources in context [26]. Altogether, further services may be needed, such as video consultations online, to expand the use of digital communication systems to a larger percentage of patients seeking primary care [27]. While staff members favor means that give patients a sense that the service is client centered and appreciate being up to date with other sectors in society [28], eHealth innovations that make sense in terms of quality and safety are likely to attract a more general uptake [19].

Recognizing the patient as a partner in matters pertaining to health and health care has become best practice, although it is still a work in progress with several models available [29]; shared decision making is one route to enhancing opportunities for patient participation, much like the standards for person-centered or patient-centered care. All in all, these create a mutual recognition of knowledge and experience between patients and health care professionals, including the recognition of patient preferences and health literacy—the latter in order to sustain a better understanding and engagement in health issues [30,31]. Digital tools, offering benefits such as the opportunity to describe one's concerns, symptoms, and health issues at a time, place, and pace that suit oneself, appear on current evidence to be good for enhanced values in primary care [32]. Study findings indicate that staff favored patients' appreciation and were willing to walk that extra mile to meet patient expectations, much like health care professionals who cautiously embrace digital have been found to favor increased efficiency, besides the prospect of providing patients with alternatives that align with their preferences [11]. To the best of our knowledge, this aspect has not been widely recognized as an incentive for facilitating implementation, but we suggest that ethics should be further investigated as a means for understanding such processes.

Our findings signify that, to staff, the digital communication service serves certain types of contacts better than others, but patients need further guidance as to which route is most appropriate for which issue. A potential means to enhance digital services and optimize their use by patients is to include patient representatives during both development and implementation projects [33]. Such enterprises, as well as everyday practice in the digital era, need to address the potential injustice between resourceful and frail individuals and groups in society [34]. The increased risk of inequity due to digital communication services renders a need for innovations that are easier to use and more effective than current alternatives [35].

Limitations

While this study adds to the growing body of understanding of eHealth in primary care by proposing the further dimension of the importance of justifications for implementation, it was based on data collected in 5 primary care centers that had all volunteered to take part in a pilot test. Although the findings illustrate the complexity of implementation enterprises, the inclusion of more centers, across the entire spectrum of attitudes toward digital communication services, could have yielded additional input [36], as could potentially the inclusion of staff not engaged in the use of the digital service, particularly in terms of barriers to implementation of digital communication systems in primary care.

Conclusion

A digital communication system may be simple enough to grasp but still present challenges requiring attention and in-house solutions in order to master it in daily practice. The health care professionals in this study considered the digital communication system to be more or less appropriate for different patients, but it may have aided the primary care nurse or team to settle certain issues more easily—or it may have created more problems than a telephone conversation. However, the possibility to see photographs and the opportunity to master the patient anamnesis prior to further contact made the primary care triage better and more efficient.

For an innovation such as a digital communication system to pay off in regular primary care, the implementation process should entail joint team engagement, with the readiness, resources, skills, and mandate to change routines as necessary. Patients need to use the service consciously for appropriate issues. By means of careful strategies, further systematic clinical and research efforts can better understand what works, where, for whom, how, and why—or why not. While staff members valued a digital communication system that is considered a good service by patients, ethical ideals should be considered when implementing digital communication systems in the primary care context.

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Authors' Contributions

ACE, AS, PB, and EN developed the study plan; ACE and EN conducted the interviews. ACE led the analysis, and all the authors contributed to the naïve analysis and repeated discussions. ACE drafted the manuscript; all coauthors made substantial contributions in discrete sections and to the overall text, including agreeing to the final version.

Conflicts of Interest

None declared.

Multimedia Appendix 1
Overview of global elements, categories, and subcategories.
[DOC File , 74 KB - humanfactors_v7i4e21698_app1.doc]

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Original Paper

A Novel Educational Prescription Web-Based Application to Support Education for Caregivers of People Living With Dementia: Development and Usability Study With Clinicians

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Abstract

Background: It is estimated that 564,000 Canadians are currently living with dementia and there are approximately 486,000 to 1.1 million informal family/friend caregivers. Family/friend caregivers often receive little to no education or training about dementia but are expected to provide ongoing support for a complex condition. Web-based family/friend caregiver interventions may be helpful, but little is known about how best to implement them.

Objective: The objectives of this study were to 1) design and develop a novel education prescription application to help scale and spread web-based dementia education to family/friend caregivers, 2) conduct user testing, and 3) conduct a larger-scale field trial.

Methods: A novel education prescription web-based application was designed and developed. Initial user testing used task completion and the “think aloud” technique with a small sample of representative clinicians who work with people living with dementia and family/friend caregivers. Following iterative incorporation of feedback, a larger field trial was conducted with a convenience sample of clinicians. Account invitations were sent to 55 clinicians and, following a 2-month trial period, surveys were administered to participants including the System Usability Scale and the Net Promoter Score.

Results: During the initial user testing phase, participants (N=7) from representative disciplines easily completed associated tasks, and had very positive feedback with respect to the usability of the application. The System Usability Scale score during this phase was 91.4. Suggestions from feedback were incorporated into the application. During the larger field trial phase, participants (total N=55; activated account n=17; did not activate account n=38) were given access to the iGeriCare education prescription application. During this period, 2 participants created educational prescriptions; a total of 3 educational prescriptions were sent. Survey completers who did not activate their account (n=5) identified that their lack of use was due to time constraints, competing priorities, or forgetting to use the application. Survey completers who activated their account (n=5) identified their lower use was due to lack of time, lack of eligible family/friend caregivers during trial period, and competing priorities due to the COVID-19 pandemic. The System Usability Scale score during this phase was 78.75, and the Net Promoter Score was 50.

Conclusions: Study findings indicate a generally positive response for the usability of a web-based application for clinicians to prescribe dementia education to family/friend caregivers. The dissonance between the promising data and widespread enthusiasm for the design and purpose of the education prescription application found in the initial user testing phase and subsequent lack of significant adoption in the field trial represents both an important lesson for other novel health technologies and a potential area for further investigation. Further research is required to better understand factors associated with implementation of this type of intervention and impact on dissemination of education to family/friend caregivers.

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KEYWORDS

dementia; caregiver; education prescription; online education; internet; eHealth; knowledge translation; implementation science; scale and spread

Introduction

Overview

Dementia is among the most prevalent long-term health conditions in Canada, with over 564,000 Canadians living with dementia and over 486,000 self-identified family/friend caregivers [1-4]. These numbers are predicted to increase substantially due to our aging population. In Canada, approximately 25,000 new cases of dementia are diagnosed each year; the number of people living with dementia is expected to increase by 66% to approximately 937,000 by 2031 [5].

Approximately 85% of people living with dementia rely on family/friend caregivers to provide support, despite the majority of these caregivers having no formal education or training related to the illness [6-8]. The Canadian National Dementia Strategy, Ontario Dementia Strategy, Health Quality Ontario Quality Standards for Dementia, and other clinical guidelines each highlight dementia caregiver education as an important component of quality care [3,4,9-12].

Web-based education for family/friend caregivers of people living with dementia has been shown to be effective for a number of caregiver outcomes. Several recent systematic reviews suggest web-based intervention programs have positive effects on self-efficacy, self-esteem, and strain of family/friend caregivers of adults living with a chronic condition [13-16]. There is also literature substantiating that web-based educational programs can benefit the mental health of family/friend caregivers for adults suffering from a chronic condition, particularly for the outcomes of caregiver depression, stress and distress, and anxiety [17,18]. These findings are particularly relevant for family/friend caregivers of people living with dementia, given the increased levels of distress and mental health conditions among family/friend caregivers [15,19]. Despite the evidence for the efficacy of web-based caregiver education, there are very few high-quality and freely-available programs available to family/friend caregivers of people living with dementia.

To respond to this unaddressed need, the award-winning iGeriCare online caregiver educational initiative was launched by a team of experts in online learning and dementia from McMaster University. iGeriCare contains multimedia lessons and resources, hosts live online events with content experts, and offers a series of microlearning emails to help educate family/friend caregivers of people living with dementia. iGeriCare targets caregivers through print-promotional materials (eg, clinic posters, print-based educational prescription pad, postcards), digital and social media marketing, and collaboration with community partners and intervention agents.

A qualitative study with dementia clinicians and other key stakeholders highlighted the utility of the educational prescription pad [20]. Participants reported that the educational prescription pad was a very efficient and effective way to direct family/friend caregivers to high-quality dementia education in the clinical setting [20]. When asked, participants agreed that an electronic version of the educational prescription concept would be potentially beneficial [20].

This work led to and informed the design and creation of a web-based educational prescription application. This application allows clinicians to electronically “prescribe” iGeriCare multimedia lessons to family/friend caregivers by sending an email to the caregiver with a link to a tailored curriculum of lessons.

Objectives

In this paper, we describe 1) the design and development of the web-based education prescription application; 2) the initial user-testing phase, where we documented a small sample of clinicians’ initial impressions of the education prescription application; and 3) a field-trial phase, in order to better understand issues related to broader user acceptance and the feasibility of the education prescription application under real-world conditions.

Methods

Design and Development

The education prescription application is built using Laravel, an open source PHP framework that provides a solid foundation for web applications. The application is deployed on an Amazon Web Services EC2 instance and uses a MYSQL 8 database for data storage. This architecture allows for dynamic scaling and load balancing according to demand.

The development team, consisting of a project lead and a single full stack developer, met weekly to keep development focused and on track. A model-view-controller design pattern was employed to organize the application’s information structures. The front-end presentation is based on a clean Material Design approach in order to keep the user experience (ie, UI/UX) simple and intuitive.

Email notifications to family/friend caregivers are dispatched using a RESTful API from Mailgun, a third-party service that allows tracking of typical mail events such as opens, link clicks, and bounces. These email links are tokenized for additional tracking, and they direct the caregiver to prescribed content on the iGeriCare website.

Core refinements to functionality and the overall user experience evolved from discussions with other team members, informed by opinion and evidence from the initial user testing and qualitative interviews. Additional administrative and management features were added based on input from user testing and the field trial.

Initial User Testing

A convenience sample of 7 representative health care providers who work with family/friend caregivers of people living with dementia were invited to provide feedback. This sample size has been shown to be relatively efficient and effective for usability testing [21]. The participants were recruited via email from healthcare providers who had previously voiced an interest in the education prescription application concept, while attempting to include some representation from diverse specialties and organizations (eg, family medicine, psychiatry, community advocacy organizations). User testing was carried out by a research assistant with extensive experience conducting participant interviews and a student from McMaster University's Bachelor of Health Sciences program. The user testing took place in the participants' workplace setting from November 5th, 2019 to January 14th, 2020. Participants accessed the education prescription application using their preferred personal devices, which in every case was either a desktop or laptop computer.

The usability testing protocol was derived from Krug's usability testing methodology, namely the "think aloud" method [22]. This protocol was used with a focus on "task completion".

Participants opened an invitation email to the education prescription application before being presented with a series of tasks to conduct within the application interface without outside assistance. Tasks included the following: open account invitation and activate, create profile, review dashboard, create educational prescription, review prescription metrics, and log out.

These tasks were chosen to reflect situations that users would encounter during normal use. After the task completion was complete, participants engaged in a brief semistructured interview and completed the 10-item System Usability Scale (see Multimedia Appendix 1). The System Usability Scale, an industry standard survey, is a brief but useful tool for obtaining reliable and valid results from usability tests with small sample sizes [23]. The feedback of participants from the "think aloud" method during task completion and subsequent semistructured interviews was recorded in writing and synthesized.

Feedback from the initial user testing was then incorporated into an updated beta version of the application, which was used for the field trial.

Field Trial

Clinicians or organizations that had previously expressed interested in pilot testing the education prescription application or were recruited from a family medicine medical conference were invited via email to participate in the field trial. The goal was to achieve a minimum of at least 25 participants from a range of representative clinical disciplines/specialties and organizations working with family/friend caregivers of people living with dementia. In total, 55 participants were invited to participate. These participants had accounts created for them to use the fully functional beta version of the education prescription application. The field trial took place from February 4th, 2020 to June 1st, 2020.

The field trial was conducted with a mixed methods approach consisting of several distinct sources of data. The field trial period was defined as beginning immediately upon participant account creation and ending either after their 10th prescription or 2 months after account creation. Participants who were invited to the field trial and were inactive after 2 weeks were sent a reminder email to activate their account. Throughout the field trial, participants had the opportunity to provide written feedback through the education prescription application. At the end of the field trial, participants who activated their account were sent a "completer's survey," and those who did not activate their account were sent a "non-completer's survey" using SurveyMonkey. Additional data was also collected at the end of the field trial, including the System Usability Scale ratings, Net Promoter Score, and utilization metrics recorded on the education prescription application website and through the application database. Net Promoter Score is a management tool that can be used to gauge customer satisfaction [24-26]. Using an 11-point scale, the Net Promoter Score asks respondents their "likelihood to recommend" a product or service based on their experience. The Net Promoter Score classifies respondents as either "detractors" (rated 0-6), "passives" (rated 7-8), or "promoters" (rated 9-10) and calculates the percentage of respondents in each group [26]. The percentage of detractors is then subtracted from the percentage of total promoters to give the final Net Promoter Score. Net Promoter Scores can range from -100 to +100.

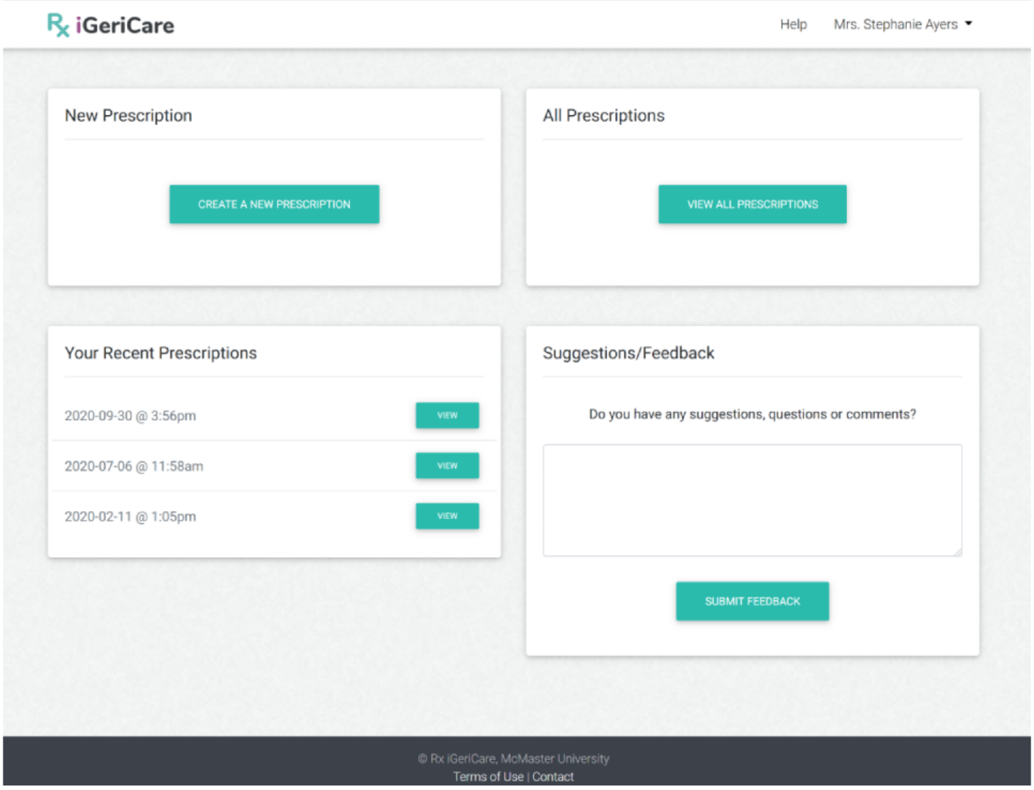
The Hamilton Integrated Research Ethics Board reviewed the protocol and determined the study was quality improvement. The study was granted an exemption from full review.

Results

Education Prescription Application Description

Upon accessing the education prescription web application URL, the user is presented with a *login screen* which they can login to with the email and password that were used to create their account. Upon logging in, the user is directed to the *dashboard* (see Figure 1), which allows the user to navigate to and use the features of the application, such as *making a new prescription* (see Figure 2), *tracking their previous prescriptions*, or *giving feedback* on the application. These functions are all accessed by directing the user to a new page that allows them to complete the relevant task. Additionally, all pages after login have a banner at the top including the iGeriCare logo, which, if clicked, will bring the user back to the home page. All pages after login also have menu items to allow for the editing of account profile information and to request help/technical support.

Figure 1. Education prescription application dashboard screen.



2020-09-30 @ 3:56pm

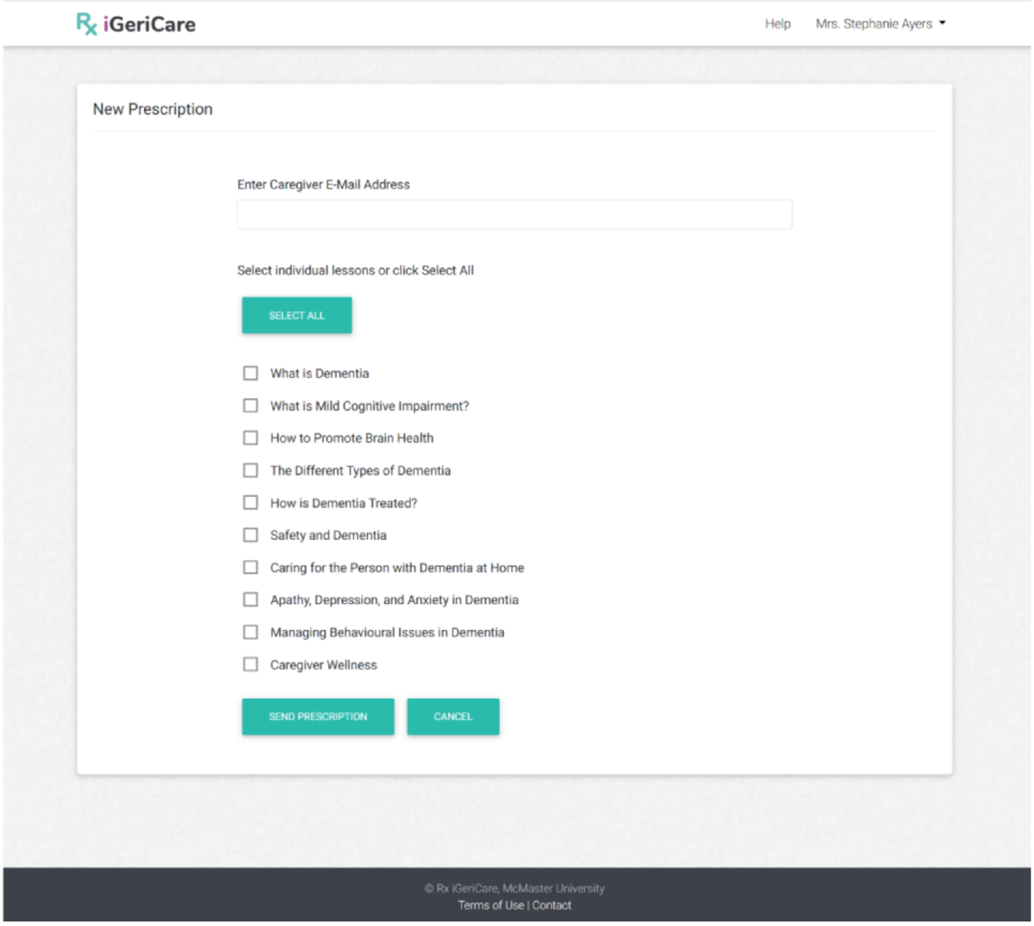
2020-07-06 @ 11:58am

2020-02-11 @ 1:05pm

Do you have any suggestions, questions or comments?

© Rx iGeriCare, McMaster University

Figure 2. Education prescription application screen to create a new prescription.



Enter Caregiver E-Mail Address

Select individual lessons or click Select All

- ☐ What is Dementia
- ☐ What is Mild Cognitive Impairment?
- ☐ How to Promote Brain Health
- ☐ The Different Types of Dementia
- ☐ How is Dementia Treated?
- ☐ Safety and Dementia
- ☐ Caring for the Person with Dementia at Home
- ☐ Apathy, Depression, and Anxiety in Dementia
- ☐ Managing Behavioural Issues in Dementia
- ☐ Caregiver Wellness

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Initial User Testing

The initial user testing phase involved 7 user testers. Participants were located in Hamilton, Ontario and were from the following disciplines: family medicine (n=2), neurology (n=1), psychiatry (n=1), geriatrics (n=1), and community advocacy organization (n=2). The average System Usability Scale score for all initial user testers was 91.4 (N=7), with an average score among clinicians of 91.0 (n=5) and that of the community organization user testers being 92.5 (n=2). The System Usability Scale score of a typical application is 68, with a score of 80.3 representing the 90th percentile [23]. This places the education prescription application's overall and subgroup scores within the 99th percentile of scores, which indicates a highly intuitive, well-designed, and functional application.

This data is supported by the feedback received in the semistructured interviews with initial user testers. The users overwhelmingly praised the logical design, ease-of-use, minimalist aesthetic, and utility of the education prescription application. All initial testers agreed that the term "educational prescription" was a descriptive and correct name for the application, and that it had the potential to give added legitimacy to the emails in the eyes of family/friend caregivers. Participants identified that they would like to know the password requirements at the account creation stage. Following the initial user testing phase, developers implemented this feedback and included password requirements on the account creation screen.

Field Trial

Fifty-five participants were registered for the field trial phase, which included physicians and nonphysicians that respectively represented numerous specialties and roles, a mix of both urban and rural regions, as well as different Canadian provinces. Participants were recruited predominantly from a family medicine medical conference and from physicians who had been approached previously about the education prescription application. Due to the nature of our field trial recruitment strategy, we have limited information on the background of most of the participants. Participant demographics can be seen in Table 1.

Although 17 participants activated their accounts, only 2 participants created educational prescriptions. Fifty-three participants did not send any prescriptions during their field trial phase. A total of 3 educational prescriptions were sent; one participant sent 1 educational prescription, and another sent 2 educational prescriptions. No participants submitted written feedback through the education prescription application dashboard.

Of the 55 invited participants, 10 responses were received for the posttrial survey which included responses from 5 participants that activated their account and 5 nonactivators.

Table 1. Field trial participant demographics (N=55).

Description	Activators (n=17), n	Nonactivators (n=38), n
Physician disciplines		
Geriatrician	2	—[a]
Family medicine	7	—
Other roles (exclusively long-term care staff)		
Manager	4	—
Education	9	20
Administration	1	—
Human resources	1	—
Unknown	—	18
Province		
Ontario	12	20
Alberta	3	—
Manitoba	1	—
Unknown	1	18
Region characteristics		
Urban	15	20
Rural	1	18
Unknown	1	—

[a] Not applicable

Nonactivator Survey

There were 5 respondents for this survey; each respondent completed all questions. Participants were allowed to select multiple responses for each question. There were 3 responses that identified the primary reason for lack of use of the application was that they were "too busy." Another 3 responses identified that they "forgot to use the app." When asked if there were any changes that could be made to encourage the use of the application, 2 responses said "no," 1 response said that they were "too busy for any change to have affected [their] action," and 2 responses said that additional email reminders to activate their account may have been useful. One response said they "could not comment due to [their] lack of familiarity with the app."

Activator Survey

There were 5 respondents for this survey; one of these respondents only completed the first question and did not go on to complete the remainder of the survey. Again, participants were allowed to select multiple responses for each question. When asked about reasons for low use of the application, the most popular responses were similar to those among nonactivators. Two responses identified that they were "too busy," 2 responses identified "they forgot," and an additional 2 responses said they "saw no dementia care partners during the field trial period." It is interesting to note that one response specifically identified the COVID-19 pandemic as a reason for their low use of the education prescription application. Respondents did not identify anything that could be done differently with the education prescription application; one response highlighted that they were a "big fan of the tool," and encouraged continued use of the application. Respondents all identified that they would like to use this application more frequently. The System Usability Scale score for the activator survey was 78.75, which falls within the "good" and "excellent" categories. The Net Promoter Score was 50, which is considered "excellent."

Discussion

Principal Findings

In this study, we designed and developed a novel educational prescription web application for clinicians to efficiently prescribe iGeriCare multimedia lessons to family/friend caregivers of people living with dementia. Initial user testing validated the design and usability of the application, with very positive feedback on the application's user-friendliness and functionality. The field trial was designed to look at real-world feasibility, usability, and function rather than broader implementation issues or scale and spread. Despite initial user testing validation, during the field trial most participants did not use the application at all, and those who used it wrote very few prescriptions. Feedback from participants suggests that this was due to generally being too busy and not a function of the application itself. Timing of the field trial overlapped with the COVID-19 pandemic, which also had a substantial impact on use during the field trial. Nonetheless, participants voiced positive comments and enthusiasm for the application. To our knowledge, this is the first study describing the design, development, and usability testing of this type of novel application for educational prescriptions.

Nonpharmacological Prescriptions and Information Provision

There is very little evidence surrounding the success or value of nonpharmacological prescriptions, such as the "social prescribing model" [27]. Research on "information provision" more generally also suffers from a lack of high quality research that could inform the implementation of the education prescription application; however, there are some systematic reviews that indicate some general trends, such as the positive psychological effects of disease knowledge on people living with dementia and family/friend caregivers, and practical skills-based education's stronger association with positive health outcomes [28,29]. Additionally, literature exploring the efficacy of multimedia information provision compared to print information and verbal education by healthcare professionals tends to indicate it is as, or more, effective than these methods, justifying the chosen medium for iGeriCare's online learning [28].

Diffusion of Innovation

Another theoretical framework relevant to the field of healthcare technology implementation is the "diffusion of innovation" theory, which describes "how, why, and at what rate new ideas and technology spread" [30,31]. This theory pioneered the concept of early adopters being the critical force in driving widespread acceptance of novel technologies, policies, and ideas, and has been successfully applied and adapted to health and information technologies by major institutions such as the National Health Service [32,33]. Wainwright and Waring note that professionally dominated organizational cultures tend to rely strongly on authority adoption decisions for effective uptake of novel information technology [33]. This effect was found to scale with the size of the organization adopting a technology, with larger organizations such as healthcare systems and hospital networks having more difficulty adopting technology without official sanction. The limited uptake by independent physicians observed in the field trial despite positive user-testing feedback on the application itself may be explained by this mechanism, given the novel and voluntary nature of education prescription application use.

Barriers to eHealth Technology Adoption

The findings of this study are also relevant to the field of implementation science, especially relating to healthcare technology. The NASSS framework (designed to evaluate nonadoption, abandonment, and challenges to the scale-up, spread, and sustainability of health and care technologies) is an evidence-based, theory-informed, and pragmatic framework describing seven domains of healthcare technology, and how simplicity or complexity in these domains effects the likelihood of successful implementation and proliferation [34]. The NASSS framework consists of a series of questions in 7 domains: (1) the condition (or illness), (2) the technology, (3) the value proposition, (4) the adopter system (staff, patient, and lay caregivers), (5) the organization, (6) the wider context (institutional and societal), and (7) the interaction and mutual adaptation between all domains over time [34]. Investigating the 7 domains in reference to the education prescription application further substantiates that the *technology*, *value*, *organizations*, *wider system*, and *adaptability* of the education prescription application avoid complexity and facilitate implementation [35].

Some potential complexity arises in the “condition” domain, as “dementia” is an umbrella term for a syndrome caused by several different disorders, with highly variable symptom severity and rates of progression [36]. Moreover, as a condition that typically affects older adults, many of the application’s eventual prescription recipients (eg, the family/friend caregivers) may also be older adult spousal caregivers. Based on our earlier qualitative research, some clinicians still view older adults as reluctant to use email- or web-based technologies, despite evidence to the contrary [20]. Those clinician attitudes may have dissuaded them from using the education prescription application with older family/friend caregivers. In the “adopter system” domain, our earlier qualitative research had also identified physician reluctance to use any additional electronic prescribing tool that was not integrated directly with their electronic medical records and clinical workflows [20].

A recent scoping review on the adoption of eHealth technology by physicians identified several barriers to the adoption and implementation of eHealth technologies that may be relevant to understanding low usage of the education prescription application during the field trial. Studies have identified the lack of harmonization of eHealth systems as a notable barrier, consistent with our qualitative research with respect to physicians wanting the application integrated with their electronic medical records systems [20,37]. While not voiced by participants in our field trial specifically, privacy and security concerns may have played a role with respect to low usage, as physicians are unaccustomed to using email to send messages to people living with dementia or their families. Lack of time and workload were also identified in this scoping review, which would be consistent with participant feedback during our qualitative interviews.

Conclusions

This study highlights an interesting tension or gap between positive usability feedback and actual use of novel information technologies in a healthcare setting. In particular, the dissonance between the promising data and widespread enthusiasm about the design and purpose of the education prescription application found in the initial user testing phase and subsequent lack of significant adoption in the field trial represents both an important lesson for other novel health technologies and a potential area for further investigation. The timing of the onset of the COVID-19 pandemic was likely an important factor for the low adoption by participants. Had our trial began a few months *after* the onset of the pandemic, it is possible that we might have had greater uptake from individual participants as well as organizations. In the first month of the pandemic, there was initially a lot less clinical activity due to competing priorities stemming from the pandemic; however, after the first month or two, there was increasing and widespread interest in virtual tools and virtual education. An additional impact caused by the COVID-19 pandemic was the fact that some clinicians saw no family/friend caregivers of people living with dementia during the trial period.

Future field trials for the iGeriCare education prescription application will focus on implementation settings with high volumes of family/friend caregivers of people living with dementia such as dementia clinics, memory clinics, long-term care home organizations, and community dementia advocacy organizations, which will allow us to further our understanding of the most probable implementation settings.

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Conflicts of Interest

AJL and RS are co-owners of the iGeriCare dementia education intervention with McMaster University. AJL, JB, and McMaster University are the co-owners of the education prescription application.

Multimedia Appendix 1
System usability scale (SUS).
[PDF File (Adobe PDF File), 16 KB - humanfactors_v7i4e23904_app1.pdf]

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Abbreviations

NASSS: non-adoption, abandonment, scale-up, spread, sustainability

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Original Paper

Privacy Perceptions and Concerns in Image-Based Dietary Assessment Systems: Questionnaire-Based Study

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Abstract

Background: Complying with individual privacy perceptions is essential when processing personal information for research. Our specific research area is performance development of elite athletes, wherein nutritional aspects are important. Before adopting new automated tools that capture such data, it is crucial to understand and address the privacy concerns of the research subjects that are to be studied. Privacy as contextual integrity emphasizes understanding contextual sensitivity in an information flow. In this study, we explore privacy perceptions in image-based dietary assessments. This research field lacks empirical evidence on what will be considered as privacy violations when exploring trends in long-running studies. Prior studies have only classified images as either private or public depending on their basic content. An assessment and analysis are thus needed to prevent unwanted consequences of privacy breach and other issues perceived as sensitive when designing systems for dietary assessment by using food images.

Objective: The aim of this study was to investigate common perceptions of computer systems using food images for dietary assessment. The study delves into perceived risks and data-sharing behaviors.

Methods: We investigated the privacy perceptions of 105 individuals by using a web-based survey. We analyzed these perceptions along with perceived risks in sharing dietary information with third parties.

Results: We found that understanding the motive behind the use of data increases its chances of sharing with a social group.

Conclusions: In this study, we highlight various privacy concerns that can be addressed during the design phase. A system design that is compliant with general data protection regulations will increase participants' and stakeholders' trust in an image-based dietary assessment system. Innovative solutions are needed to reduce the intrusiveness of a continuous assessment. Individuals show varying behaviors for sharing metadata, as knowing what the data is being used for, increases the chance of it being shared.

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KEYWORDS

privacy perception; privacy; dietary assessment; mobile food records; image-based dietary assessment; data sharing; human factors, mobile phone

Introduction

Background

Food images are highly relevant for use in medical research and sport science. They can capture continuous and accurate measurement of diets, and therefore are imperative in understanding the relationship between food intake and athletic development [1] or between food intake and health problems such as noncommunicable diseases [2]. The ubiquitous and increasingly capable smartphone is, in particular, becoming an essential asset that many studies now include the use of smartphones to gather data, thereby enabling new findings and development of new research methodologies [3]. The use of smartphone cameras to document meals has already been suggested as a way of improving nutrition research data and generating new insights [4-16]. By importing food pictures into an image-based dietary assessment (IBDA) system, trained professionals can go through individual dietary habits and offer personalized recommendations. Capling et al [17] surveyed the issues in dietary assessment methods in athletes and highlighted the problems of bias, accuracy, and burden on the user. IBDA systems are designed to address those issues. Thompson and Subar [8] argue that IBDA methods have the potential for research as they require less effort compared to traditional dietary assessment techniques for reaching comparable accuracy.

Although research on human subjects is already strictly regulated by local, national, and international boards and procedures, the increased usage of personal information recorded automatically through new technology comes with new concerns for the security and privacy of the subjects. Little attention has been given to the specific individual privacy requirements related to the design of IBDA systems [7,18], and how privacy awareness in larger cohorts can change over time and with regulatory discussions and coverage of privacy controversies in media [19]. For research studies based on IBDA data such as large epidemiological studies and sports science studies [1], the lack of a proper privacy framework for food-related images makes it difficult to follow Privacy by Design [20] guidelines, which recommend incorporating privacy requirements early on from the design phase, and risk not being compliant with legal and ethical laws and regulations. Participation in voluntary studies relies heavily on trust [21], and any damage to reputation can have severe consequences to organizations that obtain data based on informed consent. Thus, it is crucial to understand the privacy perceptions and concerns before implementing solutions at a population-wide scale.

To improve our understanding of the privacy requirements in population-based research data, we conducted a web-based *survey* wherein subjects were asked about their perceptions of privacy with regard to capturing food images by using a smartphone camera. Taking food pictures is already a trend on many social networks, where people typically post images of their meals during vacations and special events [22], and therefore, this is something that many can relate to. Since our general field of study is performance development of elite athletes, we selected a cohort of young participants (<35 years of age). Further, to avoid selection bias by using just a local cohort of athletes, we selected motivated cohort members from throughout the world. It is important to notice that our ongoing interdisciplinary work has involved sports science and elite athletes of several national (soccer) teams spread throughout Europe. Hence, having similar characteristics such as age, despite not elite athletes yet, in this first study, resembles this distributed target cohort. We purposely did not use the elite athlete cohort in this inaugural study owing to previous experiences of introducing new technologies to them [23,24]; our experience is that the dropout rate of such distant cohort members is way too large after the first week or so. Instead, we selected a distributed cohort that we knew would be motivated to be data contributors over a longer period.

Another important lesson from previous epidemiological-related work is that the data capturing should not be intrusive. We have previously attempted to use, for instance, 24-hour dietary recall–inspired methods with pictures taken during meals, but this showed to be too intrusive and too time-consuming for elite athletes. Moreover, the dropout rates of these elite athletes were very steep with these methods. Hence, we developed this survey by using alternative schemes for data assessment, wherein pictures of meals were captured similar to that captured in social media engagement.

From a more general perspective on privacy, food images offer an interesting case to study, as few food images might not carry much sensitive information. However, a large individual data set of images that is continuously recorded over long periods (>2 weeks) and linked to an individual's identity might disclose information that many find too sensitive to share. Such disclosure is a growing public concern [25,26] and therefore is an interesting use case for us to explore. Our hope is that the insight gained in our survey will be useful when designing data collection projects, thereby increasing trust and compliance, which are both necessary for public engagement that most cohort studies rely so heavily upon.

Literature Review

Systematic reviews of dietary assessment methods [17,27] have highlighted the issues of the burden on the user, accuracy of reported data, and bias in existing methods. Both studies argue about the potential of using IBDAs to address some of these concerns. Various studies [9-16] have validated the effectiveness of an IBDA system. However, they do not discuss any privacy concerns that might arise due to data collection in such tools. Furthermore, privacy risks are amplified by the increased willingness to self-disclose on one's smartphone [28]. In this regard, Christin et al [29] studied potential privacy violations in participatory studies that collect and process sensory data recorded by mobile devices. This work investigates violations such as revealing the location by a global positioning sensor in a mobile phone and provides strategies for safeguarding privacy. Their approach only attempts to identify privacy risks linked to sensory data. Avancha et al [30] studied privacy requirements for personal health care by using mobile technology. Their extensive work investigates privacy in a mobile health (mHealth) context. They elaborately defined a conceptual framework for privacy in mHealth from legal and technological aspects. Their work also provides properties for a privacy-aware mHealth system. Some of the privacy-relevant requirements discussed in this work are inspired by their work.

Zerr et al [31] explored classifying an image as private or public based on its contents. Their work highlights preliminary research focus in this domain. They built a machine learning model from photos marked by humans as private or public. Spyromitros-Xioufis et al [32] expanded on the work of Zerr et al by using classifiers based on the content of the image by using tags (eg, erotic, alcohol, drinking). A further layer of personalization was added by training the categories that a user wants to keep private. Squicciarini et al [33] further improved the classification of Zerr et al [31]. While these approaches lay important groundwork for privacy perception on images, they do not study contextual privacy implications for a specialized purpose such as for dietary assessment. In this work, we attempt to understand the privacy implications of recording dietary intake by using images, and to the best of our knowledge, this topic has not been covered earlier.

The work on IBDA methods by Boushey et al [4,11] and O'Loughlin et al [7] mainly discuss the identification of food from images. Their work does not discuss the privacy implications of recording diets over a long period. Thomaz et al [34] investigated privacy violations while recording eating behaviors with a wearable camera. Their work tries to understand the privacy implications of using a wearable camera. The wearable camera discussed in their work takes an image at periodic intervals, which might capture other images as well. They identify privacy implications such as capturing other people's faces or taking pictures inside a restricted location. The work further addresses these issues by offering novel solutions such as capturing images during certain hours instead of continuous captures. Similar to the work of Thomaz et al [34], Greiner and Yang [35] investigated issues with continuous recording by using a wearable camera for dietary assessments in obesity studies. They recommend postprocessing of the captured video in order to avoid any privacy violations. In our work, we do not target a wearable camera. Rather, we investigate the privacy implications of recording diets by taking images of food by individuals in a continuous study. We define a continuous study as taking pictures of food over a period of time instead of taking pictures periodically as in the study by Thomaz et al [34]. We build upon the fact that individuals are already taking selective pictures of food during vacations and sharing them on social networks [22]. Individuals are often not aware of their privacy being exposed by their data [19,25]. It appears that the awareness about data use, when shared with third parties, is often overlooked.

Methods

Questionnaire and Ethical Approval

To improve our understanding of the privacy perception related to the capture and use of food images, we conducted a study by using a web-based questionnaire (Multimedia Appendix 1) hosted by Nettskjema, a secure web-based survey tool hosted by the University of Oslo, Norway [36]. The questionnaire was developed using close-ended questions for their statistical analyses [37]. We simplified the questions, added a probability-severity matrix, and refined our goals through multiple pretesting/run-throughs in the laboratory. Some questions are repeated in the questionnaire to reduce biased context [37]. Responses were collected between February and June 2019. Based on our institution's research policy, we applied for ethics approval from the Norwegian Centre for Research Data. We did not collect any personally identifiable information. After a review, we obtained an exemption from the Norwegian Centre for Research Data. The full questionnaire is available in Multimedia Appendix 2 along with the collected data.

Design

The survey was designed to record participants' perceptions in the following scenarios: (1) Scenario A, the participant having to record and share dietary data as an athlete; (2) Scenario B, the possibility and severity of privacy leak from one's dietary data; and (3) Scenario C, sharing dietary data and reports among different social groups.

The scenarios were designed to be familiar to our participants and to cover various angles on data sharing. For Scenario A, sharing is both internally and externally motivated and controlled by the subject; however, the subject is not in control of the processing. For Scenario B, the subject is not in control of the data processing but has concerns about the processing outcomes, and for C, the sharing is consensual but is based on external motivation from different social groups, for example, receiving feedback from a doctor or sharing with family/friends as part of social behavior/interaction.

We used these scenarios to record our participants' perceptions and attitudes toward sharing data. Note that we considered the perceptions on a scenario valid even for participants who never encountered that scenario in real life beforehand. One's perceptions can affect one's participation in a study if the concerns are not addressed at the beginning of a study.

Our questionnaire starts by familiarizing participants with food pictures on social networks (Scenario A). It then asks about the use of social networks and experience with taking food pictures. Additionally, participants are asked about their preference of IBDA methods over other similarly used techniques for dietary assessment. Attitudes toward privacy and personal control over data were collected on a 5-level *Likert* item, ranging from *strongly disagree* to *strongly agree*. These include perceptions toward responsibility for privacy, intrusiveness, and general attitude toward dietary practices [22].

Next, the participants are asked to consider Scenario A—an athlete who records his/her diet by taking pictures. We specify that every meal is recorded by taking a picture, including drinks, and even at events outside training by using a mobile app. We specify that the app allows the team owner, manager, coach, and doctor to monitor his/her diet and recommend diet plans. Continuing with questions from Scenario A, we further obtain responses toward the privacy and usability of metadata collected through such a system. Table 1 shows an excerpt of the questionnaire. For the complete questionnaire, refer to the Multimedia Appendix 2.

Table 1. Few questions from the questionnaire with their possible responses.

Question category, symbol	Question text	Response
Social media usage		
G1	Do you use any social media platforms like Facebook, Twitter, Instagram, Snapchat, etc?	Yes/No
IBDA[a]-related questions		
E1	Is taking a picture of food easier than writing down what you ate?	5-point Likert scale
E2	Is taking a picture of food easier than recording an audio describing what you ate?	5-point Likert scale
E3	Is it intrusive to take pictures of food every time you eat?	5-point Likert scale
E4	Should any use of your data require an explanation in simple clear words?	5-point Likert scale
E5	Can your doctor share your data for research with his/her colleagues without your consent?	5-point Likert scale
Demographic questions		
D1	What is your educational qualification?	Level
D2	Do you follow a religious diet?	Yes/No

[a] IBDA: image-based dietary assessment.

Regarding metadata collected through an IBDA system, we presented existing social network jargon that many are familiar with. For example, some users *tag* the location of a restaurant when posting a food picture. Further, we presented the hypothetical situation of a third party that gains control of a participant's diet data of 1 year. Based on that data, a few aspects of the individual might be inferred. We presented Scenario B and collected responses on what the participants thought can be inferred. The inferred information examples were hypothetical, and to our knowledge, no such work exists. It was designed to evaluate perceptions toward what is possible and how sensitive particular information is to the participant. The responses were collected on a 3-item likelihood and sensitivity *Likert* scale.

In addition to perceived threats with sharing food pictures and subsequently data set, we collected responses about which social groups an individual was voluntarily willing to share information about their diet with. The information as food images and attached metadata typically associated with an image was considered for sharing. In addition to food images, we added additional parameters such as medications and diet plans. The groups provided were *Family*, *Friends*, *Doctor*, *Team*, and *Fans*. Participants indicated their binary responses by checking corresponding blocks in the questionnaire. Additionally, we provided an option if they thought the information is sensitive and they do not wish to share with anyone. At the end of the questionnaire, the participants were asked a series of demographic questions, including some additional ones about their diet and allergy. The collected data from Nettskjema were downloaded and analyzed after the end of the study. The results are presented in the Results section.

Analysis

We performed the Kruskal-Wallis test [38] to determine the differences among responses for E1-E5 based on participants' religious diets. Consistently, we obtained $P>.05$ supporting the hypotheses that the responses are uniform across the participants. The actual P values that we obtained were $P=.14$, $P=.15$, $P=.56$, $P=.18$, and $P=.78$. We performed another set of Kruskal-Wallis tests to determine whether the responses among European and non-European participants had statistically significant differences. For E1-E5, the observed P values, that is, $P=.20$, $P=.14$, $P=.28$, $P=.92$, and $P=.50$ indicated that they were not different. Therefore, we proceeded with reporting ordinal variables in our results by using compound bar charts.

Additionally, we measured consensus among the reported ordinal values by using the Tastle and Wierman's consensus measure [39]. We report the consensus values for E1-E5 as $Cns(E1)=0.59$, $Cns(E2)=0.64$, $Cns(E3)=0.56$, $Cns(E4)=0.61$, and $Cns(E5)=0.52$. We observed a moderate amount of agreement in the reported data. For the concerns and the likelihood of them being inferred from one's dietary data, we performed the Pearson correlation analysis. The perceived *likelihood* did not indicate a strong correlation with the *concern*. The maximum correlation coefficient we observed was between the likelihood and severity of concern for "financial status" with $r=0.41$ ($P<.001$). However, it was still a low correlation. We report our observed ordinal values later in the Results section. We did not use a prediction model in our analysis as we did not find any predictor variables to be significantly related to the outcome in our analysis ($P>.05$).

Recruitment

Chung at al [22] showed that people are more likely to take food pictures when traveling. We leveraged this insight in combination with Goodman's *snowball sampling* methodology [40] to recruit a varied cohort to our study. Initially, we recruited 5 individuals in different regions of the world who were traveling and hence more likely to have reflected on the use of food pictures in our scenarios. We briefed our initial cohort about the goal of our study and provided them with information about the collected data. The initial cohort was then instructed to further recruit other individuals they met throughout their travels who had personal characteristics matching the selection criteria, in accordance with Goodman's methodology. We provided direct support for the participant that had questions about the study. In total, 105 participants responded to our questionnaire.

Of the 105 participants, 99 (94.2%) indicated having an account on a social network. Of the 99 participants, 95 (96%) reported seeing food pictures at least once over social networks. Table 2 summarizes the participants' distribution across various factors such as age, gender, and region. Approximately 47.6% (50/105) of our participants identified themselves as male, 51.4% (54/105) as female, and 0.9% (1/105) as nonbinary. These participants were from 35 different countries around the world, spread over 6 continents. Of the 105 participants, 99 (94.3%) were younger than 35 years, which corresponds to the age up to which peak performances can be maintained by athletes [41]. We also collected information about the participants' education levels. Approximately 90.5% (95/105) of the participants indicated that they attained an education more than high school; 44 participants indicated having higher than a bachelor's degree (postgraduate degree, n=35; doctorate degree, n=9). Only 16.2% (17/105) of the participants were following a strict religious diet. More than one-third of the participants (39/105, 37.1%) indicated having food allergies.

Table 2. Demographic information of the participants (N=105).

Demographic information	Total population, N=105, n (%)	Males, n=50, n (%)	Females, n=54, n (%)	Nonbinary, n=1, n (%)
Region				
Africa	4 (3.8)	0 (0)	4 (100)	0 (0)
Asia	28 (26.7)	19 (68)	9 (32)	0 (0)
Australia	10 (9.5)	5 (50)	5 (50)	0 (0)
Europe	54 (51.4)	22 (41)	31 (57)	1 (2)
North America	6 (5.7)	4 (67)	2 (33)	0 (0)
South America	3 (2.9)	0 (0)	3 (100)	0 (0)
Age group (years)				
18-25	36 (34.3)	8 (22)	28 (78)	0 (0)
25-35	63 (60.0)	37 (59)	25 (40)	1 (2)
35-45	4 (3.8)	4 (100)	0 (0)	0 (0)
45-55	1 (0.9)	0 (0)	1 (100)	0 (0)
55-65	1 (0.9)	1 (100)	0 (0)	0 (0)
Religious diet				
No	88 (83.8)	40 (46)	47 (53)	1 (1)
Yes	17 (16.2)	10 (59)	7 (41)	0 (0)
Allergies				
No	65 (61.9)	38 (59)	27 (42)	0 (0)
Yes	39 (37.1)	11 (29)	27 (69)	1 (3)
Not indicated	1 (0.9)	1 (100)	0 (0)	0 (0)

Results

Overview

In this section, we discuss the perception of privacy and related attitudes based on the findings in our study. We divided our results into expectations and concerns. The expectations cover general perception toward privacy, IBDA methods, and data use. The concerns cover information that can be inferred from their dietary data. Additionally, we discuss the concerns toward exposing such information to a third party from their mobile Food Records (mFRs). Finally, we present our findings regarding the sharing of collected dietary information with different social groups.

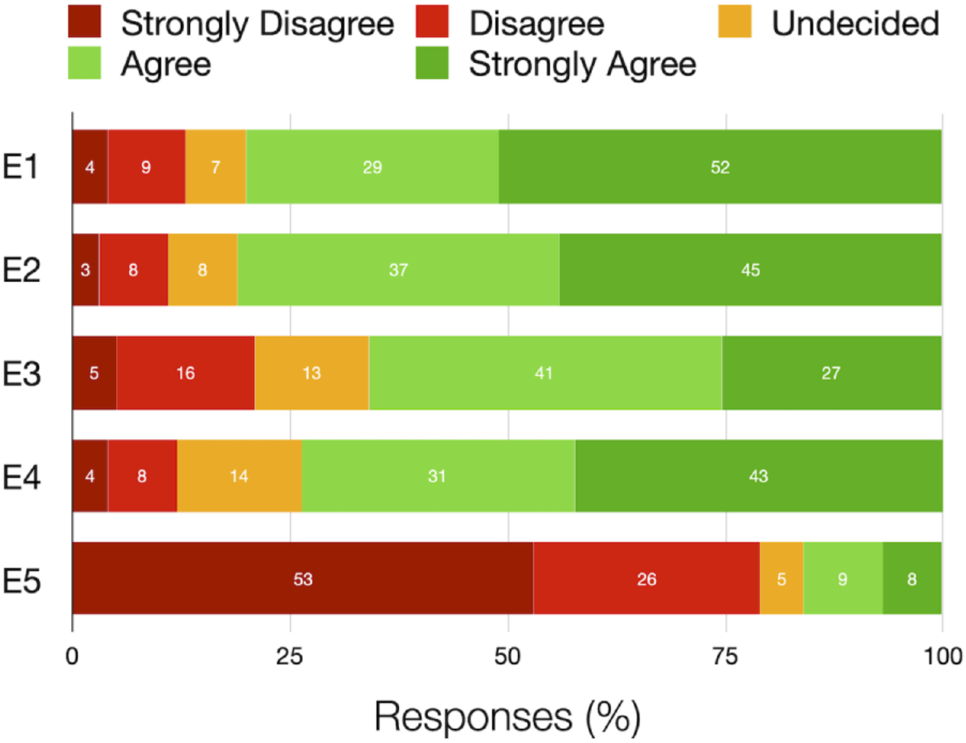
Expectations

We present the general expectations that participants have indicated toward IBDA methods. We also explored their attitudes toward data collection and use.

Effort

Approximately 80.9% (85/105) of the participants agreed that capturing diet records by using a phone camera is easier than writing down their dietary intake (see E1, Figure 1). Individuals could also record audios describing their diets for accurately recording their diets. More than four-fifths of the participants (86/105, 81.9%) preferred capturing photos over recording their diets by voice (see E2, Figure 1). Only some participants were undecided about preferring image capture over writing down or recording audio (7/105, 6.7% and 8/105, 7.6%; respectively). About half of the participants (52/105, 49.6%) had previously posted food images on social networks. We considered these participants as experienced because they are familiar with the required training for an IBDA-based study. Even those participants who lacked experience (53/105, 50.4%) in posting food images showed similar attitudes toward ease of recording their diet intakes by using photography. For a successful IBDA-based study, continuous recording of participants' diets is required. Compared to the irregular posting of images on social networks, continuous recording requires extra effort from a participant. When we asked the intrusiveness of this requirement (see E3, Figure 1), about two-thirds of the participants (69/105, 65.7%) indicated that it would be intrusive.

Figure 1. Collected responses toward E1-E5 (see Table 1). The values in the graph indicate the percentage of responses.



Data Use

Individuals tend to have very little or no information about how their data are being used. Many individuals feel that they have no control [42]. In 2018, general data protection regulation (GDPR) [43,44] granted additional rights to individuals about their data in Europe. In our study, nearly half of our participants (54/105, 51.4%) were based in Europe (see Table 2). We recorded our participants' expectations and attitudes toward data use, some of which are enforced by GDPR. Overall, three-fourths of the participants (78/105, 74.2%) wanted to know about any use of their data (see E4, Figure 1). They preferred it to be explained in simpler terms over the complex "*terms of use*." While Europeans have a legal right to demand such explanations, we excluded data from them to see what the participants from outside Europe prefer. Even among non-Europeans (38/51, 75%), we observed a similar interest in the participants in knowing what their data are being used for.

Concerns

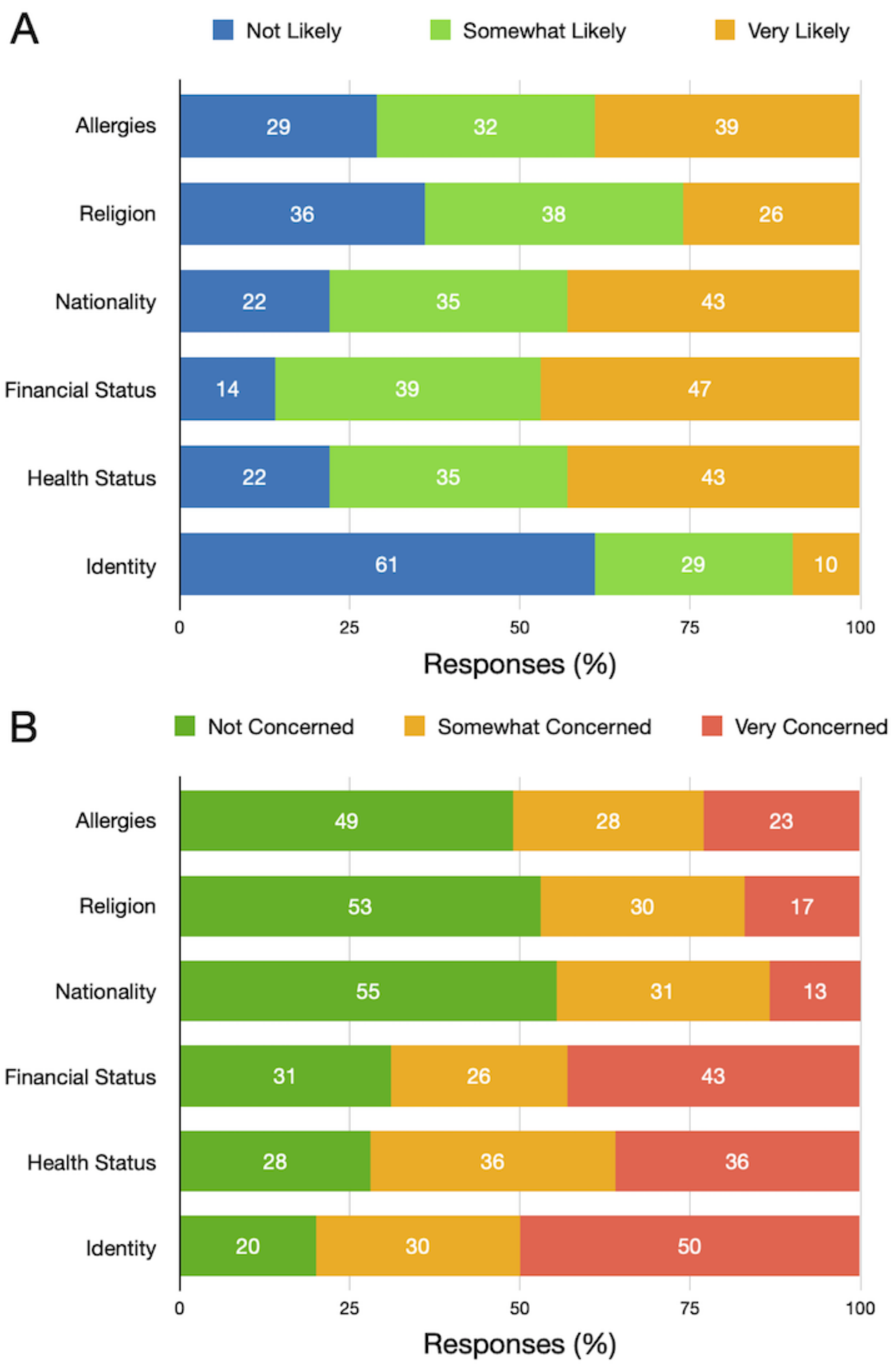
Trust is important for participation in epidemiological research [21]. The early stages of newly developed methods rely heavily on voluntary participation from willing individuals. Building and maintaining trust in research is critical, especially while handling personal information. Data leaks can expose information about individuals that can be sold to third parties with potentially malicious intent. In our study, we presented a scenario in which mFR data of an athlete were leaked to a third party. We are not aware of works inferring information about an individual from their mFRs. We investigated the participants' attitudes toward issues that might arise after their information is leaked. We discuss attitudes toward what is perceived to be exploitable and how much concerned the participants are. We collected the responses on a 3-point Likert scale.

Allergies

With regard to food allergies, only a fraction of the participants (24/105, 22.8%) were very concerned about it being exposed to a third party (Figure 2). About one-third of the participants (30/105, 28.6%) were somewhat concerned. If we only consider only the participants with allergies (39/105, 37.1%), they were found to be relatively less worried. Only 13% (5/39) of the participants with allergies were particularly concerned, while 28% (11/39) indicated somewhat concerned. The majority (23/39, 59%) of the participants with allergies were not concerned about a third party learning about their allergies.

About the possibility of deriving allergies from their mFRs, more than two-thirds (75/105, 71.4%) thought that allergies can be inferred. A little more than a quarter (30/105, 28.6%) thought that it was not very likely to be derived from the mFR of an individual. This trend was very similar among participants with allergies. Approximately 30% (12/39) of the participants with allergies thought that it was not likely that it can be inferred from their mFRs.

Figure 2. A. Perceived inference from image-based dietary assessment data set; B. Concerns toward a third party learning such attributes. The values in the graph indicate the percentage of responses.



Religion

Religious belief is often considered sensitive information in regional laws [43]. It can also affect the dietary choices of an individual. However, depending on the social and cultural aspects, individuals may share this information openly. In our study, about two-thirds (67/105, 63.8%) of the participants indicated that it is likely that their religion can be inferred from their mFRs. As stated earlier in Table 2, 16% (17/105) of our participants followed a strict religious diet. They showed similar traits. Three-fourths (12/17, 76%) of the participants following religious diets indicated that it is likely that their religion can be derived from their mFRs.

With regard to a third party learning about their religion, a little more than half (56/105, 53.3%) of the participants were not concerned. Only 17.1% (18/105) were *very concerned* about a third party learning about their religion. Participants following religious diets (n=17) were slightly more concerned about a third party learning about their religion. Approximately 65% (11/17) of the participants following religious diets indicated that they were concerned about a third party learning about their religion from the mFRs.

Identity

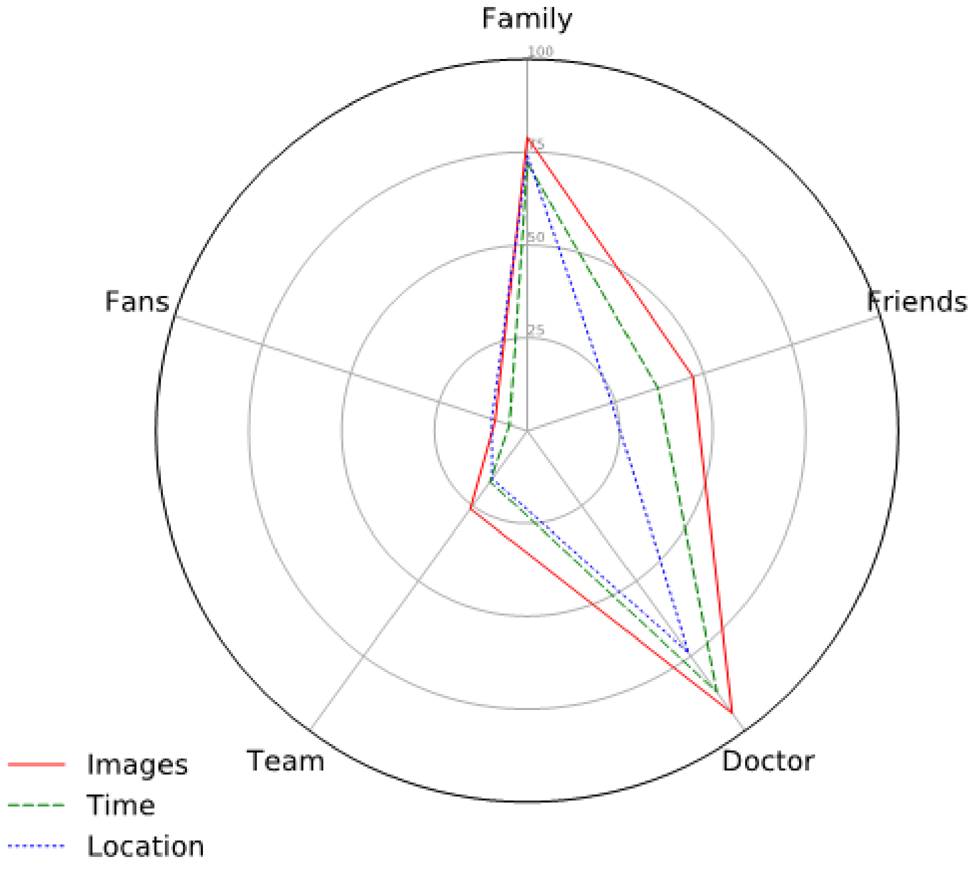
As personalized dietary interventions are more effective [45], IBDA systems may require personally identifiable information. Exposing the identity of an individual is one of the prominent privacy concerns in the modern era [46,47]. With regard to inferring identity from mFRs, participants of both genders showed similar attitudes. The majority (64/105, 60.9%) thought that it was not likely to infer identity from their mFRs (Figure 2). Approximately 70% (38/54) of the females and 50% (25/50) of the males responded that way. While many found it unlikely to infer one's identity from mFRs, exposed identity was still a concern to many of the participants. In terms of gender, male participants showed a slightly higher (41/50, 82% vs 43/54, 80%) concern toward their identity being exposed to a third party when compared to females.

Information Sharing

Information collected by an IBDA system about an athlete's diet provides insights into dietary habits and can guide toward a proper diet. There might be additional metadata collection through an IBDA system. The information collected in the form of food images along with metadata can be mined for other purposes as well. For example, the time of dietary intake can be useful for maximizing performance on the field or predicting burnout. Similar to trends on social networks [22], an athlete might be interested in sharing this information with different social circles. We collected responses about sharing this information with different social groups as an athlete. The results showed that participants favored sharing information mostly with their doctors and family (see Figure 3).

About three-fourths (79/105, 75.2%) of the participants showed willingness to share food pictures continuously with family. In comparison to the social group *family*, the participants were more willing to share food images with their *doctors* (94/105, 89.5%). Only a quarter (26/105, 24.8%) of the participants showed willingness to share food pictures with their sports *team* while nearly half (47/105, 44.8%) showed willingness to share food pictures with *friends*. In terms of the metadata associated with dietary data, such as the time of the meal, the willingness to share further drops. Only 68.6% (72/105) of the participants agreed to share the *time of the meal* with their families in comparison to 82.9% (87/105) sharing the time of the meal with their doctors. Time of food intake is in fact an important consideration for elite athletes and coaches with respect to restitution and training planning.

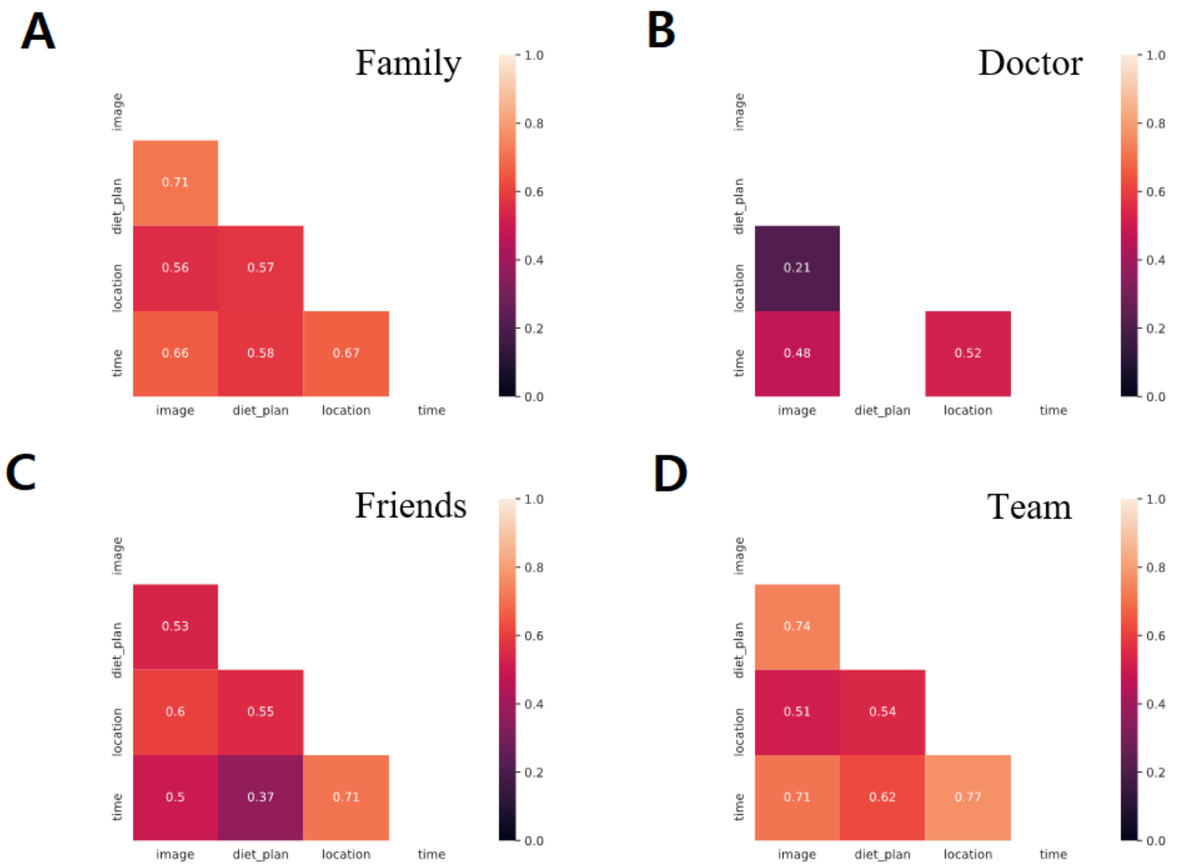
Figure 3. Radar plot showing willingness to share information with different social groups.



Individuals are more cautious about sharing their location. Only 70.5% (74/105) expressed willingness to share the location associated with diet records with *family* and also with *doctor*. Unsurprisingly, participants were not very keen on sharing location with their fans (10/105, 9.5%). About 16.2% (17/105) of the participants did not want to share their location of places they eat with anyone.

Figure 4 shows the correlation values between different metadata sharing behaviors within a group. We ignored the responses from participants who indicated their unwillingness to share with anyone. All of the remaining participants agreed on sharing the food image, diet plan, and time of eating food with a *doctor*. There was a weak correlation between willingness to share location along with the food image with a *doctor.* Within the *family* group, there was a strong correlation in sharing diet plan and time. In terms of sharing metadata with one's team, we observed a strong correlation between diet plan and food image. The willingness to share time and location with one's team was also strongly correlated.

Figure 4. Pearson correlation values for sharing meta-information such as food image, diet plan, location and time between different social groups A. Family; B. Doctor; C. Friends; D. Team. The values indicate the correlation between the willingness, or lack thereof, to share meta-information.



Discussion

In this paper, we present our findings on the perception of privacy for an IBDA system. Our findings provide a coarse view of privacy attitudes toward conducting dietary assessments with food images. Expanding upon prior works [7,18], these results explore contextual privacy violations for an IBDA system. Trust is crucial for voluntary participation in epidemiological studies [21]. When designing such systems, following Privacy by Design guidelines is beneficial for addressing privacy concerns early on and building trust. We found that participants indicated a strong dislike toward data use without consent. Explaining data collection and processing with easy-to-understand terms seems to be of interest to users. Public engagement in cohort studies is crucial for their success. We conjecture that incorporating these parameters can deliver a pleasant experience and increase users' trust in the system.

Personalized dietary interventions are more effective than universal recommendations [45]. However, these interventions require additional information about the user, some of which may be considered sensitive from the legal or an individual's point of view. In this context, information such as food allergies can be acquired by third parties to improve recommendations. The additional information about a user can lead to identity leaks. Similar to previous works [46,47], identity is still a top concern for individuals interacting with web-based systems. It might be useful to prevent that in design by separating the authentication and data storage for mFRs. Accordingly, careful considerations should be taken to share inferred details about an individual, preferably only to individuals that the user has consented to share with. In this study, the participants were not worried about whether a third party could learn about their religion from their mFRs. However, regional privacy laws may restrict sharing such information [43]. These findings are not intended to replace legal requirements while building systems. They complement them to build a trustworthy system.

Our initial assumption from the study by Chung et al [22] was that individuals are willing to share food pictures over social networks. However, we experienced the opposite for long-running continuous studies. In our study, individuals preferred to share dietary data with groups who have a clear and stated use for it, such as their dietician. Another trusted group for information sharing is family. Individuals show different behaviors for sharing metadata. Thus, metadata require different sharing policies than images. For an IBDA system, this means that metadata need to be scrubbed from a food image and stored separately.

Sharing an athlete's data with fans can be an interesting opportunity to engage with followers, such as for crowd support using HeartLink [48]. However, our study shows that individuals might refrain from sharing their data. Participants show greater willingness to share information with groups they trust or when they know what it will be used for. Motivating users to share self-reported data can be challenging. Functionality, ease of use, and privacy are considered crucial for any self-reporting health app [49]. Even chronically ill patients are willing to share data if they receive personalized feedback [49]. Such attitudes can lead to exploring use-based privacy policies for their data [50].

Elite sport clubs, particularly in our elite soccer domain, have nutritional experts hired as part of their management and support team. Such experts are involved in providing detailed dietary plans for their athletes, and they know in detail about most of the common meals provided on-premise for the athletes. For instance, our main elite soccer clubs involved in our cooperation, as a rule, have breakfast and lunch together in their training facilities. Involving such experts using our proposed scheme means that they receive the needed data from their athletes when outside the training facilities to complete the picture.

We investigated the privacy perceptions and concerns for conducting long-running studies using IBDA methods. For epidemiological studies, it is important for users to continuously record diets without any biases. In this study, individuals preferred recording diets using a digital camera over other methods. However, taking a picture of every meal is still perceived as intrusive for some users. For long-running studies, prediction models can be employed to reduce the labor of taking pictures [18]. In summary, this study provides initial insights into the privacy requirements for an IBDA system. Thus, our work provides the basis for discussion in the research community for building and deploying IBDA systems for population-wide studies.

Our study has the following limitation. A questionnaire-based study fails to identify the causation of behavior. For privacy reasons, we did not collect the contact information from the participants. Hence, any further study with the same set of participants is not possible.

In conclusion, we conducted a questionnaire-based study to understand the privacy perceptions and concerns for building IBDA systems. The privacy concerns can be addressed during the design phase to mitigate risks and strengthen participants' and stakeholders' trust in a system. We find a growing interest to know what the collected data are being used for. While IBDA methods are preferred for ease of use, continuous assessment is still seen as intrusive. GDPR compliance is an attractive feature for individuals worldwide. While uncertain about the inferences from mFRs, identity remains a top concern with regard to privacy for individuals. Knowing what the data is being used for, increases the chances of it being shared. Individuals are concerned about metadata sharing with third parties. We recently started a large interdisciplinary study involving computer scientists, sports scientists, psychologists, mathematicians, and medical experts (epidemiologists, nutritional scientists, physicians). Our select cohort includes over 400 female elite soccer athletes, from Norway to Portugal, and we intend to conduct our next study in this cohort.

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Conflicts of Interest

None declared.

Multimedia Appendix 1
The complete questionnaire from nettskjema.
[PDF File (Adobe PDF File), 1706 KB - humanfactors_v7i4e19085_app1.pdf]

Multimedia Appendix 2
The collected data from the study along with column descriptions for reproducing results. The readme and column descriptions are available in markdown format and PDF. The data file is available in TSV (tab-separated values) format.
[ZIP File (Zip Archive), 72 KB - humanfactors_v7i4e19085_app2.zip]

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Abbreviations

GDPR: general data protection regulation
IBDA: image-based dietary assessment
mFR: mobile food record
mHealth: mobile health

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Original Paper

New Patient Education Video on Colonoscopy Preparation: Development and Evaluation Study

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Abstract

Background: Although several patient education materials on colonoscopy preparation exist, few studies have evaluated or compared them; hence, there is no professional consensus on recommended content or media to use.

Objective: This study aims to address this need by developing and evaluating a new video on colonoscopy preparation.

Methods: We developed a new video explaining split-dose bowel preparation for colonoscopy. Of similar content videos on the internet (n=20), the most favorably reviewed video among patient and physician advisers was used as the comparator for the study. A total of 232 individuals attending gastroenterology or urology clinics reviewed the new and comparator videos. The order of administration of the new and comparator videos was randomly counterbalanced to assess the impact of presentation order. Respondents rated each video on the following dimensions: information amount, clarity, trustworthiness, understandability, new or familiar information, reassurance, information learned, understanding from the patient's point of view, appeal, and the likelihood of recommending the video to others.

Results: Overall, 71.6% (166/232) of the participants preferred the new video, 25.0% (58/232) preferred the comparator video, and 3.4% (8/232) were not sure. Furthermore, 64.0% (71/111) of those who viewed the new video first preferred it, whereas 77.7% (94/121) of the participants who viewed the new video second preferred it. Multivariable logistic regression analysis also demonstrated that participants were more likely to prefer the new video if they had viewed it second. Participants who preferred the new video rated it as clearer and more trustworthy than those who preferred the comparator video.

Conclusions: This study developed and assessed the strengths of a newly developed colonoscopy educational video.

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KEYWORDS

bowel preparation; evaluation study; medical informatics; information dissemination; information literacy; patient preference; implementation science; translational medical research; patient education

Introduction

Background

The lifetime risk of developing colorectal cancer is 4.5% among men and 4.2% among women in the United States [1]. The chief defense against colorectal cancer morbidity and mortality is through prevention and early detection by screening for colorectal cancer and precursor colorectal polyps. Colonoscopy is essential as the first-line colorectal cancer screening test, to follow up on the positive results of other initial colorectal cancer screening tests, for surveillance of those with colorectal neoplasia, and for assessment of symptoms such as rectal bleeding. An accurate and successful colonoscopy involves an onerous patient preparation, including cleansing the colon of residual materials. However, 10% to 20% of colonoscopies continue to fail because of poor preparation [2]. Poor preparation can lead to increased duration and repetition of the colonoscopy [3], which, in addition to recipient inconvenience and worse health care outcomes, leads to increased costs [4]. Educational materials such as videos can improve bowel preparation and may reduce the need for repeat colonoscopy [5,6].

Colonoscopy is an invasive test, and there can often be a considerable amount of anxiety associated with this procedure [7]. One way to mitigate this anxiety is by providing patients with information [8]. Much of the existing information is available in written format. Our research team recently published a study evaluating revised written colonoscopy materials that were found to be superior to existing written materials [9]. However, past research by a related group found that people are interested in health information delivered in a variety of formats, including written and video formats [10-12]. In fact, clinicians use a range of different materials to inform patients about colonoscopy preparation [13]. Nevertheless, it is not well understood how patients perceive such information, although enhanced instructions improve the quality of bowel preparation [14]. Previous research indicates that patients and their families have several questions about colonoscopy that are not fully answered by existing resources [15-17]. Moreover, although several educational videos on colonoscopy are available, most of them have not been evaluated systematically. Prior studies have often not asked participants about their information needs or their assessment of the quality of the information provided in the videos.

Most importantly, there are no previous studies that have comparatively evaluated different educational videos. Therefore, physicians and clinical practice groups have little information to guide them in the selection of enhanced educational materials, including educational videos. As such, current guidelines do not recommend specific enhanced instruction materials for colonoscopy preparation, in either written or video format [15].

Information Quality

The field of social psychology has paved the way for evaluation studies examining participants' responses to two or more targets (eg, photos or information about people seen in social settings). However, very little research has been conducted by applying this methodology to compare different health-related resources such as videos. Arazy et al [18] developed an approach to evaluate information quality using heuristic principles of a multidimensional construct including dimensions such as accuracy, completeness, objectivity, and representation. Furthermore, it is important for patients to understand the health information presented to them. Nguyen and Wieland [19] suggested that low health literacy may lead to inadequate preparation, which underscores the importance of making information accessible to people of all backgrounds. Educational videos are advantageous as they may be more accessible to those with low health literacy [20]. The methodology presented in this study allows for an evaluation of the information quality of 2 colonoscopy videos and for clearer judgments about how different resources compare with each other.

Order Effects

Murdock [21] published an influential paper describing the U-shaped serial position curve that depicts the order effects of recall occurring in short-term memory. He went on to explain that primacy effects represent better memory for stimuli presented first, recency effects represent better memory for stimuli presented last, and worst memory occurs for stimuli presented in between, which produces a U-shaped curve. Indeed, people prefer to recall information in forward serial order even when it is not required by the task [22-24]. Most research in this area has focused on the recall of numbers, letters, and words; very little research has been done on the order effects of larger quantities of information, including video clips. We have begun to fill this gap with a recent study examining the order effects of rating colonoscopy information sheets [9]. In that study, we demonstrated a clear order effect for our revised information sheet: a greater preference if it was viewed first.

This research builds on existing research evaluating patient-oriented educational videos by having the same individuals compare 2 videos directly. As the goal of a new video is to be an improvement over currently available videos, we were interested in how the new video compared with an existing high-quality video in terms of quality and patient preference. The new video assessed in this study was developed by our research team. At the time of video development, we were unable to identify a video that clearly described the split-dose method of bowel preparation. The new video was conceptualized to address this content gap, as split-dose bowel preparation has been shown to lead to superior bowel cleansing and higher colonic polyp detection rates [25,26]. Split-dose bowel preparation involves the intake of half of the preparation laxative on the day before colonoscopy and half on the day of the colonoscopy.

Methods

Overview

In 2017, our research team developed a project titled "Optimizing colonoscopy procedures and reducing unnecessary and over use" and explored the information needs and preferences of patients undergoing colonoscopy [16]. On the basis of the expressed needs and inputs from patients and health care providers, we developed revised educational resources for patients considering or preparing for colonoscopy. The educational materials went beyond simply explaining the preparation instructions and used visual aids and clear language with less medical jargon, shorter sentences, and brief paragraphs, with the goal of making the information clearer to the average reader [27,28]. Given that visual explanations may enhance learning [29], we also developed videos to demonstrate a patient's experience of preparing for and undergoing a colonoscopy. These and other educational materials developed by our research team (including videos) can be accessed at MyColonoscopy [30]. The written materials have Creative Commons licenses; therefore, they may be used in other settings.

Video Selection

New Video Development

To supplement the written materials available on the MyColonoscopy website, our team developed 2 colonoscopy educational videos. The content for the step-by-step patient education video on preparation was informed by a study that included the development of a novel patient educational booklet [31]. A recent review [32] of web-based colonoscopy bowel preparation videos further assisted efforts to identify key content areas to address in the videos. Finally, an expert advisory group and interviews with individuals who had recently undergone colonoscopy provided additional insights on the barriers to good quality colonoscopy preparation [33]. Feedback from advisory groups ultimately led to a much stronger final product. As our research team is located in Canada, versions of this video are available in both English and French. We developed videos for colonoscopy preparation and patient experience for colonoscopy. In this study, we evaluated the English version of the video on preparing for colonoscopy (the video is 6 minutes long).

Comparison of Video Selection

The comparator video was selected by searching YouTube with terms such as "colonoscopy preparation," "preparing for colonoscopy," "colonoscopy prep," and "bowel prep." The results yielded several (n=20) videos that varied in length (some were too long compared with the length of the new video), varied in the amount of information provided on the process of bowel preparation, and did not involve a demonstration of the preparation. Ultimately, we narrowed it down to 3 videos that were relatively short (under 10 min) and focused on the bowel preparation aspect of colonoscopy. We then surveyed the expert advisory (individuals who had not participated in the development of the revised video) and patient advisory groups (mentioned above) by asking them to rate each video on the following dimensions: amount of information, clarity, trustworthiness, ease of viewing and understanding, novelty or familiarity of the information (very familiar to very new), reassurance (very worried to very reassured), information learned, understanding from the patient's point of view, appeal, and whether they would recommend the video to someone undergoing colonoscopy. The highest-ranked video was from the University of Utah Healthcare and made for a strong comparison with our new video (the video is 3 minutes long). Reference to the video developer or originating site was removed from both videos for evaluation purposes.

Participants

Participants were recruited from the waiting rooms of gastroenterology and urology clinics at the 2 largest hospitals and 2 community-based outpatient gastroenterology clinics in Winnipeg, Manitoba. The patients were seen in this setting for consultation on a wide variety of gastrointestinal and urological problems. Participants were invited by a research assistant to complete a survey evaluating the 2 colonoscopy videos. If the person agreed, the research assistant provided them with an information sheet with a brief description of the study and a web address to complete the survey on the web. They could complete the web-based survey at their convenience. A total of 3 different recruitment approaches were used to recruit participants from the clinics. First, some participants were given a Can $10 (US $7.47) gift card when they agreed to participate but before the completion of the survey; this had a response rate of 46.0% (127 of 276 who were approached to participate completed the survey). Second, some participants received a gift card after completing the survey; this had a response rate of 43.8% (77/176). A final recruitment approach involved emailing invitations to participants who had completed previous survey studies by our group. This group received a gift card after completion (response rate of 47%, 28/60). The overall response rate was 45.3% (232/512). All participants reviewed the videos independently after they left the clinics.

Measurement

Participants were asked to review one at a time the new and comparator videos, where the order of video presentation was randomly counterbalanced. They were then asked to rate each video on the following dimensions: amount of information, clarity, trustworthiness, ease of viewing and understanding, novelty or familiarity of the information (very familiar to very new), reassurance (very worried to very reassured), information learned, understanding from the patient's point of view, appeal, and whether they would recommend the video to someone undergoing a colonoscopy. These dimensions were rated using a 5-point Likert-type scale. Open-ended questions included likes and dislikes about the videos and suggestions for improvement. After the participants viewed both videos and responded to these questions, they were asked, "Which video do you think would be most helpful for people who are considering having a colonoscopy?" They were then asked 4 comparison questions on similar dimensions to those described above (ie, clarity, trustworthiness, ease of watching and understandability, and reassurance). Finally, they were asked an open-ended question about why their preferred video was better than the other video. Participants were also asked background questions, including age, sex, primary language spoken, education, history of gastroenterology visits, and history of a colonoscopy. The survey questions used in this study are given in Multimedia Appendix 1. Multimedia Appendices 2 and 3 contain the new and comparator videos, respectively. This study was approved by the University of Manitoba Health Research Ethics Board.

Statistical Methods

IBM SPSS statistics version 24.0 was used to conduct the data analysis. Descriptive statistics (including means and proportions) were used to summarize sociodemographic information and the responses to questions about video ratings and preferences. Confidence intervals are reported as they are typically used in survey research and allow for convenient comparisons within and across different survey questions and groups of respondents. Confidence intervals have been recommended rather than pairwise significance tests for this type of comparison as they help the reader understand the magnitude of differences rather than simply concluding whether a difference is statistically significant [34,35].

Logistic regression was used to examine the predictors of preference for the new video. The following predictors were used: order, previous colonoscopy, gender, age, education, and language most often spoken at home. A median-split approach was used to transform age and education into dichotomous variables.

Open-ended questions were analyzed using a descriptive content analysis approach [36]. Authors MB and JG coded these responses and organized codes into categories.

Results

As can be seen in Table 1, the group viewing the new video first was very similar to the group viewing the comparator video first. More than half of each sample was female and had a little over three years of education after high school. Most of each sample had previously seen a gastroenterologist and undergone a colonoscopy.

Table 1. Sociodemographic characteristics of respondents.

Characteristics	New video first (n=111)	Comparator video first (n=121)
Age (years), mean (95% CI)	52.21 (49.10-55.32)	52.16 (49.61-54.71)
Female, % (95% CI)	52.3 (42.6-61.8)	57.9 (48.5-66.8)
English as primary language, % (95% CI)	92.8 (86.3-96.8)	92.6 (86.3-96.5)
Education (years), mean (95% CI)	15.54 (14.81-16.27)	15.99 (15.26-16.72)
Had visited a gastroenterologist before the current colonoscopy, % (95% CI)	64.0 (54.3-72.9)	71.1 (62.1-79.0)
Had a previous colonoscopy, % (95% CI)	68.5 (59.0-77.0)	59.5% (50.2-68.3)

Video Preference

Overall, 71.6% (166/232) of the participants preferred the new video, 25.0% (58/232) preferred the comparator video, and 3.4% (8/232) were not sure. Table 2 displays the results for participants' preferred video based on the order of presentation. Almost two-thirds of those who viewed the new video first preferred it. Interestingly, more than three-quarters of those who viewed the comparator video first preferred the new video, and there was a larger difference in preference for the new video in this group. Table 3 displays the results for participants' preferred video based on the history of colonoscopy. Almost three-quarters of individuals who had previously received a colonoscopy preferred the new video, whereas two-thirds of those who had not previously received a colonoscopy preferred the new video, with overlapping confidence intervals.

Table 2. Preferred video related to the order of presentation of the videos.

Preference	New video first (n=111)		Comparator video first (n=121)	
	Participants, n (%)	95% CI	Participants, % (n)	95% CI
Prefer new video	71 (64.0)	54.3-72.9	94 (77.7)	69.2-84.8
Prefer comparator video	40 (30.6)	22.2-40.1	27 (19.8)	13.1-28.1
Difference in preference, %	33.4	24.7-42.9	57.9	48.5-66.8

Table 3. Preferred video related to history of colonoscopy.

Preference	Previous colonoscopy (n=148)		No previous colonoscopy (n=84)	
	Participants, n (%)	95% CI	Participants, n (%)	95% CI
Prefer new video	109 (74.3)	66.5-81.1	55 (66)	54-76
Prefer comparator video	39 (23.0)	16.5-30.6	29 (29)	19-40
Difference in preference, %	51.3	43.0-59.6	37	27-48

Table 4 examines the predictors of preference for the new video. Of the 6 potential predictors, only 1 was significant. Participants were twice as likely to prefer the new video if they had viewed the comparator video first, which is consistent with the results from Table 2 (odds ratio 2.20, 95% CI 1.16-4.18).

Table 4. Predictors of preference for new video (n=232).

Predictor	Odds ratio (95% CI)
Order (0[a]=new video first and 1=comparator video first)	2.20[b] (1.16-4.18)
Previous colonoscopy (0[a]=yes and 1=no)	1.31 (0.68-2.54)
Gender (0[a]=male and 1=female)	1.43 (0.76-2.71)
Age (0[a]=aged <55 years and 1=aged ≥55 years)	1.84 (0.97-3.49)
Education (0[a]=<16 years and 1=≥16 years)	0.78 (0.41-1.49)
Language spoken at home (0[a]=not English and 1=English)	1.20 (0.38-3.75)

[a] 0 corresponds to the reference group.

[b] Significance is present if confidence interval does not cross 1.

Video Ratings

Multimedia Appendix 4 displays the overall mean ratings of the evaluated dimensions of each video regardless of the order or previous colonoscopy experience. As can be seen, the new video received higher ratings in all categories except familiarity compared with the comparator video.

Table 5 displays the components of evaluation ratings of the 2 videos by colonoscopy experience (one or more previous colonoscopies vs no previous colonoscopy). It was found that the new video received higher evaluation ratings in almost all categories, regardless of previous colonoscopy experience. Among those who had previously undergone colonoscopy, the new video received significantly higher ratings in every category except trustworthiness. Among those with no prior colonoscopy experience, the new video received significantly higher ratings on the amount of information, understanding from the patient's perspective, video appeal, and whether they would recommend the video. Not surprisingly, individuals who previously had a colonoscopy rated the content of both videos as more familiar.

Table 5. Rating of the dimensions of the current and revised videos, stratified by previous colonoscopy experience.

Dimension	Rating of new video (n=232), mean (95% CI)		Rating of comparator video (n=232), mean (95% CI)	
	Had colonoscopy previously (n=148)	No previous colonoscopy (n=84)	Had colonoscopy previously (n=148)	No previous colonoscopy (n=84)
Amount of information[a]	3.07[b] (3.01-3.13)	3.12[c] (3.03-3.21)	2.82 (2.73-2.92)	2.89 (2.80-2.99)
Clarity[d]	4.31[b] (4.18-4.44)	4.37 (4.26-4.48)	3.75 (3.60-3.90)	4.13 (3.98-4.28)
Trustworthy[d]	4.28 (4.15-4.41)	4.30 (4.16-4.44)	4.01 (3.98-4.26)	4.12 (3.98-4.26)
Easy to watch or understand[d]	4.37[b] (4.26-4.48)	4.27 (4.15-4.40)	3.90 (3.76-4.04)	4.13 (3.97-4.29)
Familiarity[e]	1.95[b] (1.78-2.12)	3.41 (3.12-3.68)	2.10 (1.93-2.26)	3.49 (3.24-3.74)
Reassurance[f]	3.85[b] (3.72-3.97)	3.73 (3.53-3.92)	3.46 (3.32-3.60)	3.55 (3.38-3.71)
Information learned[d]	4.01[b] (3.87-4.14)	4.14 (4.00-4.28)	3.68 (3.54-3.81)	3.86 (3.67-4.05)
Understand patient's point of view[g]	3.91[b] (3.76-4.06)	3.95[c] (3.79-4.11)	3.30 (3.13-3.47)	3.54 (3.31-3.76)
Appealing[d]	3.98[b] (3.85-4.11)	3.93[c] (3.76-4.09)	3.39 (3.24-3.54)	3.52 (3.35-3.70)
Recommend video[d]	4.28[b] (4.17-4.39)	4.23[c] (4.09-4.36)	3.70 (3.54-3.85)	3.83 (3.65-4.02)

[a] The amount of information was rated on a scale from 1 (too little) to 5 (way too much).

[b] These values denote nonoverlapping confidence intervals in the previous colonoscopy group; comparison of new versus comparator video.

[c] These values denote nonoverlapping confidence intervals in the no previous colonoscopy group; comparison of new versus comparator video.

[d] All other variables were rated on a scale from 1 (strongly disagree) to 5 (strongly agree).

[e] The familiarity variable was rated on a scale from 1 (very familiar) to 5 (very new).

[f] Reassurances were rated on a scale from 1 (very worried) to 5 (very reassured).

[g] Understand patient's point of view (understanding what it is like to have a colonoscopy from the patient's point of view).

Table 6 displays the components of the evaluation ratings of the 2 videos according to the order of presentation of the videos. It was found that the new video received higher evaluation ratings regardless of the viewing order. Participants who viewed the new video first provided higher ratings to it in every category except trustworthiness and familiarity. If the comparator video was viewed first, it did not obtain any ratings higher than the new video.

Table 6. Evaluation of the dimensions of the current and revised videos, stratified by the order of presentation of videos.

Dimension	New video viewed first, mean (95% CI)		Comparator video viewed first, mean (95% CI)	
	New video (n=111)	Comparator video (n=111)	New video (n=121)	Comparator video (n=121)
Amount of information[a]	3.05 (2.99-3.12)	2.67 (2.55-2.78)	3.12 (3.04-3.19)	3.02 (2.95-3.08)
Clarity[b]	4.28[c] (4.14-4.42)	3.66 (3.51-3.86)	4.38 (4.26-4.50)	4.07 (3.93-4.22)
Trustworthy[b]	4.19 (4.03-4.35)	3.96 (3.82-4.09)	4.37 (4.26-4.48)	4.14 (4.00-4.28)
Easy to watch or understand[b]	4.31[c] (4.19-4.42)	3.78 (3.62-3.93)	4.36 (4.25-4.48)	4.17 (4.03-4.31)
Familiarity[d]	2.36 (2.12-2.60)	2.51 (2.29-2.74)	2.58 (2.33-2.83)	2.68 (2.44-2.91)
Reassurance[e]	3.69[c] (3.55-3.82)	3.34 (3.19-3.50)	3.91 (3.75-4.07)	3.63 (3.49-3.77)
Information learned[b]	4.08[c] (3.96-4.20)	3.48 (3.32-3.64)	4.03 (3.87-4.19)	3.98 (3.84-4.12)
Understand patient's point of view[f]	3.75[c](3.59-3.91)	3.32 (3.14-3.51)	4.09 (3.94-4.25)	3.44 (3.24-3.64)
Appealing[b]	3.78[c] (3.64-3.91)	3.29 (3.10-3.47)	4.13 (3.98-4.28)	3.58 (3.44-3.72)
Recommend video[b]	4.16[c] (4.05-4.27)	3.49 (3.30-3.68)	4.35 (4.22-4.48)	3.98 (3.84-4.12)

[a] The amount of information was rated on a scale from 1 (too little) to 5 (way too much).

[b] All other variables were rated on a scale from 1 (strongly disagree) to 5 (strongly agree).

[c] Denotes nonoverlapping confidence intervals in the group that viewed the new video first.

[d] The familiarity variable was rated on a scale from 1 (very familiar) to 5 (very new).

[e] Reassurances were rated on a scale from 1 (very worried) to 5 (very reassured).

[f] Understand patient's point of view (understanding what it is like to have a colonoscopy from the patient's point of view).

By comparing with the 2 videos (Table 7), it was found that participants who preferred the new video gave higher clarity and trustworthiness ratings than those who preferred the comparator video.

Table 7. Comparison ratings of videos, stratified by preferred video.

Comparison dimension	Preferred new video (n=165), mean (95% CI)	Preferred comparator video (n=58), mean (95% CI)
Clarity compared with the other video[a]	3.42[b] (3.30-3.54)	2.79[b] (2.58-3.01)
Trustworthiness compared with the other video[c]	2.89[b] (2.76-3.02)	2.38[b] (2.20-2.56)
Readability or understandability compared with the other video[d]	3.21 (3.08-3.34)	2.91 (2.71-3.12)
Reassurance compared with the other video[e]	3.09 (2.97-3.22)	2.81 (2.62-3.00)

[a] Rating scale for clarity is from 1 (less clear than the video I did not prefer) to 4 (clearer than the video I did not prefer).

[b] Denotes nonoverlapping confidence intervals.

[c] Rating scale for trustworthiness is from 1 (less trustworthy than the video I did not prefer) to 4 (more trustworthy than the video I did not prefer).

[d] Rating scale for readability is from 1 (less easy to read and understand than video I did not prefer) to 4 (easier to read and understand than video I did not prefer).

[e] Rating scale for reassurance is from 1 (more worrying than the video I did not prefer) to 4 (more reassuring than the video I did not prefer).

Multimedia Appendix 5 displays the components of evaluation ratings of the 2 videos by education level (low education=less than 16 years vs high education=16 years or more). It was found that the new video received higher evaluation ratings regardless of the education level. Those in the lower education level group rated the new video more favorably than the comparator video in almost all dimensions (other than *familiarity*).

Multimedia Appendix 6 includes the Pearson correlations of the variables used to evaluate the 2 videos. Cohen [37] suggested cutoff scores for small (*r*=.1), medium (*r*=.3), and large (*r*=.5) Pearson correlations. For the new video, almost all the correlations were significant at the .01 level. For instance, there were moderate and significant positive correlations for clarity and trustworthiness, ease of watching or understandability, reassurance, patient's point of view, appeal, and likelihood of recommending the video to others. Familiarity was not related to most variables; however, it was positively associated with the information learned. A very similar pattern was observed for the ratings of the comparator video. The small-to-moderate size of most correlations suggest that the concepts are related but not completely overlapping. Appeal and recommendation of the video to others had moderate-to-large positive correlations in most categories, suggesting that these 2 (appeal and recommendation to others) are summarizing variables.

In the content analysis of open-ended questions, we found that many participants liked the amount of information or details in the new video, whereas others felt that the new video contained too much information and thought that the video was too long. The amount of information in the new video was identified as a strength among those who preferred it. On the other hand, the shorter video length was identified as a strength among those who preferred the comparator video. Many participants commented on the pacing of the video and found the narration in the new video to be easier to listen to and follow; many felt that the pace of the comparator video was too fast. Regardless of the video, clarity of the information was important to viewers. Visuals and graphics within the video were important for a few respondents. A few participants indicated that they would have liked information about *red flags* (ie, things that could go wrong) related to the preparation.

Discussion

Principal Findings

We have developed and assessed patient preferences for a new colonoscopy educational video. This is one of the first studies to evaluate revised educational materials and directly compare them with existing materials among a group of participants (a within-subject design). It builds on a recently published study by our group [9] that outlined a novel methodological approach for evaluating consumers' judgments concerning the quality of newly developed written colonoscopy information in comparison with existing written information.

An order effect was demonstrated in the previous study and in this study. Participants were twice as likely to prefer the new video if they had viewed the comparator video first—the recency effect; that is, if the new video were viewed second, it was more strongly preferred. These findings emphasize the importance of counterbalancing in a comparative design study to ensure that order effects are assessed and accounted for. There has been little previous research done in this area, particularly regarding the evaluation of health information, including patient colonoscopy preparation educational materials.

In this study, we also examined whether there was a difference in response rate using different recruitment methods. A similar response rate among different recruitment methods suggested that the participants were unlikely to complete the survey if they were provided a gift card before the completion of the survey. It will be more efficient (and economical) in future studies to provide a gift card after the completion of the survey.

We are not aware of any previous study that compared 2 colonoscopy educational videos in a randomized controlled trial (RCT). An RCT compared standard written colonoscopy preparation instructions with written instructions and a video that provided visual instructions about the preparation process [6]. Patients randomized to the video condition had better ratings of bowel preparation than those in the standard instructions condition, but there was no difference in satisfaction with the procedure.

In our study, almost three-quarters of individuals who had previously undergone a colonoscopy preferred the new video. This is probably because of the fact that people who have previously undergone colonoscopy have a better understanding of the effort and steps required to prepare and undergo the procedure compared with those who have not. However, most participants, regardless of their colonoscopy experience, still preferred the new video. Regardless of previous colonoscopy experience, colonoscopy procedure can still cause significant anxiety in patients. Providing higher quality educational materials can help alleviate some of this anxiety [8]. The new video helped viewers feel more reassured compared with the comparator video, which is important in alleviating some of this anxiety.

Given that many patients do not feel adequately informed about the colonoscopy procedure [16], it is crucial to provide patients with materials to enhance their understanding. In a recent systematic review of enhanced education for bowel preparation (ie, counseling or training sessions, educational booklets, or videos), researchers found that enhanced education methods improve bowel preparation and promote better visualization of the colon in patients preparing for colonoscopy [38]. The advantages of some of these approaches are that they are widely accessible and cost less [38]. A video may have an additional advantage of being comprehensible to people of varying levels of health literacy [20]. Previous research has demonstrated that the comprehension of colonoscopy information is one factor that is related to health literacy and suggests the importance of developing materials for individuals with varying levels of health literacy [39]. In this study, participants with lower levels of education rated the new video more favorably than the comparator video in almost all dimensions, which suggests an enhanced role of the new video in clinical practice. On the other hand, written materials have an advantage as patients can review specific sections of information that are of interest to them. Therefore, presenting information in different formats provides consumers the options to select their preferred format for obtaining information.

Limitations

This study has a few limitations. First, most participants were enrolled in this study through waiting room recruitment; therefore, whether the results would be generalizable to those coming directly for colonoscopy will need to be evaluated in future studies. Although the overall response rate was reasonable (232/512, 45.3%), we cannot comment on the perceptions of nonrespondents, as in any other survey study. The survey included a reasonable number of people (84/232, 36.2%) with no previous experience with colonoscopy. The survey included mainly older adults and had a limited number of people who were younger, did not speak English at home, and had very limited education. This may limit the generalizability of the findings to these other groups.

Conclusions

We have developed a new colonoscopy educational video based on the reported needs of patients and health care providers and demonstrated patients’ preference for this new resource as compared with a high-quality video. We have also developed an approach to evaluate and compare different educational materials, which yielded a preference for the new educational video. This study extended our previous findings with counterbalanced presentation of information [9], demonstrating an order effect in evaluation studies. This approach can be used to evaluate other patient-centered information materials. The next step in this research would be to determine whether the new (patient-preferred) video has a better impact than a comparator video on the quality of the bowel preparation and/or leads to more successful colonoscopy and assessment among different patient populations. Other future directions include determining (1) the effectiveness of video education for colonoscopy among very low-literacy populations and among populations who have historically poor preparation rates and (2) whether providing a *good* educational video on the web increases the likelihood of primary care practitioners providing information on bowel preparation for colonoscopy to patients and/or encourages patients to ask for the split-dose method of bowel preparation (more efficacious but involving early morning awakening). A final area of future study should be the effects of video length and presentation on its effectiveness (eg, diversity of the person in the video and/or whether trustworthiness is increased if a physician is profiled rather than a patient).

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Authors' Contributions

MB participated in the study design, data analysis, data interpretation, and preparation of the manuscript. JG participated in the study design, data collection, and manuscript preparation. PF participated in video development and manuscript preparation. GR participated in obtaining funding and a survey design. JW participated in obtaining funding, survey design, and data interpretation; unfortunately, he passed away before drafting the manuscript. HS participated in obtaining funding, study design, data interpretation, and manuscript preparation. All authors (other than JW) read and approved the final manuscript.

Conflicts of Interest

None declared.

Multimedia Appendix 1
Survey questions.
[DOCX File , 26 KB - humanfactors_v7i4e15353_app1.docx]

Multimedia Appendix 2
New video.
[MP4 File (MP4 Video), 19264 KB - humanfactors_v7i4e15353_app2.mp4]

Multimedia Appendix 3
Comparator video.
[MP4 File (MP4 Video), 25451 KB - humanfactors_v7i4e15353_app3.mp4]

Multimedia Appendix 4
Overall ratings.
[DOCX File , 15 KB - humanfactors_v7i4e15353_app4.docx]

Multimedia Appendix 5
Table with ratings stratified by education.
[DOCX File , 110 KB - humanfactors_v7i4e15353_app5.docx]

Multimedia Appendix 6
Correlations.
[DOCX File , 108 KB - humanfactors_v7i4e15353_app6.docx]

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Abbreviations

RCT: randomized controlled trial

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Original Paper

Young People’s Attitude Toward Positive Psychology Interventions: Thematic Analysis

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Abstract

Background: Digital instantiations of positive psychology intervention (PPI) principles have been proposed to combat the current global youth mental health crisis; however, young people are largely not engaging with available resources.

Objective: The aim of this study is to explore young people’s attitudes toward various PPI principles to find ways of making digital instantiations of them more engaging.

Methods: We conducted an explorative workshop with 30 young people (aged 16-21 years). They rated and reviewed 29 common PPIs. Ratings and recorded discussions were analyzed using thematic analysis.

Results: Some interventions were conflicting with young people’s values or perceived as too difficult. Participants responded positively to interventions that fit them personally and allowed them to use their strengths.

Conclusions: Values, context, strengths, and other personal factors are entangled with young people’s attitudes toward digital instantiations of PPI principles.

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KEYWORDS

adolescent; mental health; health resources

Introduction

Background

We are in the midst of an escalating global youth mental health crisis [1]. Among all age groups, young people are the most likely to develop mental health problems and the least likely to have access to support [2]. Suicide has become the most common cause of death for boys and second most common for girls aged between 15 and 19 years [3]. The majority of young people do not have sufficient access to mental health support [4]. Many who endure unresolved youth mental health problems consequently deal with them for the rest of their lives [5].

Thus, mental health promotion needs to be more widely available. Research has indicated that the most efficient way of confronting the crisis is by addressing mental health on a population level, as opposed to individual treatment, and that population-level mental health is best improved by expanding mental health promotion services [2].

Positive psychology (PP) is the area of mental health research oriented toward mental health promotion. According to Seligman and Csikszentmihalyi [6], “PP is the scientific study of positive human functioning and flourishing on multiple levels that include the biological, personal, relational, institutional, cultural, and global dimensions of life.” PP is thus complementary to the more conventional disease model of mental health, which is oriented toward resolving mental health problems [7]. The main goal of PP is to improve on positive aspects of mental health, such as well-being and optimism, grounded in the assumption that all human beings have the capacity to flourish, and existing strengths. Theoretically, PP is thus a continuation of humanistic psychology [8] and, more specifically, Maslow’s [9] notions of *health and growth psychology* in contrast to *low ceiling psychology*. In terms of intervention mechanisms, PP is a growing ensemble of diverse evidence-based interventions, which we call positive psychology interventions (PPIs). PPIs are often low in complexity and do not require excessive amounts of time or expert supervision [10]. These are often shared with common *intervention principles* such as forgiveness, mindfulness, and gratitude. Gratitude interventions, for example, have shown to improve life satisfaction, well-being, and positive affect and decrease negative affect [11,12]. To illustrate, one common intervention utilizing the gratitude principles is the *Gratitude Letter*, a reflective writing activity that consists of first writing a letter about all the things a person is grateful for toward another person and then delivering this letter [13]. According to a report from the Lancet Commission on Global Mental Health and Sustainable Development, digital instantiations of existing intervention principles are the most promising avenue for making mental health interventions (including PPI) available to young people because of the wide proliferation of digital devices and the (in principle) ease of scaling up digital solutions for large audiences [14]. Consequently, youth health care providers around the world have started offering them [15,16].

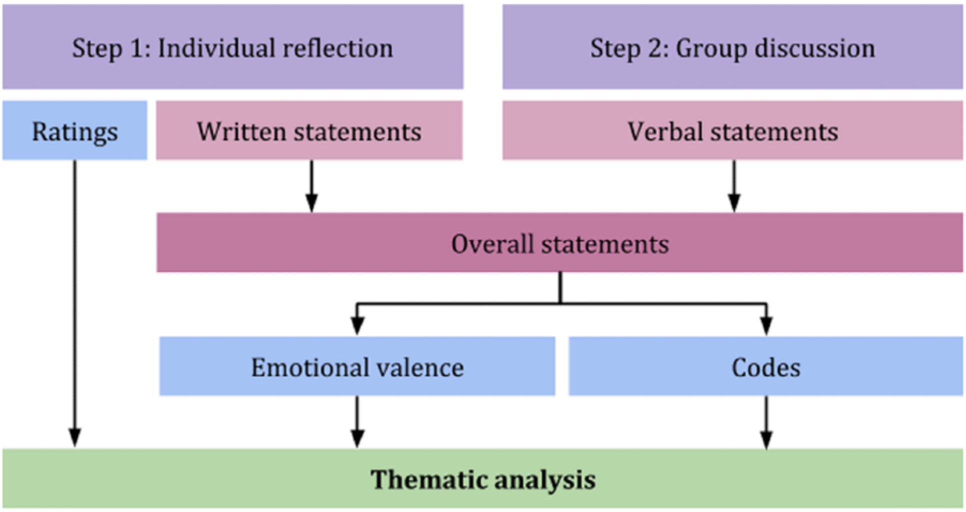
However, despite these ongoing efforts, and despite young people *reporting* interest in using digital instantiations of interventions, young people engage with such digital instantiations only to a limited degree: research revealed low uptake, low adherence, and low engagement of young people with digital mental health promotion [17,18]. A series of focus groups with young people (aged 15-16 years), which explored preferences in relation to mental health promotion apps, highlighted that “content should be made fun and interactive through the use of pictures, music, videos and games” [19]. Subsequently, another group of researchers investigated the degree to which the content of mental health promotion apps aligned with young people’s media preferences, discovering an overreliance on static content, that is, written text, and recommended more visual and interactive solutions [20]. Existing research did not investigate the degree to which these issues are a consequence of how PPI principles are translated for digital platforms, as opposed to being rooted in the PPI principles themselves.

Objectives

To explore this further, we conducted a workshop on young people’s attitudes toward PPI and their underlying intervention principles, with 30 young people aged 16-21 years. We decided on the upper end of the *young people* age range because it allowed us to have more in-depth discussions, as would otherwise potentially have been the case.

The research phase consisted of 2 steps: (1) *individual reflection* and (2) *group discussion*. During step 1, young people individually read, rated, and provided written statements on instructions for 29 common PPIs (refer to the *Methods* section for how we selected them). They received descriptions of the interventions, on paper, alongside a series of Likert scale questions to what degree the interventions fit to them personally and a textbox to express their thoughts in more detail. During step 2, they discussed the interventions in groups of 6. Both written and verbal statements were subsequently categorized by emotional valence, that is, as positive, balanced, or negative and coded. We assessed valence to allow a systematic overview of how positive, neutral, or negatively specific PPI were perceived. All collected data informed the construction of themes according to thematic analysis [21]. An overview of the study process is shown in Figure 1.

Figure 1. Overview of the 2-step research phase.



We will differentiate between specific PPIs (eg, *Gratitude Letter*), the intervention principles (eg, *Gratitude*), and their digital instantiations (eg, an app with which to write a *Gratitude Letter*). The differentiation between interventions, intervention principles, and digital instantiations aligns with the recent calls to focus on the principles more than specific interventions to produce long-term, reliable insights [22].

When analyzing our data, we discovered that the criticisms young people had *for the intervention principles* were similar to the issues that previous research had attributed *to digital translation of the existing PPI*. In other words, a common assumption in digital mental health research has been that—as research provides us with evidence-based interventions—it *only* requires engaging reinterpretations of interventions and (young) people would be interested in them. If the issue with nonengagement was rooted in how we translate interventions for digital platforms, then we would not expect to find the same criticism leveled against conventional, nondigital interventions. However, the findings of this study indicate that the issues young people see in digital instantiations of PPI are in fact *inherited* from their nondigital predecessors. We might not just need to improve the quality of digital interpretations to make them more engaging for young people but might need to reevaluate the appropriateness of their underlying intervention principles.

This paper is structured as follows. We first describe how we recruited 30 young people from a German school to participate in the workshop. We then explain how questionnaires and audio recording during the workshop were used for data collection, followed by how we analyzed the data using common statistical methods and thematic analysis. We then discuss the wider implications of our findings for the design of digital interpretations of PPI for young people.

Methods

Context

This study is part of a project that investigates how technology may be applied for mental health prevention and promotion in young people, especially how digital instantiations may be designed to be engaging for young people. Insights generated from this study will facilitate applied design research, that is, the creation of a digital toolkit to support prevention approaches for young people.

Selection of Methods and Setting

We decided to conduct a workshop with young people for the following reasons. Our goal was to investigate young people's attitude toward PPI; thus, young people would be our participants. Our questions were explorative and open ended; thus, they would best be addressed by predominantly qualitative data. We wanted our participants to speak openly and potentially critically about the subject matter; thus, they should discuss with their peers, reducing the impact of power dynamics between researchers and participants. Finally, we wanted to set up our research in a way that would provide benefits for our participants. Utilizing the multidisciplinary background of our research team, consisting of experts for design, technology, and mental health, we developed a workshop for designing digital instantiations. This workshop explored young people's attitude toward PPI and allowed them to design their own digital instantiations of intervention principles by learning to apply common industry design and design research methods, such as mood boards, personas, and low fidelity (ie, paper-based) prototypes. As a location for the workshop, we decided on a rural German high school with a specialization for art and design. The school we chose prepares students for higher education in artistic disciplines, anticipating they would act as creative design partners (as they did). Methods we taught during the workshop were discussed before with local teachers to make them suitable for the curriculum.

Ethics Approval and Proceedings

We first contacted the Department of Science and Education for the State of Saxony in Germany to inquire about the protocol for conducting research in local schools. They provided us with a series of questionnaires aimed at identifying possible harm and possible benefits for students, which could result from our research. On the basis of our answers, we were given permission to proceed with the study. We then contacted a local school. The school administration allowed the workshop to proceed. We then presented the plans for our workshop to the students. The school administration recommended a specific class for which they assessed the most potential benefit from attending the workshop.

The workshop took place over 3 days before the start of a school holiday. Students of this class were given the choice of attending the workshop or continuing with their regular lessons. All 30 students opted to attend the workshop. As part of enrolling them into the study, every participant received information about the workshop, had the opportunity to ask questions, was informed about their rights as participants, and subsequently signed an informed consent form. For those aged under 18 years, we also required written consent from their legal guardians. All documents were presented and collected during the workshop. Regarding data collection, we decided against video recording of group discussions because of privacy concerns, given the sensitivity of the topic, that is, mental health, and the nature of our participants, that is, young people (a trade-off, which meant that it was not possible to link participants and quotes during data analysis).

Participants

Our workshop had 30 participants, aged 16 to 21 years, with a median age of 18 years and variance of 1.9 years. A total of 50% (15/30) of our participants identified as female, 43% (13/30) identified as male, 3% (1/30) identified as nonbinary, and 3% (1/30) did not self-identify their gender. In terms of nationality, 70% (21/30) identified as German, 10% (3/30) identified as Polish, 3% (1/30) identified as Serbian, 3% (1/30) identified as Taiwanese, 3% (1/30) identified as Malaysian, 3% (1/30) identified as Turkish, and 3% (1/30) identified as Chinese.

Procedure

The workshop was conducted over the course of 3 days and consisted of a research phase and a design phase. The research phase is the focus of this paper and consists mainly of a 120-min long 2-step activity, that is, individual reflection and group discussion. During the subsequent design phase (not a subject of this study), the participants went on to create their own concepts for digital instantiations of PPI principles. The workshop took place in a classroom with nonmovable desks and a maximum capacity of 50. Timeline of the workshop is given in Table 1, and an overview of the general structure is shown in Figure 1. The workshop was moderated by one researcher from our group.

Table 1. Timeline of the workshop.

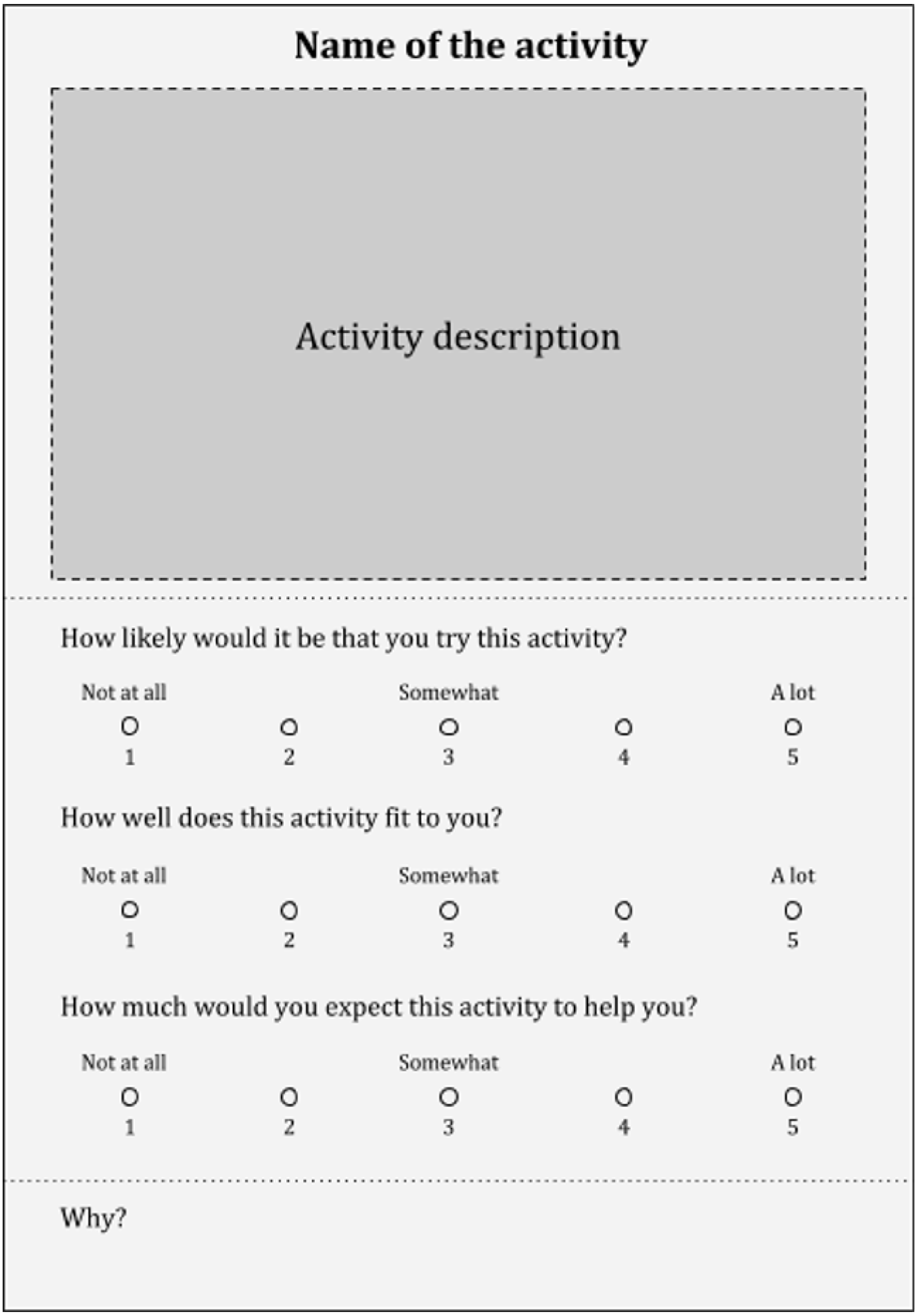
Time	Step	Description
10 AM to 10:15 AM	Introduction	Participants were reminded of the workshop's purpose and informed about the overall structure. They then received a brief introduction to PP[a] to improve their ability to process the later stages. At the end of the introduction, the participants were randomly assigned to 5 groups of 6 participants each.
10:15 AM to 10:45 AM	Step 1: individual reflection	Participants received 4 to 5 descriptions of PPI[b] ("Intervention sheets") so that each group had intervention sheets for all 29 interventions, randomly assigned to participants within groups. The general structure of the intervention sheets can be seen in Figure 2. Participants then individually read the intervention descriptions and answered 4 questions about them: 1. "How likely would it be that you try this intervention?" 2. "How well does this intervention fit to you?" 3. "How much would you expect this intervention to help you?" 4. "Why?" Questions (1) to (3) were rated on a 5-point Likert scale, with 1="not at all" and 5="a lot." Question (4) was answered in writing with space for 2 to 3 sentences (some participants opted to write longer answers on the backside of the sheet).
10:45 AM to 11 AM	Break	N/A[c]
11 AM to noon	Step 2: group discussion	Participants were asked to discuss within their group how much merit they saw in each intervention. This consisted of participants first presenting to each other the interventions they reviewed during step 1 and then discussing them. These discussions were audio recorded through recording devices placed at the center of each group's table. A moderator familiar with PP was available to answer the questions in case the descriptions were unclear.

[a] PP: positive psychology.

[b] PPI: positive psychology intervention.

[c] N/A: not applicable.

Figure 2. Intervention sheet template.



Name of the activity

Activity description

How likely would it be that you try this activity?

Not at all Somewhat A lot
○ 1 ○ 2 ○ 3 ○ 4 ○ 5

How well does this activity fit to you?

Not at all Somewhat A lot
○ 1 ○ 2 ○ 3 ○ 4 ○ 5

How much would you expect this activity to help you?

Not at all Somewhat A lot
○ 1 ○ 2 ○ 3 ○ 4 ○ 5

Why?

Interventions

To assemble a suitable selection of interventions, we consulted a web-based database for mental health experts, the Positive Psychology Toolkit [23]. To our knowledge, at present, the platform is the most comprehensive PP database. In addition, it allowed us to search by intervention principles, that is, family of related intervention strategies [24], for example, *Mindfulness* and *Gratitude*, which was useful when looking for representative PPI from common intervention strategies. We selected interventions based on the following criteria, which we derived from a discussion within our research group:

Youth Appropriateness

The interventions should be applicable to school-aged young people, that is, not explicitly reference *offices*, *coworkers*, *retirement*, or other not age-appropriate concerns, to maximize the likelihood that the interventions would align with the lived experiences of our participants.

Evidence Based

The interventions should be evidence based, that is, based on peer-reviewed research, to exclude interventions that have not yet been shown to provide benefits.

Easy Overview

We excluded *complex* interventions that consisted of multiple phases or sessions or multiweek programs, to have descriptions that would be accessible to our participants. Given that there would be limited time during the workshop for our participants to understand how these interventions worked and that our participants did not have professional mental health backgrounds, we focused on interventions with few steps.

Manageable Amount

We estimated that between 25 and 30 interventions would be ideal, to keep the overall number of interventions low enough so our participants would be able to briefly discuss all of them during a 60-min group discussion. We selected them from 315 PPIs available in the database.

Diverse Content

We included diverse kinds of interventions, spread across domains (eg, communication, happiness, and mindfulness) of varying duration (5- to 60-min interventions) and using a variety of modalities (eg, writing, photos, music, and physical intervention), to prompt a diverse range of responses.

After working through the database and applying our criteria, we arrived at a list of 29 interventions that were considered suitable for the context of the workshop (Table 2). This process was subjective; other researchers may have included some interventions we dismissed and vice versa, especially concerning youth appropriateness and diverse content. However, although an objective selection was not possible, we opted for *intersubjectivity* through consensus within our group and discussed extensively which PPI to include. We apply *intersubjectivity* in the sense of Heidegger's use of the term [25]. As there was no objective answer about which interventions to select, we instead aimed for agreement between subjective opinions within our research group.

The interventions offered by the Positive Psychology Toolkit and PP research in general are strongly influenced by Western cultures, in particular US culture. Descriptions of interventions were entirely in English, so was the underlying research, and so was (likely) the native language of most participants of the studies on which the interventions were originally validated. For our context, that is, young people from Germany, one of the researchers in our group translated the intervention descriptions into German and into a reading level that was appropriate for our participants, for example, removing technical jargons that would not be familiar to readers without a background in mental health. However, cultural assumptions and values within the interventions could not be *localized*, and it is possible that these cultural assumptions and values have had an impact on our participants' responses.

Table 2. Interventions.

ID	Name	Domain	Time (min)
1	Apologizing Effectively	Communication	5
25	Three Loving Connections	Communication	5
17	Nonjudgmental Reflection	Compassion	15
20	Reframing Critical Self-Talk	Compassion	10
21	Self-Compassion Break	Compassion	5
12	Healing Through Writing	Coping	15
15	Initiating Physical Activity	Coping	30
18	Positive Emotion Brainstorm	Emotions	15
26	Using Music to Express Feelings	Emotions	N/A[a]
13	Hope Map	Goals	30
22	Self-Contract	Goals	10
6	Gratitude by Mental Elimination	Gratitude	15
7	Gratitude for Important People	Gratitude	10
8	Gratitude Journal	Gratitude	10
9	Gratitude Letter	Gratitude	20
10	Gratitude Meditation	Gratitude	10
14	Increasing Awareness of Complaining	Gratitude	N/A
2	Chasing Happiness	Happiness	5
3	Creating Flow Experiences	Happiness	45
11	Have-a-Good-Day Exercise	Happiness	10
19	Random Acts of Kindness	Happiness	N/A
23	Spending Money on Others	Happiness	N/A
28	Writing About Intensely Positive Experiences	Happiness	10
4	Creating Quiet Time	Mindfulness	5
24	The Best Possible Self	Mindset	10
5	Daily Motivational Awareness	Motivation	5
27	Using Photography to Increase Savoring	Savoring	10
29	You, At Your Best	Strengths	60
16	My Gravestone	Values	12

[a] N/A: not applicable.

Data Analysis

We collected 146 written responses to interventions from step 1, that is, overall 146 statements the participants wrote on the same sheet of paper on which they rated the interventions. The transcribed group discussions from step 2 resulted in an additional 220 statements, that is, 366 statements overall. We labeled a *statement* any comment that related to how PPIs were perceived; we excluded the descriptions of PPIs and off-topic conversations. Alongside the statements, we also collected Likert scale ratings for all PPIs, which participants made individually during step 1.

Subsequently, thematic analysis [21] was led by one of the researchers, after which the statements were translated into English by a German native speaker (so as to be easily processed by our mostly English-speaking team). The researcher started by reading the statements without initial codes. They wrote down candidate codes while working through the statements, based on what they perceived as the best characterization of the respective statements. After working through all the statements, they started again from the beginning, reapplying codes from the first reading, while extending them with new codes and merging and splitting codes based on further reflection. In addition, the statements' emotional valence was classified as either *positive*, that is, the participant seemed to like the PPI (eg, "What I like about this intervention is..."); *balanced*, that is, it was not clear whether the participant liked the PPI or not (eg, "I don't know what to think of this intervention"); or *negative*, that is, the participant seemed to dislike the activity (eg, "What I don't like about this intervention is..."). This process was concluded after the fourth iteration because during this iteration, no further changes to the codes seemed necessary. The codes were then written out on post-it notes and grouped by perceived thematic similarities. Over the course of 1 week, codes were moved through different group configurations in search for what seemed their most meaningful combination. The process involved 4 researchers from our group and was accompanied by many discussions to reduce bias.

The Likert scale ratings from step 1 and the emotional valence of statements (positive, balanced, or negative) served for additional sense checking. Likert scale ratings were processed by calculating the median rating for each PPI and correlated with certain strategies (eg, *Mindfulness*). We identified 3 major clusters, from which the themes were constructed. We deliberately frame this process as a *construction*, as we follow Braun and Clarke's [21] position that themes do not reside within codes or are discovered. Instead, they result from the active decisions of researchers about what to emphasize and what to deemphasize while purposefully constructing a meaningful narrative [21].

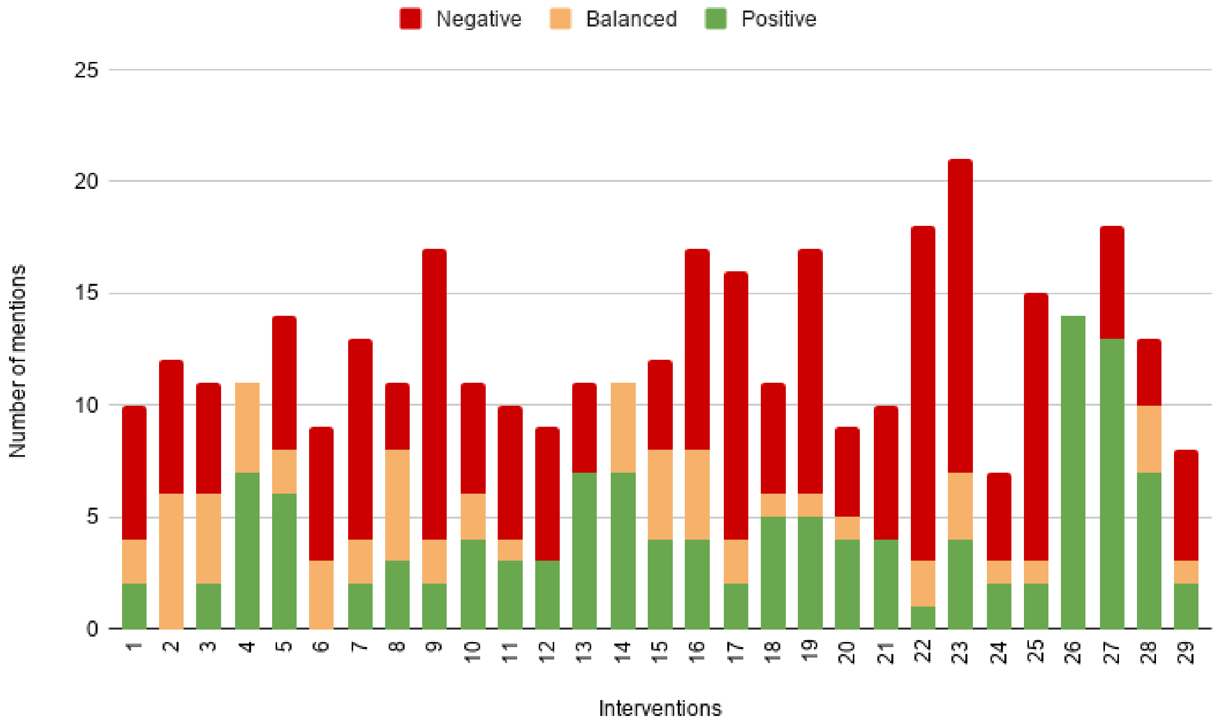
Results

PPIs

Step 1 produced 145 ratings (next to 146 written statements)—5 ratings for each of the 29 PPI—consisting of 3 components (corresponding to the 3 Likert scale questions on the score cards): *inclination* (of participants to try the PPI), *expectation* (of participants that the PPI would help them), and *fit* (to our participants interests). Although there was notable variation in ratings between PPI, within PPI, the 3 aspects (inclination, expectation, and fit) were consistently close (a plot of the data is shown in Multimedia Appendix 1). This suggests that inclination, expectation, and fit were, to our participants, related, although further statistical analysis based on a larger sample would be necessary to make this point with higher confidence. Across all ratings, if a participant gave a low rating for fit, he or she would also give a low rating for expectation and inclination. The same applies to high ratings.

By combining 146 written statements from step 1 and 220 group discussion statements from step 2, we arrived at 366 unique statements participants made toward the 29 interventions. As explained in the *Data Analysis* section, we coded each statement and categorized the emotional valence of statements as either positive, balanced, or negative. Of the 366 statements, 33.1% (121/366) were positive, 16.7% (61/366) were balanced, and 50.3% (181/366) were negative. An overview of emotional valence expressed toward PPI is shown in Figure 3.

Figure 3. Emotional valence expressed toward positive psychology intervention.



Themes

Construction of Themes

We constructed 3 themes from step 1 (ie, individual reflection) and step 2 (ie, group discussion). The rating of step 1 served for additional sensemaking, that is, when deciding whether a candidate subtheme sufficiently reflected trends or majority of opinions during the workshop. For example, if one group would have discussed a certain PPI largely negatively, but the overall rating for this PPI was positive, then we would take this discrepancy into consideration. Practically, the ratings largely aligned with the qualitative statements and thus gave us additional confidence about the appropriateness of subsequent themes. The quotes we decided to highlight are canonical examples of common statements during the workshop.

The first theme deals with points of tension between youth cultures and values embedded in PPIs. The second theme addresses the possibility of PPI failing and how it may impact young people. The third theme is concerned with the impact of individual differences and preferences on our participants' attitude toward PPI.

Theme 1: Youth Cultures

It became evident during the discussions that PPIs have a normative layer and reflect assumptions about desirable behaviors. Strategies involving, for example, gratitude and forgiveness are not morally neutral; instead, they have wrapped into them assumptions about what behaviors are *good* and that lack thereof is thus *bad*. Forgiveness, for example, may be viewed as something positive within the moral system within which PP is situated but has also been described as a trait symbolic of weakness [26]. These moral assumptions created tensions to the degree that they were perceived as diverging from the values and norms of our participants, that is, their cultures. Especially notable were tensions around the areas of (1) *inauthenticity*, (2) *docility*, (3) *pathologization*, and (4) *appropriateness*.

(1) *Inauthenticity*: Our participants were critical of interventions when they pushed toward behaviors that would not have occurred *naturally*. Performing certain behavior against one's inclinations was perceived as dishonest. These types of interventions triggered terms related to oppression, such as *forcing*, *dictating*, and *pushing* (Q1.1 to Q1.3).

Q1.1: Random Acts of Kindness:

> *I think you ought to be friendly to other people because you like them, and because you yourself are a friendly person, otherwise you force yourself into a shape that is not really you.*

Q1.2*:* Three Loving Connections:

> *I think you should spend time with people because you yourself have a personal need for that and not because some plan dictates that you should.*

Q1.3*:* Gratitude Letter:

> *For me this definitely wouldn't work, because, I would feel pushed to write a letter just to make the other person happy, not to actually reflect on the things I'm grateful for.*

(2) *Docility*: A range of interventions was criticized for promoting docile behavior. Our participants spoke negatively about interventions that recommended apologizing and being grateful (Q2.1 to Q2.3). Although they considered that some of these behaviors may be sensible in a measured approach, they worried about people being encouraged to lean toward these behaviors beyond a healthy degree (Q2.1). They also perceived some interventions as accusatory because the intervention sounded to them as if they are not already, for example, apologizing enough (Q2.2).

Q2.1: Apologizing Effectively:

> *The thing is, when I don't have confidence anyway, and then I'm expected to apologize for everything, doesn't that do more harm than good? —Seriously, maybe I apologize already too much. Like, they think you're a completely egotistical person and that you wouldn't apologize by yourself. (...) For me, this wouldn't work.*

Q2.2: Gratitude Letter:

> *I also see a risk in that. Here, with all these Gratitude things. They say, ok, write up what you are grateful for. And if you can't think of anything, are you then un-grateful? But what if there actually are no things to be grateful for? Sometimes you just feel bad, sometimes you get treated badly, and then you are supposed to be grateful. It's like, eat shit and smile. Do you know what I mean? Maybe it needs an un-grateful letter—yeah, to emphasize—to just emphasize all the things that hurt, or that did hurt, or cause problems—and to show that to someone. You hurt me, and I'm not fucking grateful. It's also easy to say what you are grateful for because people want to hear that, there is no barrier. Telling someone, this hurt me, you were unfair to me, you caused me problems, that is much more difficult. And if it's then someone who is above you, like a teacher—yeah you may be laughing but I really could write an un-grateful letter like that to one or two teachers here—but then I only get in trouble.*

Q2.3: Gratitude for Important People:

> *This is like something—I used to go to church as a kid, I had to, and this sounds incredibly preachy, like something my pastor would tell me to do. Maybe this means I'm a bad person, but I actually don't think I need to act like that.*

(3) *Pathologization*: Our participants expressed several times that perceived *negative* behavior may still lie within the range of healthy functioning and that it does not necessarily need to be corrected (Q3.1 to Q3.3). This also intersected with triggers of negative emotions for some, for example, regarding sports and weight loss (Q3.2). Triggering negative emotions is discussed more in theme 2. It was questioned whether happiness *all the time* is necessary and said that being happy *wouldn't mean anything* if its rooted in superficial reasons, such as *antidepressants*—a category within which the participant seemingly also placed PPI (Q3.3). (To note, this criticism may be rooted in us not sufficiently having explained to our participants the difference between hedonic and eudemonic happiness and PP's orientation toward the latter).

Q3.1: Random Acts of Kindness:

> *You may be mentally entirely healthy, and everything is fine and you're still just an asshole. Being an*

> *asshole doesn't mean you're sick or need therapy, it only means you're an asshole.*

Q3.2: Initiating Physical Activity:

> *I know I'm a bit overweight, but that also means that I hear all the time that I'm supposed to do more sports. Weight loss may not be what they have in mind with this intervention, but the topic is still a major trigger for me. Some people just do not like to do sports. It's ok not to like sports. You don't need to do sports to be a normal healthy person.*

Q3.3: Chasing Happiness:

> *Must I feel happy all the time? They seem to assume—if you aren't happy then something surely is wrong with you, so you better try to be happier. Right? It may sound strange, but I think its ok that I don't feel happy all the time. I may not even feel happy most of the time. If I wanted to feel happy all the time, I could just gobble up some anti-depressant meds, but that wouldn't really mean anything, would it?*

(4) *Appropriateness*: Our participants suggested that the appropriateness of a PPI is bound by its context and that context could provide an anchor to normalize an intervention (Q4.2 to Q4.3). Some interventions made more sense to our participants when placed in relation to special times. Although, for example, gift giving without a contextual anchor could appear strange; the birthday of a friend could constitute such an anchor and thus normalize the intervention (Q4.2). Similarly, one participant stated she would feel uncomfortable if given a Gratitude Letter *out of the blue*, that is, lacking a contextual anchor, and that she would feel *disturbed* by it (Q4.1).

Q4.1: Gratitude Letter:

> *Imagine you get a letter like that—I'm just saying, out of the blue a buddy walks up to you and gives you one of those letters, I'd be seriously wondering what the hell went wrong with him. I'm always there for my friends, obviously, and sure I'm happy about the occasional "thanks," but if someone would go through the trouble of writing a letter like that, I probably wouldn't feel happy, more disturbed.*

Q4.2: Spending Money on Others:

> *A friend of mine recently celebrated her birthday—I was feeling a bit down at the time, but I got up and got her movie tickets—and I noticed that when I gave them to her, I actually felt better. I thought that was a bit odd at the time, but now I read this, and I think, yeah, that does make perfect sense to me.*

Q4.3: You, At Your Best:

> *Yeah, so, with this intervention, "You, at your best," I actually did something like this a while back. When I finished middle school, I noticed that in many ways I wasn't really happy with myself. So, before I started here, I sat down at home, and just sketched out how I wanted to be—probably didn't take as much time for it as they recommend here, but essentially the same thing.*

In summary, our participants highlighted a series of issues related to tensions between their personal values and norms and those imbued in PPI. Culture and context seemed to play relevant roles in determining when an intervention would be appropriate. Wider implications of this theme are discussed in the *Discussion* section.

Theme 2: Conditions and Consequences of Failure

Our participants were concerned that many interventions harbored the potential to fail and how they would deal with the setback if that would happen. Related to this, they expressed concerns over PPI inadvertently, making them feel worse instead of better. This theme is structured into the subthemes (1) *intrinsic factors*, (2) *extrinsic factors*, and (3) *triggering of negative emotions*.

(1) *Intrinsic factors*: Participants pointed out an inherent degree of difficulty of some PPIs (Q1.1 to Q1.2). They attributed this difficulty to either the intervention itself (Q1.1), own perceived shortcomings (Q1.2), or a lack of experience with PPIs (Q1.3). One participant compared PPIs with yoga exercises, in that experience is necessary for exercises to become easier but that first starting is the most difficult step (Q1.3).

Q1.1: Creating Flow Experiences:

> *I also think this is difficult—this is complicated, and not necessarily something that you can do quickly. You first must understand all the steps. You almost have to study in order to understand this.*

Q1.2: Nonjudgmental Reflection:

> *It would be difficult for me to not have judgmental thoughts.*

Q1.3: Gratitude Meditation:

> *I mean, I've never done anything like this, maybe for someone who does nothing but meditating from dusk 'til dawn—maybe then that's easy, but seriously—do you understand this? This may be something like yoga, where you get better at doing the poses over time, but it's really damn difficult to get started.*

(2) *Extrinsic factors:* This subtheme relates to difficulties that are not necessarily rooted in the intervention but in some contingent elements, for example, how other people involved in the intervention may respond (Q2.1 and Q2.3) or potentially falling short of overambitious goals (Q2.2). One participant emphasized that getting a positive response from the receiver of a gift during the Spending Money on Others intervention "may actually make you feel better" (it does [24]) but that it still involved a risk of rejection (Q2.1). Risk of rejection also came up during another participant's response to Three Loving Connections, asking what should be done "if the people don't want to meet you though" (Q2.3). Another participant reflected on negative experiences with the New Year's resolutions, which she likened to the Self-Contract PPI and raised the issue of what to do if one falls short of their own set goals (Q2.2).

Q2.1: Spending Money on Others:

> *If you get the wrong response after giving someone a gift then that doesn't really help you. But if you get a positive response—A positive response may actually make you feel better, but it could end up being disappointing otherwise.*

Q2.2: Self-Contract:

> *This "self-contract" thing sounds like new year's resolutions to me—I've been through that with my dad. We planned which grade I should reach in which subject, and then that didn't work out. And then that was just really depressing. So, what happens if I can't fulfill the contract? Then I'm just standing there, disappointed.*

Q2.3: Three Loving Connections:

> *For me, I'd be worried about getting rejected, if I'm honest. I may not be the most social person, and in principle that's ok for me, but if the goal of this intervention is to meet more people—it says nothing what to do if the people don't want to meet you though.*

(3) *Triggering negative emotions*: This subtheme relates to PPIs being a potential cause, that is, trigger, for negative emotions. Both a focus on negative (Q3.1) and positive (Q3.2) memories could, according to our participants, become a trigger for them. Additional risk was identified in relation to Daily Motivational Awareness, an activity that asks people to reflect on what drives them. One of our participants worried how to reconcile if *nothing* motivated her, saying that "realizing that would be really depressing for me" (Q3.3). Explicit reference to a PPI being *depressing* also came up in response to My Gravestone, where people are tasked to reflect on what they would want to be remembered for. The participant noted that this PPI would "put all the focus on dying," saying that they "don't want to think about that" (Q3.4).

Q3.1: Healing Through Writing:

> *What hurt me? That sounds contra-productive. You are supposed to really think deeply about something that hurt you, and really immerse yourself in that pain? Fuck that shit. I don't want that—I really don't want to put a magnifying glass on that. If someone would say, ok, please write this down, then I'd say, piss off, easy as that.*

Q3.2: The Best Possible Self:

> *I'm just feeling that my memory of my "best self" from the past could lead to the thought that this good time is now over and that I've lost something positive. If the response to that would be a clinging to the past, then I don't think that would be good.*

Q3.3: Daily Motivational Awareness:

> *What if nothing motivates me? So, what if I do things only because I must do them, but beyond that I cannot find a reason for it? Realizing that would be really depressing for me.*

Q3.4: My Gravestone:

> *It's as depressing as it sounds. You put all the focus on dying. I don't want to think about that. I mean, I understand—it's supposed to create perspective, ok, but—what I would end up thinking about is dying—and that's just depressing.*

In summary, our participants discussed the risk of interventions failing them, either because the intervention itself may be too complicated or because other factors outside of the intervention may not manifest as they should. They also spoke about the issue of negative emotions being triggered by PPIs. Wider implications of this theme are discussed in the *Discussion* section.

Theme 3: The Impact of Personality and Modality

This theme deals with individual factors in relation to PPI, that is, factors that are highly subjective, differ between people, and are rooted in tastes and preferences. There are 2 subthemes: (1) *impact of personality differences* on PPIs and (2) *role of modalities* within those interventions.

(1) *Impact of personality differences:* Young people are no homogenous group with regards to their interests and preferences, and their individual differences impact how they respond to PPIs (Q1.1 to Q1.4). In some instances, this was explained with reference to personality traits, such as a tendency toward anxiety (Q1.1) or lack of patience (Q1.3). In other instances, participants just noted that an activity would be uninteresting for them, without going into details as to why (Q1.2). One participant who said she was too anxious for meditation referenced an alternative activity that would work better for her, playing soccer (Q1.1). Another participant reflected on a writing-based PPI, saying that she did not have "a talent to write stories like that" (Q1.3). Participants commented positively on PPI, which allowed them to use what they saw as personal strengths (Q1.4).

Q1.1: Gratitude Meditation:

> *I personally don't think this intervention fits to me because I personally am too anxious for meditation. I mean, the goal is to relax, right? I can relax better when playing soccer, or something like that, afterwards I am calm, relaxed.*

Q1.2: Nonjudgmental Reflection:

> *You know me (name redacted), I don't need to try this to know that I wouldn't enjoy this crap at all. Nothing about this is even remotely interesting for me.*

Q1.3: You, At Your Best:

> *I didn't particularly like this, because not everyone got a talent to write stories like that; I mean, to formulate this properly (...) I wouldn't have the patience to sit down, pick something and write it out. For other people this could work, if they had the time and inclination, but for me, or even for most people maybe, this wouldn't work.*

Q1.4*:* Gratitude Journal:

> *Reading an intervention and seeing that it plays off something I'm already good at definitely makes it*

> *more likely for me to try it out. The intervention itself may already be difficult, without me having to deal with something I'm bad at on top of that. For example, I just don't like to write, I'm not good at it, and it frustrates me. So why would I pick an intervention that forces me to write, instead of doing something I'm good at and enjoy?*

(2) *Role of modalities*: Participants commented predominantly negatively on writing-based activities, stating that they would rather avoid this modality if possible (Q2.1 to Q2.2). Conversely, music (Q2.2) and photography (2.3) were commented on positively. In relation to music, one participant stated that "when (she) feels bad, (she) listens to music anyway" (Q2.2). In relation to photography, it seemed more important to one participant that there would be some visual options, "doesn't matter if photos or videos, but something visual would be great for me" (Q2.3).

Q2.1: Reframing Critical Self-Talk:

> *What I like about this one—at least you do not have to write anything—always all this writing with these exercises. This shows, it doesn't have to be writing all the time, you only need to think about it in this exercise, that's much more pleasant—and if I want to write it down, then I can still do that.*

Q2.2: Using Music to Express Feelings:

> *Finally, an intervention that fits to me—When I feel bad, I listen to music anyway—and usually it ends up helping me. I was asking myself when finally, an intervention comes up that I like, most things are just about writing.*

Q2.3: Using Photography to Increase Savoring:

> *Photography would be fun for me—that seems like a great way to store positive memories—doesn't matter if photos or videos, but something visual would be great for me.*

In summary, attitude toward PPIs seemed predicated on personal preferences and strengths, partially in relation to personality and partially in relation to which modalities were dominant in a PPI. Writing components were especially criticized.

Discussion

Context

As described in the beginning, previous research had identified a lack of engagement from young people with digital instantiations of PPI and proposed to explain this through how PP principles are usually instantiated digitally, that is, with an overreliance on static context, such as written text. We investigated whether the lack of engagement of young people with digital instantiations may also be rooted in the underlying intervention principles, from which the digital instantiations PPI are derived. The findings of this study support this assumption; we will now discuss the findings in more detail.

Principal Findings

Steps 1 and 2 of the workshop both explored participants' attitude toward PPI, part of which was the quantitative rating of interventions and part of which were the qualitative statements about interventions. Both lines of inquiry converged toward the following notable insights.

Youth cultures may inform participants' attitudes toward a PPI, which became visible when values and norms of our participants came into conflict with values and norms embedded in a PPI. Special concern was given to authenticity and a notable aversion toward PPIs that enforced docile behavior or that pathologized what our participants categorized as *normal* behavior. Our data suggest that young people should have a significant choice when it comes to when to apply which PPI, including how to shape the PPI to make it more appropriate for their context.

Young people may see PPIs as potential sources of negative emotions. If they feel that a PPI is too difficult—either inherently or made too difficult by too ambitious goals—then that may become a red flag that keeps young people from engaging with the activity. Further, components in some PPIs may become triggers for negative emotions, for example, a reflection PPI that may bring up negative memories. PPI instructions so far do not seem to take this possibility into account, at least not to a degree that our participants saw as sufficient. Research into how to safeguard PPIs from inadvertently becoming triggers for negative emotions—that is, which kinds of components most likely could become triggers—seems necessary. If we knew which interventions have a higher likelihood of triggering negative emotions, we could, for example, amend them with a suitable warning or not give them out to young people who are, at that point, not stable enough.

Individual preferences had a major impact on young people's attitudes toward interventions. When talking about what they thought about interventions, our participants did so mostly in relation to their own preferences and interests. Although some preferences or aversions were more prevalent than others—for example, a general disdain for writing-based activities and preference for visual- and audio-based instantiations—there was an overall notable diversity in what young people felt appropriate for themselves. This diversity means that there cannot be a one-size-fits-all approach to youth mental health promotion. Instead, choice and customization may be the most relevant goals in any attempt to proliferate digital instantiations of PPI among young people. This may be especially relevant as the cultural context in which an intervention is first validated may not translate to another context, for example, Gratitude interventions have not yet been validated with German youth.

One promising way of approaching the complexities of individually varying interests and preferences may be found at the intersection of mental health and games research. Fleming et al [27] have developed a taxonomy of predispositions with which young people approach mental health tools, differentiating between *players or gamers*, that is, those from whom fun had the highest priority; *engagers*, that is, those for whom support to their well-being had the highest priority but who are open to gamified approaches; *skeptics*, that is, those who do not see value in digital interventions; and *Straight-talkers*, that is, those who explicitly do not want any gamified content in their mental health applications. Building on taxonomies like this would allow the creation of more focused strategies, such as how to best address *engagers*, instead of just aiming at *young people* in general.

Several issues brought up by our participants further intersect with ongoing discussions of PPI and underlying intervention principles; we have addressed these issues in the following sections.

PPIs and Failure

Our participants were concerned about PPIs potentially making them feel worse, not better. Three possible reasons for this were given: the intervention itself being too difficult, for example, having too many steps; other people responding negatively, for example, an apology being rejected; and interventions triggering negative emotions, for example, by invoking problematic memories.

The literature on a PPI *backfiring*, as other researchers have called it [28], is sparse. Gratitude interventions were demonstrated to sometimes trigger feelings of “obligation, indebtedness, embarrassment, awkwardness and guilt” in a 2017 study in the United Kingdom [12]. There have been concerns that failing at a PPI may, for people with depression, result in a feeling of failure and give them “further evidence that they are defective” [28]. One PPI discussed during the workshop—*Healing Through Writing*—asks the person to reflect on a particularly painful memory. However, a 2009 study in the *Journal of Abnormal Child Psychology* has demonstrated that these types of memories are potential triggers for suicidal ideations in urban youth [29].

Beyond that, there is limited research on PPI *backfiring*. There are 2 possible reasons for this lack of research. First, it could be that PPI rarely go wrong and that our participants were overly cautious of something that in reality does not significantly factor into the application of PPI. If so, then our data at least suggest that the *concern* of PPIs *backfiring* is present among young people, which in turn means that PPI instructions should address it. Alternatively, the lack of research into PPI failing may also be an artifact of publication bias; it is possible that PPI studies that encounter significant issues only rarely make it to print. We are not able to say which of those is the case but suggest that it warrants further investigation.

Faithfully Translating PPIs for Digital Platforms

The shortcomings of PPIs with regard to individual preferences and modalities line up with the aforementioned study on PP apps for young people [20], which showed an overreliance on static text and writing and a lack of customization for young people to shape interventions according to their own preferences and strengths, in contrast to what young people expect from digital instantiations [19]. The researchers attributed these issues to technology design, saying that “the design of these technologies needs to be more closely oriented to what young people are actually interested in” [20]. Although we do not disagree with this assessment, our study indicates that the issue is rooted in a deeper level. The overreliance on text and lack of customization may not per se be a consequence of an insufficiently ambitious design but instead may be a consequence of faithfully instantiating PPI principles into a digital context.

The impact of personal preferences on effectiveness is increasingly recognized in PP research. The Person-Activity Fit (PAF) model describes how the overlap between *person features*, such as preferences and strengths, and *intervention features*, such as dosage and variety, impact how well a PPI is performed, which in turn impacts the subsequent well-being increase [13]. Both previous research on digital instantiations of PPI principles for young people [20] and our research presented in this paper suggest that PAF between young people and PPI principles may be overall low, at least with regard to how PPI are currently being delivered, in both digital and analog formats.

Design Implications

Instantiating conventionally text-based PPI for a digital platform could mean an opportunity to reinterpret these interventions to better fit with expectations and needs of young people across various cultures and subcultures. Activities in conventional PPI are mostly predicated on paper, pens, and the material constrictions they come with. For example, a conventional diary entry would not allow a young person to just sit in front of a piece of paper and talk about what is on their mind. For a digital diary, however, accommodating verbal speech is trivial, opening the diary activity to young people who have less affinity to writing. Furthermore, worksheets accompanying PPIs usually present one way of approaching an activity, for example, providing a table and asking the person to fill it in. Digitally, it is possible to provide a range of options to accommodate differences between young people and allow them to choose. As stipulated by Michel et al [20], there is no technological barrier to replacing writing with audio or video recording and to integrate more interactive modalities into all types of evidence-based PPI. Doing so may help to resolve engagement issues with PP apps for young people. However, we cannot simply take, for example, *Gratitude Journal*; replace its writing components with audio; and assume that its existing evidence base is not impacted by this translation.

The reason why addressing individual preferences and modalities in the context of new digital instantiations of PPI for young people is nontrivial is intimately entangled with one of the most significant gaps in PP research, as has been pointed out from *inside* the field [30] and from *outside* of it [28]: a lack of verified mechanisms of action (MOAs). Ideally, MOA would tell us what aspects of a PPI contribute to its effectiveness, which in turn would allow us to translate the PPI more confidently to best fit the diverse audiences and types of platforms, without the risk of losing the effectiveness of interventions. Unfortunately, most MOAs for PPIs are only speculative [24]. For example, *Gratitude Letter* is the most effective intervention within PP [24]; the activity usually consists of writing a letter to a person you are grateful for and then delivering that letter. However, we do not know if it makes a difference (1) to write the letter by hand or digitally; (2) to deliver it in person or via email; (3) to extend the letter with images, videos, audio recordings, or other multimedia; or (4) to craft the letter entirely as an audio recording or a video log, etc. Although *Gratitude Letter* is a widely used successful intervention, we do not know enough about it to confidently instantiate it digitally without losing its effectiveness.

Overall, to address the issue of young people's lack of engagement with digital instantiations of intervention strategies, extensive further research is necessary. This includes facilitating the creation of culturally appropriate intervention strategies, exploring risks, and safeguarding strategies relating to PPI and further research into the MOA of the PPI, for example, via microrandomized trials [31]. This will allow us to preserve the evidence base of the established PPI while translating them into engaging, mental health–promoting digital experiences for young people. We have seen young people been able to express their needs and wants very clearly, which further emphasizes the role of co-design workshops as a primary mechanism to create digital interventions [32].

PP and the Tyranny of the Positive Attitude

Some criticism during the workshop was directed at what our participants felt was too much focus on positive emotions within the PPI they were shown. This criticism mirrors a larger discussion of what has been coined *Tyranny of the Positive Attitude* [33,34], a perception that PP attempts to ignore negative emotions despite their importance to a well-balanced psyche. It is not entirely clear how justified this perception was. In 1990, around the time the modern school of PP was born, Seligman [35] wrote about the importance of negative emotions and the dangers of overly focusing on the positive. In 2016, PP's (current) *second wave* made an explicit effort to conceptually integrate negative emotions, trauma, suffering, mortality, and adversity into a larger positive framework [36]. Thus, there seems to be some disconnect between the theoretical underpinnings of PP, which long recognize and appreciate the nuanced relevance of negative emotions, and the perception that negative emotions are pushed aside in PP, as in our workshop. A possible explanation could be that our participants responded to individual PPIs, not PP overall. Although the field of PP integrates negative emotions, individual PPI may appear to be overly focused on positive emotions. Our workshop suggested that some young people may respond distinctly negatively to those PPIs. Meanwhile, some PPIs that did have their focus on integrating negative emotions, such as *Healing Through Writing*, were criticized as potentially triggering negative emotions (theme 2). Preference toward one or the other may be a matter of individual differences. We suggest that similar future studies with young people include an explicit discussion of *happiness* to prime aspects of the (presumably) less intuitive notion of eudemonic happiness.

Limitations

We will now address some limitations of this study, with regard to the role of our setting (ie, a school), our participants (ie, classmates from largely shared environments), and how we exposed them to PPI (ie, through descriptions of activities, not the activities themselves).

This paper is based on one workshop with 30 young people from a specific area in Germany; both the number of participants and their cultural context limit the extent to which our findings generalize. Instead, our data serve as a starting point for future explorations into other groups and cultures of young people.

Our specific setting (ie, in-class workshop) may have been impacted by peer pressure, for example, of not speaking too positively about some kinds of PPI. As the individual ratings from step 1 aligned with opinions expressed during the group discussion in step 2, we do not expect peer pressure to have had a big impact; however, it could have skewed the group discussions. Responses to intervention principles such as kindness, gratitude, and forgiveness, while being around classmates, could have been skewed by teenagers attempting to manage their identity within their social group, for example, trying to conform to gender stereotypes. To alleviate the impact of this, we started with participants responding to PPI individually and in writing, but the setting may have still influenced their responses.

Furthermore, although PP is generally considered useful for anyone regardless of underlying mental health problems, previous experience with mental health problems may skew someone's opinion toward PP. We did not evaluate the mental health status of our participants. As they all have been from the same class and thus share an environment for long periods, it is possible that shared stress factors may have impacted their attitude as a whole in a way that would not show up in another sample from another school.

In addition, we noticed during the analysis that many of our participants criticized interventions for not taking negative emotions into account. PP overall recognizes the importance of negative emotions, and when we introduced the topic to our participants, we explained this. However, they still evidently felt that the specific interventions they discussed did not sufficiently account for negative emotions. A different selection of interventions with an explicit focus on negative emotions may have resonated better with our participants.

Finally, our participants responded to instructions for PPI, not to first-hand experiences of applying the PPI. It is almost certain that actively applying the PPI would have impacted our participants' opinions, although it is less certain in which way. For example, when our participants reflected on whether they expected a PPI to help them, their answers were speculative and not necessarily rooted in experience. The attitudes they expressed may not predict if and how they would perceive these interventions in a real-world setting; they might, however, indicate the willingness to try or reject similar intervention strategies outright.

Conclusions

To make PP useful for young people, we need to find ways to present the interventions as being suitable for the culture and context of young people, be aware of their degree of difficulty, and find ways of aligning interventions with young people's personalities and strengths. These adjustments seem to be necessary if we expect young people to engage with digital instantiations of PPI principles. Across all our findings, there was a need for customization and choice. It is possible for young people to select and choose which interventions they feel are most useful to them and to further shape these interventions to their own needs, strengths, interests, backgrounds, values, and context in general. Digital technologies are uniquely suitable to facilitate this kind of freedom; but, as past research has shown, they are not yet delivering on it. Future research needs to identify on a more granular level how components of PPI interact with different types of young people's personalities, interests, and strengths, to allow the design of useful and engaging platforms, which offer young people both the necessary freedom and scaffolding to create individually ideal PPIs. Specifically, we would like to see more research identifying the MOA of interventions and how these mechanisms may be expressed on digital platforms. If these insights would exist, it would become possible to systematically create digital interpretations of interventions, flexible to individual needs and preferences of young people, while preserving their validated effectiveness.

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Conflicts of Interest

None declared.

Multimedia Appendix 1
Data showing the relationship between fit, expectation, and inclination, as indicated by the Likert scale rating during step 1 of the research phase.
[XLSX File (Microsoft Excel File), 15 KB - humanfactors_v7i4e21145_app1.xlsx]

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Abbreviations

MOA: mechanism of action
PAF: Person-Activity Fit
PP: positive psychology
PPI: positive psychology intervention

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Original Paper

Differences in Memory, Perceptions, and Preferences of Multimedia Consumer Medication Information: Experimental Performance and Self-Report Study

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Abstract

Background: Electronic health resources are becoming prevalent. However, consumer medication information (CMI) is still predominantly text based. Incorporating multimedia into CMI (eg, images, narration) may improve consumers' memory of the information as well as their perceptions and preferences of these materials.

Objective: This study examined whether adding images and narration to CMI impacted patients' (1) memory, (2) perceptions of comprehensibility, utility, or design quality, and (3) overall preferences.

Methods: We presented 36 participants with CMI in 3 formats: (1) text, (2) text + images, and (3) narration + images, and subsequently asked them to recall information. After seeing all 3 CMI formats, participants rated the formats in terms of comprehensibility, utility, and design quality, and ranked them from most to least favorite.

Results: Interestingly, no significant differences in memory were observed ($F_{2,70}$=0.1, P=0.901). Thus, this study did not find evidence to support multimedia or modality principles in the context of CMI. Despite the absence of effects on memory, the CMI format significantly impacted perceptions of the materials. Specifically, participants rated the text + images format highest in terms of comprehensibility (χ^2_2=26.5, P<.001) and design quality (χ^2_2=35.69, P<.001). Although the omnibus test suggested a difference in utility ratings as well (χ^2_2=8.21, P=.016), no significant differences were found after correcting for multiple comparisons. Consistent with perception findings, the preference ranks yielded a significant difference (χ^2_2=26.00, P<.001), whereby participants preferred the text + images format overall. Indeed, 75% (27/36) of participants chose the text + images format as their most favorite. Thus, although there were no objective memory differences between the formats, we observed subjective differences in comprehensibility, design quality, and overall preferences.

Conclusions: This study revealed that although multimedia did not appear to influence memory of CMI, it did impact participants' opinions about the materials. The lack of observed differences in memory may have been due to ceiling effects, memory rather than understanding as an index of learning, the fragmented nature of the information in CMI itself, or the size or characteristics of the sample (ie, young, educated subjects with adequate health literacy skills). The differences in the subjective (ie, perceptions and preferences) and objective (ie, memory) results highlight the value of using both types of measures. Moreover, findings from this study could be used to inform future research on how CMI could be designed to better suit the preferences of consumers and potentially increase the likelihood that CMI is used. Additional research is warranted to explore whether multimedia impacts memory of CMI under different conditions (eg, older participants, subjects with lower levels of health literacy, more difficult stimuli, or extended time for decay).

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KEYWORDS

consumer medication information; medication guides; patient medication information; prescription drug information leaflet; patient information leaflets; multimedia learning; health literacy; eHealth literacy; consumer health informatics; cognitive theory of multimedia learning

Introduction

Background

Facilitating consumers to find, assess, and understand health information and to make effective decisions based on that information is the impetus for research on health literacy [1]. Further, the increasing availability of online and digital health information motivates a similar need to study digital or eHealth literacy [2]. eHealth literacy is “the ability to seek, find, understand, and appraise health information from electronic sources and apply the knowledge gained to addressing or solving a health problem” [2]. Digital media (eg, internet, mobile apps) have the potential to create new opportunities and streamline information for consumers (eg, tailoring, progressive disclosure). However, they also have the potential to create additional challenges for consumers trying to find and use health information, so the design of the system and how the information is written require careful consideration and study.

One example of consumers requiring health information is when they take medications. Approximately, 4 in 10 Canadians (40.5%) between the ages of 6 and 79 years take at least 1 prescription medication and, unsurprisingly, people are more likely to take medications the older they are [3]. Given the widespread use of prescription medications, consumers should understand and remember information about the medications they take in order to maximize the therapeutic benefits and minimize the risks. Moreover, memory (ie, recalling or recognizing information) and comprehension (ie, understanding information) are factors proposed to affect therapy adherence [4,5]. In this study, we are emphasizing the importance of recalling information about the medication (eg, administration, storage, side effects) as opposed to remembering the particular time to use a medication—a distinct area warranting research. Essentially, by providing consumers with medication information, we are trying to help them understand how to take the medication, what to avoid, what to watch out for, etc. A systematic review of written medication information indicated that consumers appreciate and use this information and it may improve medication adherence [6].

Methods of communicating medication information to consumers need to be carefully studied, designed, and deployed. Relying solely on verbal communications for medication information is not prudent because memory is generally poor. Specifically, consumers only remember 20% to 60% of information that health care professionals discuss verbally immediately after the interaction [7-9]. Therefore, it is important to supply complementary and supplementary information to consumers to improve comprehension, memory, and ideally adherence and therapeutic benefits while minimizing risks. Moreover, merely providing long text-only handouts may not encourage consumers to read, understand, and remember the information.

It is important to explore materials that offer more than simply text to determine the impact of visuals and potentially narration to create more appealing and robust representations of medication information. Many studies have shown that multimedia benefits learning, and there are principles guiding how multimedia can be most effectively applied [10-12]. For example, it may be worthwhile exploring the use of data visualizations for communicating the likelihood of side effects rather than merely relying on vague terms such as “possible” or “common.” There are a variety of worthwhile avenues for exploration to improve medication information beyond what is currently available. This study used a common consumer resource for medication information (ie, consumer medication information [CMI]) and systematically transformed it using multimedia (ie, added images to text, replaced text with narration) to determine the effect of incorporating multimedia on memory, perceptions of comprehensibility, utility, and design quality, as well as overall preference.

CMI

CMI attempts to address the need for medication information that can be subsequently referenced. CMI, for the purposes of this study, is the term used for the text-based paper information sheet(s) typically given to consumers at Canadian pharmacies when a prescription is filled for the first time. Although there is guidance for CMI, it is not regulated by Health Canada and unfortunately, as a result, there are often considerable disparities between CMI sourced from different pharmacy chains [13].

CMI contains typical information about what the medication is used to treat and its common dosage, but it may not match the individual consumer’s actual prescription or condition. CMI conveys a variety of general information about the medication including the following: dispensing pharmacy (eg, name, address, phone number), consumer’s name, prescriber’s name, date, brand and chemical (or generic) names of the medication, drug identification number (DIN), conditions that the medication is usually used to treat, how the medication is typically administered, potential side effects, important information about the medication, and how to store the medication.

Many posit that, as currently designed and delivered, CMI and other similar types of medication information offer limited value to users. Findings from a review on written medication information suggests that its value is currently limited because of language complexity, poor visual presentation, lack of tailoring, and use of words rather than numbers to convey risk of side effects [14]. Others have argued that medication information is often difficult to read and not suitable for consumers, especially older people [15] or those with limited health literacy [13,16-18]. Moreover, medication information may not be adequately addressing user information needs by failing to provide answers to questions consumers want to know about their medications [6]. Although we are generally seeing a shift from hard copy materials to digital options or replacements, this has not yet been observed with respect to CMI. However, when this shift inevitably occurs, we should be prepared with evidence to inform the design and deployment of these materials to optimize consumers' learning and use of them.

Multimedia

Multimedia is an approach to information design that has yet to be systematically applied and investigated for its potential benefits in disseminating health information to consumers [19]. Multimedia research is motivated by evidence that combining multiple methods of communication to convey information is more successful than relying on a single method. Thus, the definition of multimedia is "presenting words (such as printed text or spoken text) and pictures (such as illustrations, photos, animation, or video)" [12]. Domains such as education, entertainment, advertising, and more recently health care have embraced the benefits of multimedia [20]. Additionally, investigations of the potential benefits of multimedia for communication of health information [21], and even medication information specifically [22], for consumers have begun. However, these studies have largely overlooked the body of research done in multimedia learning and therefore the materials developed may not be as effective as possible [19].

Mayer [10] developed the cognitive theory of multimedia learning (CTML) to integrate the evidence and depict how people process multimedia presentations. Effects consistently observed and reported in multimedia learning studies have been organized into a set of multimedia principles that are used to both (1) describe why particular cognitive phenomena occur and (2) guide multimedia design to ensure it is done most effectively [10-12]. Thus, it is important to leverage existing evidence-based multimedia principles for the design of new multimedia health information to optimize its efficacy [19].

Given its demonstrated benefits in other domains, multimedia is a promising method of enhancing understanding and memory of medication information. There are many multimedia principles and new ones are continuously being developed [12]. However, this study only explored the following multimedia and modality principles: (1) people learn better from words and images than words alone [10], and (2) people learn better from narration and images than from written words and images [10].

Motivation and Research Questions

There are emerging studies that are attempting to improve CMI and other medication information for consumers. However, there were 4 primary factors that were not adequately addressed in other studies that motivated this study: (1) the failure to isolate the effect of multimedia, (2) the limited use of multimedia in stimuli, (3) the exploration of possible multimedia effects for younger people with adequate health literacy, and (4) the dearth of studies examining narration.

First, most previous studies that explored potential opportunities to improve different types of medication information have manipulated multiple aspects of design and content simultaneously. Moreover, most of the recent research seeking to improve medication information for consumers has concentrated on modifying both its content and its layout. There is evidence that various layout redesigns (eg, 2 columns, segmented sections, modelled after over-the-counter drug facts boxes [23]) improve consumers' perceptions of medication information, such as ratings of comprehensibility [24], utility, or design quality, or all 3 [25], as well as ease of locating information [26], attractiveness, readability [27], attitude toward the materials, and intention to read it [28]. In addition to increasing consumers' subjective ratings, layout redesigns have also bolstered different aspects of performance, such as locating information more quickly and effectively [24,29], as well as improving comprehension [24,27-30]. However, a major shortcoming of these studies is that the redesigned layouts was paired with changes in the length of the materials. Thus, the content was not controlled and instead were also modified in conjunction with layout. Therefore, comparisons were often between lengthier (control or current practice) and briefer stimuli, which confounded their results. For example, one study [30] compared a 4-page medication guide with a 1-page redesign. Thus, it is not necessarily surprising that consumers understood the shorter materials better, as there was less information that could potentially distract them or exceed their cognitive processing capabilities. Similarly, studies that have added multimedia to medication information typically made modifications to content as well [28,31]. For example, in addition to adding icons to represent dosing schedule, one study also increased the font size, lowered readability scores, and shortened and reorganized the content [31]. Again, the impact of multimedia cannot be distinguished from the effects of other modifications to the stimuli.

Investigations such as those above are valuable because they demonstrate that design and content changes can improve perceptions (eg, ratings of comprehensibility, utility, design quality, attractiveness, readability, attitudes and intentions) and performance (eg, comprehension, memory, information location) of medication information. However, by changing multiple aspects of the stimuli simultaneously, their methods preclude attributing gains to individual factors (eg, multimedia, length, readability, organization, layout). In contrast, this study used the same content for all 3 formats to determine if multimedia affected memory, perceptions, and/or preferences. That is, the exact same words and sequence of words were used to describe a medication, regardless of whether its presentation format (ie, text, text + images, or narration + images). This control allowed for the potential effect of multimedia to be isolated.

Second, studies exploring the impact of multimedia on medication information have generally limited the use of images to complement text to a narrow component of medication information, such as dosing schedules [31,32], directions and precautions [33], or only a few symbols and an image of the medication itself [28]. Thus, to address this shortcoming in the existing literature around use of multimedia medication information, this study included images throughout the entire presentation (eg, indications, side effects).

Third, most studies have focused their efforts on improving medication information using multimedia for particular groups of people who may inherently have more difficulty processing this information and therefore may have the most to gain. Specifically, multimedia medication information has been explored for older people [31,34] and people with limited health literacy [33,35]. However, it is also worthwhile to determine if multimedia benefits people who do not belong to these groups.

Fourth, no studies were identified that have explored the use of narration for medication information specifically. In response, the proposed study created a format of CMI using narration to convey information in lieu of text with complementary images.

Research Questions and Approach

This study examined memory, perceptions, and preferences by investigating the following 7 research questions: (1) Is there evidence of a multimedia effect for CMI on memory (ie, does adding images to text impact memory for CMI)?, (2) Is there evidence of a modality effect for CMI on memory (ie, does using narration instead text accompanied by images impact memory for CMI)?, (3) Are there differences in how participants perceive the CMI formats in terms of comprehensibility?, (4) Are there differences in how participants perceive the CMI formats in terms of utility?, (5) Are there differences in how participants perceive the CMI formats in terms of design quality?, (6) Do most participants' share a favorite CMI format?, and (7) Do most participants' share a least favorite CMI format?

We used an objective approach to investigating participants' memory and a subjective approach to determining their perceptions and preferences regarding CMI in 3 formats: text, text + images, and narration + images. We tested participants' memory by having them respond to free recall questions for each CMI format. We determined perceptions by having participants rate the CMI in terms of comprehensibility, utility, and design quality. Finally, participants ranked the 3 formats from most to least favorite to indicate overall preference.

Methods

Sample Size Calculation

The number of participants needed to achieve a significant difference between conditions in this study was estimated based on findings from a meta-analysis comparing the effectiveness of static images versus animations [36]. Höffler and Leutner [36] found that the mean weighted effect size was 0.44 for declarative knowledge (ie, memory) in 40 studies. Thus, to calculate the number of participants for the proposed study, we adopted a critical effect size of 0.45, significance level of 0.05, and power of 0.8. Using the aforementioned parameters for 1-tailed tests, as memory hypotheses were directional, a sample size of 28 participants was suggested [37]. However, given the counterbalancing, we needed a number divisible by 6, and to be even more conservative (ie, run 1 more participant in each sequence than suggested), 36 participants were recruited for this study.

Recruitment and Remuneration

To advertise the study, the investigators sent out a call for participants through the University of Victoria's School of Health Information Science listserv and hung posters on campus to advertise the study. Each participant received a gift card worth Can $20 (US $15.38) as compensation for their time.

Participant Exclusion

Participants were excluded by self-report from the study for any of the following reasons: (1) they had a medical or health professional background (eg, nurses, pharmacists, doctors), (2) they were not proficient in the English language, or (3) they had compromised visual or auditory acuity that was not effectively compensated for by assistive devices (eg, glasses, hearing aids).

Two participants were identified as outliers due to their age (ie, >3 SD from the mean age) and replaced with 2 new participants to maintain equal numbers of participants in each sequence.

Materials

Stimuli Selection

Two authors (HM and JB) generated a list of 23 medications to consider for use as stimuli. Possible CMI stimuli were collected and reviewed from a leading community pharmacy chain. The investigators transcribed and compared the CMI based on the conditions that the medications treated and routes of medication administration, as well as the length (ie, number of words) and readability of the materials. Three medications (Betaderm [Taro Pharmaceuticals Inc], cromolyn, and Flovent [GlaxoSmithKline]) were selected based on their uniqueness from each other in terms of name, route of administration, and informational content, as well as the similarity in the length and readability of their CMI.

CMI Formats

Three different CMI formats served as conditions in this study: text, text + images, and narration + images. Three health care professionals (2 nurses and 1 pharmacist) reviewed the final materials to ensure that they were representative of typical CMI, a technique used in other studies to validate stimuli [38]. The following sections will describe in more detail how we developed the 3 different formats.

Text Format (Control)

The text format served as the control condition for this experiment because it closely resembled CMI that consumers currently receive from Canadian pharmacies. We transcribed the content from the CMI of a leading community pharmacy and simplified it slightly to create the text format. Specifically, the date, DIN, address, and phone number of the community pharmacy, as well as other branding and logos, were excluded from the text format. Additionally, the "general information" section and "storage" instructions for the CMI were excluded, as they were nearly or virtually identical for all 3 medications. Therefore, these 2 topics provided no unique learning opportunities that would be more likely to be remembered in subsequent conditions because of repeated exposure. We used

Arial 12-point font throughout, and headings were bolded (see Multimedia Appendix 1).

Text + Images Format

The text + images format was developed by complementing the text format with images from the internet (see Multimedia Appendix 2). The page layouts were 11 inches in width and as long as necessary to convey all of the information. As in the text format, Arial font was used. However, larger font sizes were used (ie, 14-point font for body text and 22-point font for medication names) for the text + images format. We made minor changes to punctuation (eg, removing periods), added a few words (eg, the name of the condition next to the picture of the condition), replaced written numbers with Arabic numerals, emphasized medication names and headings, and used boxes to group topic information. However, the content (ie, words) in the text + images format remained identical to that in the text format. Text + images formats were saved as PDF files.

Narration + Images Format

We generated the narration + images format by adding an audio recording of a volunteer reading the text format aloud and using the images from the text + images format. The narration + images format was a series of narrated PowerPoint (Microsoft Inc) slides using the same font and image sizes as the text + images format. However, the font size was reduced during exposure, as a result of the width available for showing the video in the survey software. Very few select words were retained if they were considered to frame the presentation (eg, the name of the medication, headings) or to reinforce the meaning of images (eg, names of side effects). The narrated PowerPoint presentation was screen recorded with audio and played for participants via YouTube (see Multimedia Appendix 3).

Apparatus

We gave participants hard copies of the text format on 8.5×11-inch paper to emulate the current dispensing practice of CMI at Canadian pharmacies. We displayed the remaining 2 formats (ie, text + images and narration + images) on an Apple Macbook Air laptop computer with a 13.3-inch colour display. The text + images format was displayed on a single webpage (scrolling required). Participants were shown the narration + images format as an embedded YouTube video. To keep the exposure timing consistent, participants were only able to watch the video once from start to finish. We recorded the computer screen and audio using QuickTime media player (Apple Inc), even when the computer was not involved (eg, when participants were studying text format) and made an additional audio recording using a digital recorder.

Setting

The experiment was conducted in a quiet office. Participants were seated comfortably at a desk and the experimenter sat alongside him or her with the experimental materials that were not currently in use (eg, text format).

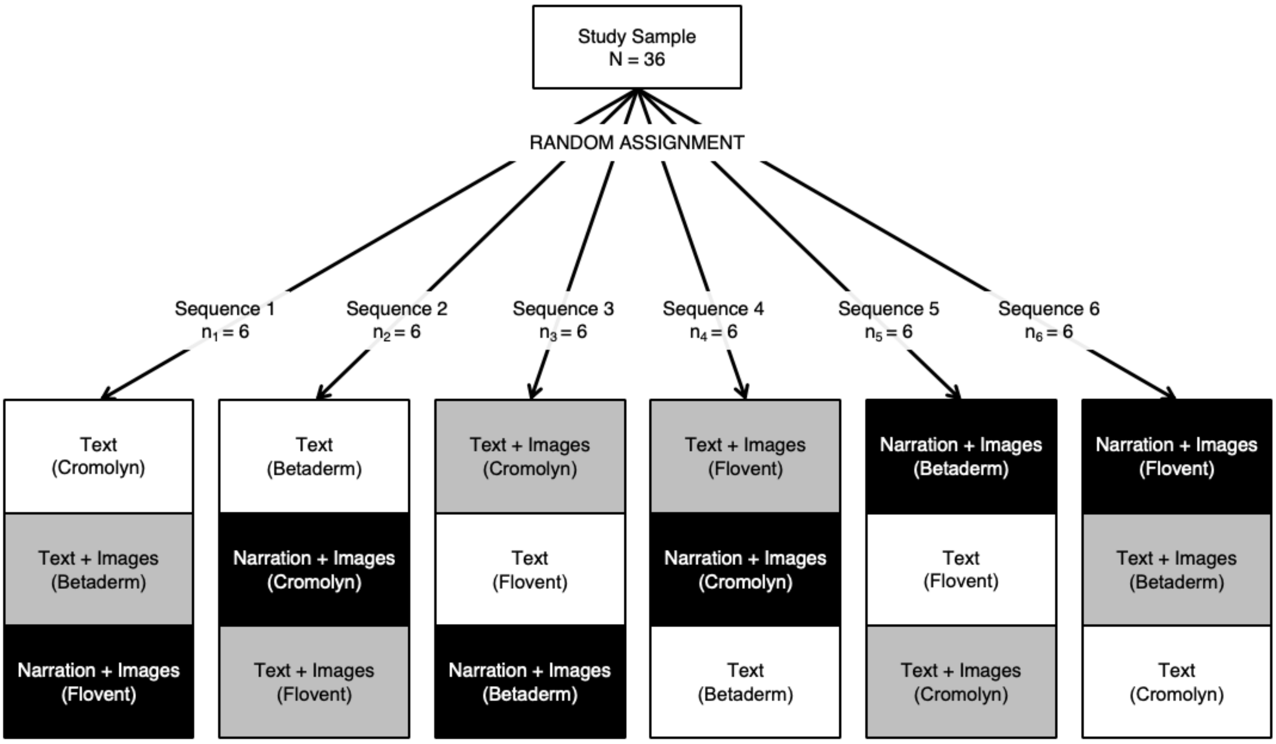
Procedure and Measures

Experimental Design

This experiment used a 1×3 randomized, counterbalanced design. The single factor (ie, independent variable) was CMI format and the 3 levels of CMI format were text, text + images, and narration + images. This study design was used to investigate the potential effect of multimedia CMI on memory, perceptions (ie, comprehensibility, utility, and design quality), and overall format preference.

All 36 participants were randomly assigned to 1 of the 6 unique presentation sequences counterbalancing for CMI format and medication (Figure 1). At the onset of each session, the participant pulled a number from a container to select the presentation sequence, which then dictated the order of CMI format and which medications were shown in each format. To ensure equal cell sizes, numbers were drawn without replacement.

Figure 1. Experimental design: randomized and counterbalanced for format and medication (in brackets).



The presentation sequences (Figure 1) determined the 3 conditions (ie, the unique combinations of format and medication). Thus, participants saw all 3 formats and a different medication in each format. The order of both the CMI format and the medications were counterbalanced. We took these precautionary measures in an attempt to minimize the potential for order effects, fatigue effects, and inherent memorability differences between medications.

Procedure

After reading and signing the informed consent form, each participant drew a piece of paper with a number on it from the container, determining his or her sequence. Next, the participants completed preliminary measures for descriptive purposes. Specifically, we administered a demographic questionnaire, the Newest Vital Sign (NVS) [39], and the eHealth Literacy Scale (eHEALS) [40].

Following administration of the preliminary measures, the procedure was identical (with the exception of the stimulus) for each of the 3 experimental trials. We adapted the experimental trial procedure from methods used by Morrow and colleagues [31] and encouraged participants to create mental models by asking them to try and understand the medication information rather than simply memorize it [41]. For each of the 3 trials, the following steps occurred:

1. Stimulus exposure: first, participants saw a condition (ie, CMI format and medication combination determined by the presentation sequence). The narration + images format ranged from 1 minute 57 seconds to 2 minutes 12 seconds. Participants saw the text and text + images formats for up to 2 minutes as well. Participants were able to move on to the next step before the time elapsed.
2. Distractor task: participants then completed a slightly modified version of the adapted Consumer Information Rating Form (CIRF) [42] as a distractor task to prevent rehearsal of the information and allow time for information to decay from memory. Additionally, the CIRF [42] familiarized the participants with the concepts of comprehensibility, utility, and design quality.
3. Memory task: the investigator then asked participants to recall information about the medication aloud (see Multimedia Appendix 4).

The aforementioned 3 steps were repeated until participants saw all 3 conditions (ie, all 3 formats and all 3 medications).

After completing the third and final experimental trial (ie, after having seen all 3 conditions), participants indicated their overall perceptions of the 3 CMI by rating each of the 3 formats on 3 dimensions: comprehensibility, utility, and design quality (see Multimedia Appendix 4). The 3 perception dimensions were based on the subscales of the adapted CIRF [42]. Participants then indicated their preferences by ranking the formats from most to least favorite; ties were not permitted (see Multimedia Appendix 4).

Analysis

CMI Memory

The audio recordings from the study were transcribed in full. The method of assessing memory was adopted from another study [43]. Specifically, each content item correctly generated by the participant that matched a CMI content item (ie, individual item of information, such as a side effect) was awarded a mark. Points were only awarded once for synonyms (eg, “topical” or “applied to the skin”) or for information that was repeated in the CMI (eg, prescription strength). However, the 3 medications did vary slightly in terms of the total number of content items. Specifically, Betaderm had 28 content items, cromolyn had 29, and Flovent had 28.

Omnibus analysis of variance (ANOVA) analyses were conducted on participants' memory scores to investigate whether the CMI format influenced memory. When the omnibus tests were significant, we made pairwise comparisons. A between-groups ANOVA explored potential memory differences in the first condition to avoid any potential influence of practice effects. A repeated-measures ANOVA determined whether memory was affected by CMI format across all 3 conditions.

Perceptions and Preference Comparison

Participants rated the 3 CMI formats on each of the 3 perceptual constructs (ie, comprehensibility, utility, and design quality) and ranked them from most to least favorite. Given the ordinal nature of the data, a series of nonparametric Friedman tests of difference among repeated measures were conducted to investigate whether participants rated CMI formats differently in terms of comprehensibility, utility, design quality, and overall preference. Where Friedman tests were significant, pairwise Wilcoxon signed rank tests were used for pairwise comparisons. Post hoc analysis with Wilcoxon signed rank tests was conducted with a Bonferroni correction applied (α=.05/3), resulting in a significance level set at $P<0.017$.

Results

Participant Characteristics

A summary of the participants' characteristics (demographic, educational, and medication related) can be found in Table 1. The mean age of the participants was 23.6 years (SD 3.8; range 18-35). Most participants in this study were female (26/36, 72%), identified as Caucasian (23/36, 64%), and reported English as their first language (31/36, 86%). All of the participants were students. The majority of participants were currently enrolled in school full-time (30/36, 83%). Participants were students of various faculties, but the 3 most common faculties were science (9/36, 25%), social sciences (8/36, 22%), and human and social development (7/36, 19%).

Participants reported using several different resources for medication information. The most commonly reported medication resources were physicians (27/36, 75%). An equal number of participants reported consulting pharmacists (16/36, 44%) and electronic resources (16/36, 44%) for information about medications. Many participants (16/36, 44%) reported not taking any prescription medications daily; however, over one-third (13/36, 36%) of participants reported taking 1 medication daily. Nearly one-half (17/36, 47%) of the participants reported following medication instructions completely.

Table 1. Participants' characteristics (N=36).

Characteristics	Frequency, n (%)
Gender	
Female	26 (72)
Male	10 (28)
Ethnicity	
Caucasian	23 (64)
Asian	10 (28)
Other ethnicity	1 (3)
Multiple ethnicities (ie, 2 or more reported)	3 (8)
First language	
English	31 (86)
Other	5 (14)
School enrollment status	
Full-time	30 (83)
Part-time	3 (8)
Cooperative education	3 (8)
Faculty of study	
Science	9 (25)
Social science	8 (22)
Human and social development	7 (19)
Education	4 (11)
Other (eg, business, engineering, fine arts, law)	8 (22)
Medication information resources consulted[a]	
Physician	27 (75)
Pharmacist	16 (44)
Electronic resources (eg, internet)	16 (44)
Family member	9 (25)
Other	1 (3)
Number of prescription medications taken daily	
0	16 (44)
1	13 (36)
2	6 (17)
3	1 (3)
Follow medication instructions	
Completely	17 (47)
Mostly	9 (25)
Somewhat	8 (22)

[a] Sum exceeds 100% because participants could report using multiple medication resources.

According to Weiss and colleagues' marking framework [39], most participants (30/36, 83%) were likely to have adequate health literacy. Six participants (17%) were classified as possibly having limited health literacy. However, no participants had a high likelihood of limited health literacy. Interestingly, using Monkman and colleagues 4-category framework [44] to classifying self-perceptions of eHealth literacy using eHEALS [40] scores, only a minority (8/36, 22%) of participants had high eHealth literacy scores [44]. The majority of participants reported only moderate (21/36, 58%) self-perceptions of eHealth literacy [44]. Concerningly, 7 participants (19%) reported low self-perceptions of eHealth literacy [44]. However, no participants lacked self-perceived eHealth literacy skills [44]. Interestingly, there was no correlation between participants' scores on the NVS [39] and the eHEALS [40], calling into question the extent of the relationship between health literacy and eHealth literacy or the respective measures used [44].

Effects of Multimedia on Memory of CMI

First, to negate any practice effects (eg, studying and rehearsing answers specific to recall questions), participants' memory in the first condition was examined. A 1-way, between-subjects ANOVA yielded no indication of CMI format affecting memory ($F_{2,33}$=0.19, P=.830). Mean number of items remembered on participants' first attempt with the memory task was 12.00 (95% CI 9.64-14.36; range 5-17) for the text format, 11.25 (95% CI 9.39-13.11; range 7-17) for the text + images format, and 11.75 (95% CI 10.24-13.26; range 9-16) for the narration + images format. Second, to minimize the effect of individual differences (eg, some participants having better memories), participants' memory in all 3 conditions was compared. Again, a 1-way, repeated-measures ANOVA determined there was no significant effect of CMI format on memory ($F_{2,70}$=0.1, P=0.901). The mean number of items remembered in the memory task for all participants was 12.44 (95% CI 11.05-13.84; range 5-25) for the text format, 12.53 (95% CI 11.28-13.78; range 6-21) for the text + images format, and 12.75 (95% CI 11.71-13.79; range 7-218) for the narration + images format.

In summary, there was no evidence to support either the multimedia principle or the modality principle. That is, participants remembered approximately the same amount of information regardless of whether the CMI was presented as text, text + images, or narration + images in the first condition and across all 3 conditions.

Comparison of Participants' Perceptions and Preferences of CMI Formats

All 3 Friedman tests comparing participants' perceptions of the 3 CMI formats were significant. Specifically, the Friedman tests yielded comprehensibility (χ^2_2=26.5, P<.001), utility (χ^2_2=8.21, P=.016), and design quality (χ^2_2=35.69, P<.001). Post hoc analyses with Wilcoxon signed-rank tests with a Bonferroni correction applied resulted in a significance level set at P<0.017. These pairwise comparisons indicated that participants rated the text + images format higher than both the text format and the narration + images format in terms of comprehensibility and design quality (Table 2). Further, narration + images was also rated significantly higher than the text format on these 2 dimensions. Despite the significant utility omnibus test, differences between the pairwise comparisons did not reach the threshold for significant differences (Table 2).

Table 2. Summary of pairwise Wilcoxon signed-rank tests for perception and preference ratings.

Perceptual dimension	Pairwise comparison	Standardized test statistic	*P* value	Significant difference at *P*<.017?
Comprehensibility	Text, text + images	–4.27	<.001	Yes
	Text, narration + images	–3.11	.002	Yes
	Narration + images, text + images	–2.61	.009	Yes
Utility	Text, text + images	–2.32	.021	No
	Text, narration + images	–1.18	.236	No
	Narration + images, text + images	–2.17	.030	No
Design quality	Text, text + images	–4.53	<.001	Yes
	Text, narration + images	–4.50	<.001	Yes
	Narration + images, text + images	–2.53	.011	Yes
Overall preference ranking	Text, text + images	–4.20	<.001	Yes
	Text, narration + images	–1.57	.116	No
	Narration + images, text + images	–3.72	<.001	Yes

Overall Preference Ranking

The majority of participants selected the text + images format as their most favorite (27/36, 75%) and the text format as their least favorite (23/36, 64%). A Friedman test of difference comparing participants' rankings of the 3 CMI formats revealed that this pattern was significant (χ^2_2=26.00, P<.001). Again, to account for multiple comparisons, a Bonferroni correction was applied to the Wilcoxon signed-rank tests, setting the threshold of significance to P<0.017. The text + images format was preferred overall to both the text format and the narration + images format. However, there was no significant difference in preference between the text and narration + images formats (see Table 2).

Discussion

Principal Results

This study sought to determine whether multimedia CMI impacted memory, perceptions, and/or preferences for CMI. A summary of the findings to the specific research questions posed at the onset of this experiment can be found in Table 3. The use of multimedia (ie, images, narration) in CMI did not appear to have any influence on memory in this experiment. Despite the lack of evidence to support any differences in memory between the CMI formats, there were observable differences in participants' perceptions of and preferences for the 3 CMI formats (see Table 3). Specifically, the text + images format was rated the highest in terms of design quality and comprehensibility and was also selected by the participants' most frequently as their most favorite CMI format.

Table 3. Summary of research areas, questions, and findings.

Research area and question	Supported (yes or no)?	Finding
Memory		
Is there evidence of a multimedia effect for CMI[a] on memory?	No	No differences in memory were observed between the text and text + images formats.
Is there evidence of a modality effect for CMI on memory?	No	No differences in memory were observed between the text + images and narration + images formats.
Perceptions		
Do participants perceive one CMI format as more comprehensible?	Yes	Participants perceived the text + images format as the most comprehensible.
Do participants perceive one CMI format as having more utility?	Mixed	The omnibus test was significant but there were no significant differences between the 3 formats after adjusting for pairwise comparisons.
Do participants perceive one CMI as superior in terms of design quality?	Yes	Participants perceived the text + images format as the most comprehensible.
Preferences		
Do most participants share a most favorite CMI format?	Yes	Most participants selected the text + images CMI format as their most favorite and it ranked significantly higher than both the text and narration + images formats.
Do most participants share a least favorite CMI format?	Mixed	Most participants ranked the text format as their least favorite, but there was no significant difference between the narration + images and text format rankings.

[a] CMI: consumer medication information.

Memory Results

Participants remembered approximately the same amount of information, regardless of what CMI format they saw and thus there was no evidence to support the multimedia or modality principles in this study. If the multimedia and modality effects were observed, the expected pattern of results would have been that participants remembered the most in the narration + images condition, followed by the text + images condition, and the least in the text condition. The results from this study suggest that the CTML [10-12] does not apply to CMI, at least with respect to memory performance as an index of learning. Similarly, King et al [33] failed to show significant effects of multimedia on memory for medication information. Although their study limited their test stimuli to medication directives (ie, directions and precautions) [33], this study used multimedia to complement as much of the written content in CMI as possible. Additionally, this study also investigated whether narration had an impact on CMI memory, which failed to generate differences either.

Do these findings (or more accurately lack thereof) insinuate that developing multimedia materials for CMI and consumer health information is a poor investment? Despite the lack of evidence to support previous assertions promoting the importance of multimedia in consumer health information [19], multimedia may still in fact be very valuable in consumer health communications. There are several reasons why multimedia consumer health information warrants continued investigation: memory ceiling effects; memory, not understanding, as an index of learning; CMI is a fragmented description, not a narrative process explanation; multimedia benefits some more than others; and multimedia improves perceptions and people prefer it.

Memory Ceiling Effects

It is possible that we observed a ceiling effect in memory performance in this study. A ceiling effect occurs when the dependent variable values are all near their maximum [45] and as such, the manipulation of the independent variable cannot result in additional gains. Performance on the memory task in this study was quite high even on the first trial, with means ranging from 11.25 to 12.00 on individual CMI items. Thus, it is possible that the experimental design (eg, stimuli content length and complexity, distractor task) did not have conditions challenging enough to create observable differences in memory due to multimedia. This finding is positive in that it indicates that people can recall much of the information contained in CMI if they study it. However, the CMI used in this study, from a leading pharmacy in Canada, was deemed to be the most "patient-centered" (ie, brief, with bullet points), and therefore these findings may not apply to CMI that is longer and/or more complex. Additionally, the distractor task was not a typical verbal interference task (eg, crossing out e's in a written passage as used by Morrow et al [31]. The CIRF [42] was used as a more naturalistic task to have participants reflect on the strengths and weaknesses of the CMI and simultaneously allowing time for potential memory decay. It would be valuable to repeat this study using more complex stimuli and potentially a different distractor task to determine if more variability in CMI memory performance can be observed under different experimental conditions.

Memory, Not Understanding, as an Index of Learning

The absence of expected learning gains due to multimedia may be attributable to this experiment only testing memory and not understanding. As previously described, the 2 primary goals of multimedia instruction are for learners to remember and understand [12]. Mayer [12] defined remembering as the "ability to reproduce or recognize presented material," whereas understanding is the "ability to use presented material in novel situations." Gains in performance due to multimedia appear to be consistent for understanding but variable for memory. Some studies have reported improved memory and comprehension due to multimedia presentations [46], yet others have found no benefits to memory, only to understanding [47-49]. Thus, perhaps because we only tested memory and not understanding, we failed to find any impact of the multimedia CMI formats. However, unlike some other consumer health information, CMI poses unique challenges to disambiguating memory from understanding and developing a valid comprehension test for medication information.

It is difficult to test for comprehension of medication information using CMI stimuli because CMI is inherently unique to each medication and it is rarely prudent to apply the knowledge about one medication broadly to a novel medication situation. Moreover, it is challenging to distinguish between what information consumers truly understand and what they simply remember. Although some researchers have reportedly tested understanding, they have only assessed memory. Indeed, Houts and colleagues [21] noted that several studies in their review "purported to assess comprehension but, in fact, studied recall since they only asked respondents to repeat information they heard or read." Thus, it is not surprising that some researchers have conflated memory, understanding, and other cognitive abilities in medication information.

Similar studies [31,34] have used a valid, naturalistic comprehension test for prescription medication. However, it requires a dosing schedule from an individual's prescription and because of the generic nature of CMI, it could not be used in this study. Specifically, the inference task charged participants to determine how many tablets would be consumed daily; thus, the participants had to calculate this value by multiplying how many tablets were taken each time and how many times a day they were taken [31]. Arguably, this inference task is a comprehension task, as it requires combining the information in a novel way to solve a problem. However, this task has limited value in the context of testing CMI, as CMI currently conveys only "typical" dosage frequency but not necessarily dosage amount. For example, CMI in this study indicated that the inhaler was typically used twice a day, but there was no information about how many puffs should be administered each time. The specific details of dose and time are prescribed uniquely, which often conveys more details and may vary further from what is descried in the CMI.

CMI is a Fragmented Description, Not a Narrative Process Explanation

The second possible explanation for why multimedia did not appear to affect memory for CMI is that CMI content may inherently be poorly suited for multimedia instruction because it requires learning discrete types of information. CMI is essentially a description of fragmented information (eg, indications, side effects, storage), whereby the topics are disconnected. In contrast, typical multimedia learning experiments explain processes (ie, sequences of events) such as how lightning works [50], the mechanics of pulleys [51], and the principles of flight [52]. In contrast, the stimuli in the present study were more descriptive than explanatory. That is, with the exception of medication instruction processes, most CMI is separated into discrete topics of information that would, from the consumers' perspective, likely appear unrelated. This might also explain why King et al [33] failed to find any differences in memory associated with adding pictograms to medication information.

As previously described, it is difficult to test for CMI understanding, and CMI should generally not be used to make inferences. Mayer and Anderson [48] also noted how differences in content make information more or less suitable for multimedia instruction. Specifically, they described how the instructional material, or inherent characteristics of the stimuli, may play a role in multimedia learning: "we used materials that explained how a system works; that is, we focused on "how-it-works" explanations that could be used to make inferences. If we had focused on material consisting mainly of arbitrary facts, we would not have been able to test for understanding. In short, our results may be limited to expository passages that describe how concrete physical, biological, or social systems work rather than descriptive or narrative passages" [48].

Thus, CMI is more aligned with Mayer and Anderson's [48] notion of arbitrary facts that cannot be tested for understanding and are more descriptive than expository in nature. Thus, it is not unreasonable to assume that no differences were observed in memory because CMI is poorly suited for gains associated with multimedia instruction, but this does not necessarily apply to other types of consumer health information.

Multimedia Benefits Some More Than Others

No gains in memory in this study may be attributable to participants being younger and/or having adequate health literacy. The participants in this study were younger, well-educated, and had adequate health literacy and eHealth literacy. One or all of these sample characteristics may have limited the potential benefits of multimedia presentation of health information or specifically CMI in this study.

Multimedia may be more beneficial for older people than for younger people. Many older people are affected by a decline in one or more cognitive capabilities, which can create negative implications for learning [53,54]. Age-related cognitive decline includes reductions in processing capacity, cognitive speed, inhibition, coordination, and integration [54]. However, the cognitive aging principle [53] asserts that the application of multimedia strategies can help older learners overcome obstacles due to age-related limitations in cognitive capabilities. Some studies have found more pronounced benefits (ie, interactions) of multimedia instruction for older people than for younger people [53,55]. Thus, the benefits of multimedia instruction for CMI may only apply to older adults. However, the evidence is mixed, as other studies have found that both younger and older people benefit equally from multimedia instruction [54,56], suggesting that despite the younger sample in this study, benefits due to multimedia instruction should still have been observed.

Benefits due to multimedia instruction may be more pronounced for people with limited literacy than for those who have adequate literacy. In a review of 55 studies comparing text alone with illustrated text, Levie and Lentz [57] found that there was some evidence to support the argument that illustrations are more helpful for poor readers than for adequate readers. Further, in their review, Houts and colleagues [21] reported that people with low literacy levels were more likely to benefit from multimedia instruction in consumer health information. Although literacy itself was not measured in this study, the high levels of health literacy and education in this sample likely precludes these participants from having literacy issues. Thus, the current sample may not have benefitted from multimedia instruction because of their adequate levels of literacy.

Multimedia Improves Perceptions and People Prefer it

Interestingly, although objectively all 3 formats were nearly equivalent in terms of memory, participants did perceive the formats differently and preferred one multimedia format overall. Specifically, participants perceived the text + images format to be more comprehensible and to have higher design quality than the other 2 formats. Additionally, there was some evidence that participants perceived the text + images format to have more utility, but this finding was not robust enough to be significant after correcting for multiple comparisons. It would have been most surprising if the utility of any of the formats was perceived differently because the content was held constant between the 3 formats. Consistent with the participants' perceptions, most participants chose the text + images format as their most favorite overall.

In contrast to the findings from this study, a previous study found that multimedia medication information impacted only the likelihood that people would refer to the handout in the future but not its ratings of user-friendliness, long-term comprehension, or effectiveness [58]. No demographic information (eg, socioeconomic status, ethnicity, age) was collected from their sample. However, based on population statistics, Advani and colleagues [58] posited that their inconclusive results on multimedia medication information preferences might be due to a sample of participants with potentially high levels of health literacy who appeared to appreciate text-only materials. However, our sample had adequate to high levels of health and eHealth literacy, which would suggest that other factors (eg, age, technology use) might be more predictive of whether or not people perceive multimedia medication information more favourably than strictly text-based materials. However, we cannot determine with any certainty what motivated these differences without additional research.

Limitations

There were several limitations that may affect the transferability and generalizability of the results of this study. Opinions and performance of young, educated, generally healthy adults, such as those in this sample of participants, may not be representative of other groups of consumers, or consumers as a whole. This study used a convenience sample, which resulted in a predominantly female sample who had higher than expected rates of prescription medication use compared with national averages [3]. Additionally, due to the stimuli exclusion process to enhance equivalency, all pills were excluded. However, pills are likely the most frequently prescribed, dispensed, and used medications. The NVS [39] has only been validated using paper administration, not online administration as in this study. Further, subscales from the adapted CIRF [42] inspired the single-item perception measures of comprehensibility, utility, and design quality. However, collapsing multiple ratings into single-item measures resulted in them being inherently less detailed and made it difficult to determine with any certainty to what extent individual factors influenced these perceptions. Finally, given the time limitations, participants were only exposed to the information in the narration + images condition once verbally, whereas—depending on their reading rates—they may have been able to revisit information in the other 2 conditions (ie, text, text + images) more than once.

Conclusions and Future Directions

There are several valuable conclusions to be drawn from this study. Like other consumer health information, effort has been exerted to develop CMI and human resources are continuously invested into dispensing them to consumers in hope that they will help educate people on the benefits and minimize the potential consequences of risks associated with medications. However, merely providing materials to consumers does not ensure that they will use them and indeed usage rates of medication information tend to be low. For example, medication information reading rates in a similar sample of university students (N=306; mean age 23.6 years) found that 37% of participants reported reading CMI always or often, and an alarming 32% participants reported reading it rarely or never [28]. Thus, if making these materials more appealing to users increases the likelihood of them being used, that would be a worthwhile investment. Therefore, it would be worthwhile to investigate whether incorporating multimedia into CMI has a positive impact on reading rates of these materials.

CMI also creates challenges around disentangling comprehension from memory. Future work would benefit from determining methods to examine comprehension independently from memory and information localization. Arguably, memory is important in circumstances when CMI is unavailable, whereas information localization and comprehension take precedence when CMI is available. Unfortunately, the current practice of distributing CMI as a hard copy often renders them unavailable. However, this situation will likely be remedied when digital methods of CMI distribution are adopted.

This study focused on only a narrow aspect of eHealth literacy competencies, but other facets of eHealth literacy could be explored using CMI. Specifically, we developed this experiment on the premise that consumers received medication information, as is currently the typical practice in North America. Therefore, the focus on this study was whether participants would remember different aspects of the information to simulate addressing or solving a health problem (eg, experiencing a side effect, missing a dose) rather than the acts of seeking, finding, and appraising health information from electronic sources. Thus, there are many other aspects of citizens' actual medication information use that warrant exploration. For example, do people use paper copies of CMI or online resources instead? What online resources do citizens prefer? If CMI was digitized, how would citizens like to receive it (eg, in a mobile app, on a pharmacy website, by email)? Moreover, at what point in the prescription process would citizens want digital CMI? What factors would impact the usage rates and efficacy of digitized CMI?

Although multimedia is a potentially valuable tool for consumer health information, the conditions in which benefits are observed may be limited to specific people, specific stimuli, or other specific contexts. For example, in this study with a sample of younger, adequately health literate people, no improvements in memory for a specific type of health information (ie, CMI) were observed. That does not preclude benefits of multimedia for other types of multimedia consumer health information for older people and/or people who have limited health or eHealth literacy, who may arguably be helped more by multimedia materials. Moreover, despite the lack of objective improvements as a result of multimedia, subjective improvements (ie, peoples' perceptions and preferences) for multimedia CMI were significantly enhanced. Although ideally we would have observed improvements in both subjective and objective measures, we cannot discount the importance of peoples' opinions of consumer health information. Multimedia consumer health information warrants more investigation with respect to what impacts it has on which specific subjective and objective measures and under what conditions (eg, stimuli topics, characteristics of the sample). If evidence suggests that performance and perceptions of certain groups of people are affected variably by multimedia information, it may further motivate argument for tailored health information that aligns with individuals' information needs.

Conflicts of Interest

None declared.

Multimedia Appendix 1
Sample of the text format.
[DOCX File , 16 KB - humanfactors_v7i4e15913_app1.docx]

Multimedia Appendix 2
Sample of the text + images format.
[DOCX File , 357 KB - humanfactors_v7i4e15913_app2.docx]

Multimedia Appendix 3
Sample of the narration + images format.
[MP4 File (MP4 Video), 5628 KB - humanfactors_v7i4e15913_app3.mp4]

Multimedia Appendix 4
Experimental tasks.
[DOCX File , 19 KB - humanfactors_v7i4e15913_app4.docx]

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Abbreviations

ANOVA: analysis of variance
CIRF: Consumer Information Rating Form
CMI: consumer medication information
CTML: cognitive theory of multimedia learning
DIN: drug identification number
eHEALS: eHealth Literacy Scale
NVS: Newest Vital Sign

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