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Qualitative and Quantitative Analysis of Definitions of e-Health and m-Health

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Objectives: Skills to employ nursing informatics to promote the health of individuals is of such importance that it is considered a core competence. Although investments are made to increase the use of e-health, there is no full understanding of the usability of e-health for healthcare. This paper presents a current picture of how e-health and m-health are defined and used as well as the effects their usage may have on the intended target group. **Methods:** Peer-reviewed open-access papers and grey literature that define e-health and m-health from PubMed, SpringerLink, and Google.com were randomized. A mixed method design with an inductive approach was employed. Open-source software were used for analysis. **Results:** The overview includes 30 definitions of e-health and m-health, respectively. The definitions were thematised into 14 narrative themes. The results of the study, and primarily a three-level model, provide an understanding of how different types of e-health and m-health can be put into practice, and the effects or consequences of using them, which may be either positive or negative. **Conclusions:** Mobility and flexibility is important for both m-health and e-health. Five keywords that characterize the definitions of e-health and m-health are "health", "mobile", "use", "information", and "technology". E-health or m-health cannot replace human actors because e-health and m-health consist of social and material interactions. Using e-health and m-health is, thus, about developing healthcare without compromising native relics.

Keywords: Data Mining, Meaningful Use, Health Information Exchange, Health Information Systems, Terminology as Topic

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I. Introduction

The United Nations Sustainable Development Goals (SDG) promote a sustainable future for all by leaving no one behind. This includes improving the access to information and communication technology (ICT) and using it to increase access to health services in all parts of a nation [1]. Electronic services that are used in healthcare are often referred to as electronic health (e-health) or mobile health (m-health). The difference between e-health and m-health is that m-health refers to services that are mobile and wireless, such as mobile phones [2]. However, some argue that m-health includes all telecommunication devices for the transfer of healthcare information between participants at different locations [3].

E-health (and m-health) may strengthen communication and information exchange between healthcare professionals, and between patients and healthcare professionals. E-health may be suitable as a supplement or in combination with physical meetings with healthcare providers [4]. E-health may also empower and influence individuals positively, providing opportunities for self-care [1,5].

Since the 21st century began, the interest in e-health to promote good health and wellbeing, to increase residents' influence, and to improve the healthcare sector, has gained a boost globally [6]. Iran and Brazil have devoted considerable resources to making healthcare available to the entire population, although work remains to be done to secure sustainability [7,8]. E-health has proved useful for evaluating educational interventions in Finland [9]. Research based in Norway has focused on supporting family caregivers in their role [10]. In Sweden, the common vision of the government and the Swedish Association of Local Authorities and Regions (SALAR) aims, by 2025, to include the use of digital means to promote equal care and better welfare for all, with a focus on the individual's abilities. According to SALAR, "the concept of eHealth includes all social services conducted by central or local government or by private actors, all health care and, to the extent relevant, dental care" to achieve good and equal health, and to increase residents' independence in society [11].

Obstacles to using e-health is that there are still patients who do not use or have access to the Internet, which must be respected [12]. A study shows that a clear majority of nurses and specialty-certified nurses who work with patients with chronic heart diseases in Sweden use computers during each work shift and during their free time [13]. Nevertheless, there has been great scepticism as to how patients can benefit from e-health. Several participants in [13] have argued that many patients do not know how to use digital technologies and that patient safety cannot be guaranteed, or that the best for a patient would be a physical meeting with a nurse to visit with the patient in his or her home.

1. Challenges with Electronic Health

One possible explanation of why investments in e-health often fail is a lack of communication between various healthcare institutions [13]. Some of the results of these studies could be interpreted as implying that there is a tacit understanding of what e-health means [14]; no one has, therefore, designed clear guidelines for how e-health can be used in healthcare. Further challenges with e-health, in Sweden and globally, are that tools and services based on e-health are often designed for people who already have good opportunities to connect to the Internet and are digitally literate [5]. This means that e-health can bridge the gaps in society, or it can increase them if the most vulnerable groups are not reached, such as those with limited access to the Internet or mobile technology, or who are not digitally literate [1]. Ethical aspects, such as why and how e-health is used must also be recognized [15].

The technology itself is rarely the biggest challenge in terms of e-health. Major challenges include finance, ethics, digital literacy, trust, understanding of the benefits of e-health, and understanding of how e-health as a concept should be defined [16]. One way to address the challenges of e-health is to provide information and education on what e-health means and what practical benefit it has for patients and staff, and to ensure that the user and the system have the same goals [17]. All of this is related to the concept of "semantic interoperability".

> *Semantic interoperability concerns issues of how to best facilitate the coding, transmission, and use of meaning across seamless health services, between providers, patients, citizens, and authorities, as well as research and training. The information transferred may be at the level of individual patients, or it may be aggregated information for quality assurance, policy, remuneration, or research* [18].

According to Zhao et al. [19], semantic interoperability includes at least two parts: the ability to exchange information, and the ability to interpret the exchanged information. Zhao et al. [19] stated that it is important to have a consensus on how to define the terms in use. Communication can be improved between those who use e-health by highlighting the many definitions and meanings of e-health that exist [14].

Oh et al. [14] conducted a systematic review of reviewed literature and grey literature with the aim of providing knowledge of published or proposed definitions of e-health. They collected 51 unique definitions from six databases and used the NVivo 2.0 tool for text analysis. The eight themes were health, technology, stakeholders, activities, attitudes, place, outcomes, and commerce. One conclusion from the study was that there are three keywords that are characteristics for defining e-health: health, technology, and commerce. In their study, the term "health" more often refers to healthcare as a "process" than as a "result". Oh et al. [14] believe that enhanced knowledge about used and proposed definitions of e-health can improve communication between the many individuals or organizations that use the concept.

The purpose of this work was to clarify the definitions of e-

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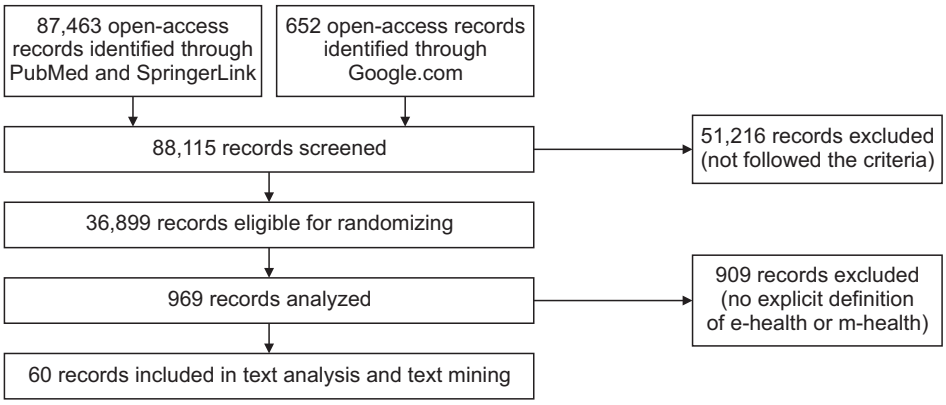

Figure 1. Flow diagram for the search process.

health and m-health. The aim was to improve understanding of what e-health and m-health are, how they are used, and their effects on the target group.

II. Methods

We drew from the work by Oh et al. [14] for the model of literature analysis for this study. Since their study, m-health has become a frequently mentioned term in healthcare, which is why this study included m-health too. They mainly focused on definitions of e-health and only to a lesser extent on how each definition is translated into practical use and the effect that use may have on the target group. One benefit with the type of methods and analysis employed in this study is the ability to provide a broad and comprehensive summary of the phenomena being studied, in this case e-health and m-health [20]. The rationale for using the selected databases is that they are widely used in the healthcare and medicine fields. A search engine was used because it is one of the most common approaches used by the community to search for sources on the Internet. In addition, this study contributes to open-source communities, which have been sources of inspiration for some of the algorithms [21,22].

1. Data Collection

The databases PubMed and SpringerLink, and the search engine Google.com were searched using open access only. The inclusion criteria required that a source be open-access, available in English or Swedish, and contain text that explicitly defines or attempts to define e-health or m-health. A short time span between January 2018 and February 2019 was used to include current sources.

The following keywords were used for PubMed and SpringerLink: "eHealth" OR "e-health" OR "electronic health" OR "digital health" and "eHälsa" OR "e-hälsa" OR "elektronisk hälsa" OR "digital hälsa". To find definitions of m-health, the following keywords were used: "mHealth" OR "m-health" OR "mobile health" and "mHälsa" OR "m-hälsa" OR "mobil hälsa". Sources in English and Swedish were used because the study emanates from the Swedish context. For PubMed and SpringerLink, the criteria were being scientific, previewed, and published within the chosen time span.

The Google Search engine (https://www.google.com) was used with a limitation to the hits that included scientific publications or grey literature [14]. The keywords used were: "what is eHealth" OR "what is e-Health" OR "what is digital health" and "vad är eHälsa" OR "vad är e-hälsa" OR "vad är digital hälsa". The searches on m-health generated significantly fewer hits, which is why the timespan was extended to include 2017. A summary of the search is presented in Figure 1, and a summary of the results is presented in Supplementary A, Tables S1–S4.

A randomiser (https://www.randomizer.org) was used to systematize and avoid bias in terms of selecting the papers or pages from the 36,899 records. A randomizer was appropriate because the purpose was to select a portion of the relevant sources but still be able to find patterns and reduce bias in doing so. The randomizer was set to generate 100 rounds of ten unique numbers from 1 to 1,000 in each round. If the current source did not present an explicit definition of e-health or m-health in the first round, numbers from the next round were used and so on, until 10 unique definitions for each database were generated. The goal was to find 10 definitions of e-health and m-health, respectively, per database (a total of 60 definitions) to obtain a current picture of e-health and m-health yet be adequate for text analysis and text mining. Only sources that explicitly defined or attempted to define e-health or m-health were used [14] (Supplementary B).

A total of 909 scientific papers and webpages were excluded because they did not explicitly define e-health or m-health, but only wrote its abbreviation, for example: e-health (electronic health). Pages from Google were excluded mainly

because they did not follow the criteria, namely, being scientific papers or grey literature from government agencies or major recognized organizations. Generally, the Google Search results contained more explicit definitions than the search results obtained with PubMed and SpringerLink. All searches were made from Sweden and with the Microsoft Edge v.44 browser.

2. Qualitative Analysis

E-health and m-health were analyzed with a three-level model [23,24] based on its definition (conceptual X), use (empirical X'), and what effects the use may have on the intended target group (indicator X''). The main advantage of the three-level model is that a single-level or a two-level approach to measurement is not adequate. In a two-level model, a third level is being concealed in either of the two levels. Bailey adds that a three-level model is not perfect but will facilitate the task at hand. The three levels are conceptual, empirical, and indicator.

(1) Conceptual X: E-health (or m-health) as a concept means that someone has a mental image of e-health. That is, e-health does not exist as any external reality.

(2) Empirical X': E-Health exists as an external reality, for example, as a service or application. An example of e-health at the empirical level is the 1177 Vårdguiden (Healthcare Guide 1177). The Healthcare Guide 1177 is something that can be used.

(3) Indicator X'': Evidence that something exists on the empirical level is created. An example is a study designed to understand how many and which individuals use the Healthcare Guide 1177, or if these individuals visit a healthcare center less often than residents who do not use the Healthcare Guide 1177.

With the application of the R Qualitative Data Analysis Package (RQDA, http://rqda.r-forge.r-project.org/) for the development environment R (https://www.r-project.org/), the definitions were thematized in a narrative form based on their meaning and purpose. (See also supplemental material). Medical Subject Headings (MeSH, https://meshb.nlm.nih.gov/) was used to support the interpretation of what the concepts and terms in the definitions mean. It should be added that the thematicization was performed without knowing which themes Oh et al. [14] presented.

3. Quantitative Analysis

Quantitative analysis was performed with text-mining. Text-mining means that the text from the definitions is seen as unstructured data consisting of individual words. These words are manipulated to detect meaningful patterns and key terms, and are then visualized with graphs to illustrate the characteristics and nature of the definitions [25]. The Text Mining Package (tm, http://tm.r-forge.r-project.org/) for R, was used to visualize patterns in the definitions. Stop words (for instance in, on, and) were removed because their occurrences would be misleading. The terms e-health and m-health (regardless of spelling) were also removed. Because the definitions are about e-health and m-health, these terms are naturally occurring in all definitions. How often (i.e., the "distance" or "height") two terms occurred together in the 60 definitions was calculated with tm, that is, terms that often occur together have a short distance or short height [26]. There have been several studies on the validity of tm and its usage in similar and other contexts [25,27].

III. Results

1. Qualitative Analysis: The Three-Level Model

The United Nations' definitions of e-health and m-health and those suggested by Oh et al. [14] are frequently used. Several examples of definitions of e-health include mobile devices or mobile communication. That is to say, the authors have, in several instances, considered m-health to be part of e-health [28-31]. Some papers have included mobile phones and other wireless devices, such as clocks and wrist sensors, in the definition of m-health [32,33]. While most definitions indicate that digital technology supports the traditional way of working [34-37], other definitions integrate mobile technology with the traditional approach to create the concept of m-health [38,39]. The following six excerpts (Supplementary A, Tables S2–S4) provide examples of how e-health and m-health are defined and used and what effects their use can have on the intended target group.

Lupianez-Villanueva et al. [40] define e-health as follows: *eHealth tools provide a means to disseminate health information and education for both patients and health professionals and hold promise for more efficient and cost-effective care processes (X).* As an example of the use of e-health, they suggest using the Internet to search for information about mental illness, wellbeing, or lifestyle (X). To collect evidence of the use of the Internet for e-health, the authors conducted an online survey. The results show that 68% (9,541/14,000) of the participants used the Internet and shared content less often than every week. Fifty-five percent of these users were between 25 and 54 years old with a secondary education, 49% of these users had a job, and 40% lived in a medium-sized city (X'').

Samerski [41] defined e-health as follows: *personal health*

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management on the basis of statistical analyses of individual data (X). Regarding e-health, they propose digital epidemiology and digital health monitoring (X'). Digital epidemiology draws on data that have been self-produced and usually for other purposes. Based on their literature review, they found that these tools contribute to individuals being constantly monitored and the healthcare provider largely disappears (X").

The Region Örebro County (Region Örebro län) defines e-health as follows: *to use it [IT] and modern communication solutions to improve public health, healthcare, dental care, as well as caring and social services (X)*. Examples of e-health include personal alarms (X'_1) and contacting healthcare providers using the Internet, for example with the Healthcare Guide 1177, for service and advice (X'_2). From the Region Örebro County's tentative reasoning, e-health provides the conditions for increased participation and increased co-determination (X").

According to Nelissen et al. [34], m-health as a concept and definition (X) means: *medical and public health practice supported by mobile devices (mHealth)*. At the empirical level, the mobile application OMRON can be used to monitor a patients' blood pressure remotely (X'). At the indicator level (X"), they conducted interviews and blood pressure check-ups. The result shows that systolic blood pressure, as a direct consequence of m-health, decreased by 9.9 mmHg (mean value) in the proportion of participants who had a blood pressure according to target value (systolic <140 mmHg, diastolic <90 mmHg, among participants over 60 years. For those with self-reported diabetes mellitus or who were over 60 years of age, systolic/diastolic blood pressure <150/<90 mmHg) increased from 24% to 56%.

Malasinghe et al. [42] defined m-health as follows: *remote healthcare has many categories, (e.g., telehealth, mobile health) all of which mean monitoring of patients outside hospital conditions by the means of technology*. Two monitoring systems that can be used remotely for cardiac monitoring (X'_1, X'_2) and for diabetes (X'_3) are presented. Their purpose in the literature review was not to find evidence for the effects of the use; rather, it was to find evidence that these kinds of m-health exist and have potential (X").

The International Telecommunication Union (ITU) [37] defines m-health as follows: *the use of mobile technology to provide healthcare support to patients or technical support to health service providers in a direct, low-cost, and engaging manner (X)*. An example of the practical application of m-health is the use of mobile phones to maintain contact with people who are outside the healthcare system (X'). The ITU suggests that this type of m-health can empower individuals and decrease the costs for healthcare services (X"). Nevertheless, the ITU does not point to any evidence to substantiate the claim.

2. Qualitative Analysis: Thematization

The 60 definitions were divided into 14 themes (Figure 1). The two themes "using mobile, digital/electronic approaches" and "using digital/electronic approaches" represent different themes to emphasize "mobile". Similarly, "using the Internet" is a theme on its own to illustrate whether a definition highlights the Internet specifically. The theme of "enhance healthcare/services" means to support/strengthen an organization or sector. The theme of "part of the healthcare sector" means to be an integral part of an organization or a sector.

3. Quantitative Analysis: Text Mining

The most frequent terms in the 60 definitions of e-health are "health" with 41 occurrences, "use" with 17, "information" with 14, and "digital" with 11. In the definitions of m-health, the most frequent terms are "mobile" with 43 occurrences, "health" with 35, "device" with 17, and "technology" with 17 (Figure 2). What is not revealed by Figure 2 is that the term "use" occurs seven times in the definitions of m-health, which means the total number of occurrences of the term "use" is 24.

To illustrate how frequently the terms in the definitions occur together, that is, the distance between them, the terms were grouped into so-called clusters using the Euclidean and Ward algorithms (Figure 3). The terms were divided into three groups by means of the algorithms: health, information, and mobile". The "health" group has a relation to the other two groups of information and mobile. The "information" group has shortest distance, that is, it is the most closely related to the terms of "use", "healthcare", and "technology". The "mobile" group has shortest distance to the terms of "devices", "digital", "medical", and "public".

The fact that health is related to all groups and terms means that the term occurs in all 60 definitions.

IV. Discussion

According to Bailey [23], some researchers rely on only two levels. This means that these people can only describe two levels (usually theory and empirical data) when dealing with three levels: theory, empirical data, and indicator, which is a kind of mapping of the other two. Bailey [23] argues that

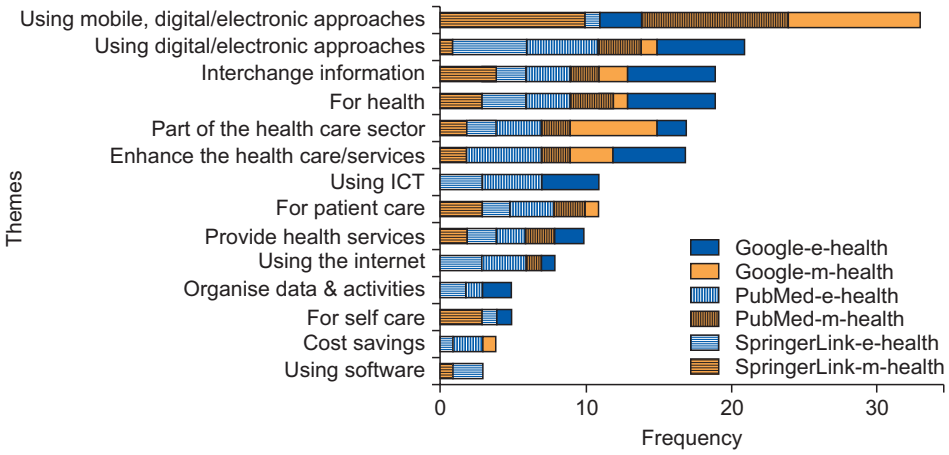

Figure 2. Themes and frequency in definitions.

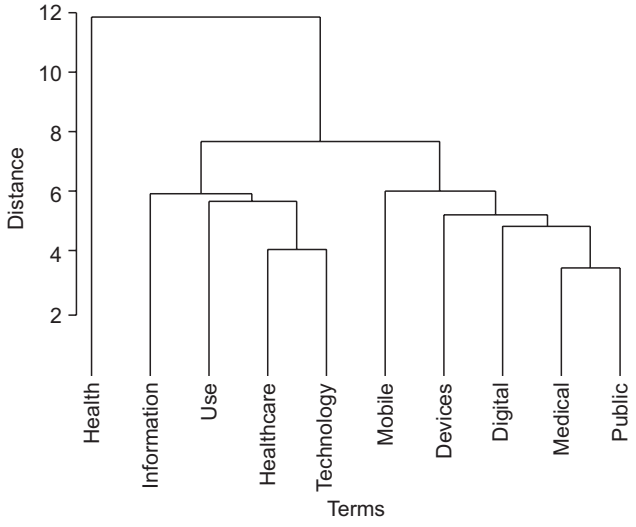

Figure 3. Dendrogram: cluster and distance between terms.

two levels are not enough and are misleading; therefore, he suggests the use of three levels. The three levels that should be used are, according to Bailey [24], the conceptual (X), empirical (X'), and indicator (X''). The indicator (X'') level is sometimes also called a theoretical level, which further explains why it becomes confusing to use only two levels. Bailey [23] also emphasizes that a researcher can focus on either the empirical (X) or indicator (X'') level, or both. The higher the congruence is between all the levels used, the higher the validity is [23]. Despite this criticism of previous studies, Bailey, too, has difficulty separating a concept from a definition [23]. We may, therefore, reasonably inquire whether three levels are enough, as Bailey suggested. In this study, e-health as a concept was placed at the same level as e-health as a definition. One alternative would be to extend the three-level model to four levels.

Models simplify a complex reality, yet the outcome of their use can reveal a lot about their validity. Since the three-level model, as the name implies, only allows a maximum of three levels to be used, the model has clear limitations in that a concept/mental image must not be placed together with the definition of the same mental image. The coherence of the frequency over the terms in the definitions (Figure 4) with the clusters and the distance between the terms (Figure 3) indicates a relatively high validity as to how the algorithms used in the tm application were applied. However, the reliability could have been higher if individual thematizations, that were then compared to see how well they matched, had been implemented. Therefore, to increase the reliability of the results, this study and future studies could use the "interrater agreement" in R. The function is used when all persons who perform a study make individual interpretations, which are then cross tabulated to learn to what extent their proposed thematizations match each other. Both the validity and reliability could have been increased further if a reference algorithm had been used to determine whether the analysis of the same definitions had generated the same results with different measuring instruments and more analyses [43].

The three-level model contributed to increasing the understanding of e-health and m-health as a concept and mental image (X). The model also increased the understanding of how a mental image (X) can be translated into practical use (X') to create a certain effect on someone or on something (X''). Despite this, there turned out to be additional challenges with using Bailey's three-level model to analyze e-health and m-health at the conceptual, empirical, and indicator levels. Bailey [24] provided examples using social phenomena, such as crime, or abstract phenomena, such as colors. E-health, like the Healthcare Guide 1177, is a phenomenon that is formed by combining material (for example, mobile phones or the Internet), social (a nurse or patient as a user), and abstract entities (a department that uses the Healthcare

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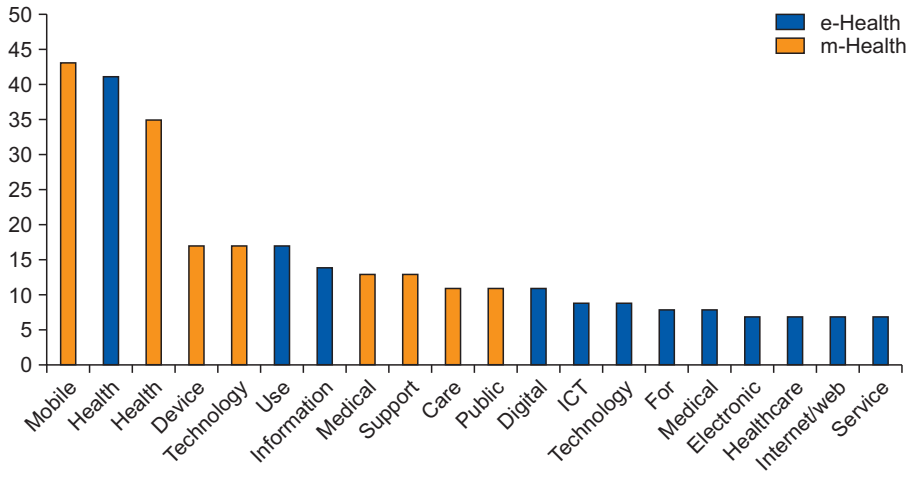

Figure 4. Frequency of the terms in the definitions.

Guide 1177), or physical units (a polyclinic)—all of which are linked as a network to create what goes under the name e-health or m-health.

1. Definitions of e-Health and m-Health

The definitions show that health, which occurred 76 times in all definitions, is by far the most important term for defining both e-health and m-health, which is not surprising. The term health also had a primary position according to Oh et al. [14]. The two other predominant terms in all definitions were "mobile" and "use" with 43 and 24 occurrences, respectively. For e-health, the second to fourth most frequently used terms were "use" with 17 occurrences, "information" with 14, and "digital" with 11. For m-health, "mobile" with 43 occurrences, "device" with 17, and "technology" with 17 come in at second to fourth place.

A majority of all 969 scientific papers, reports, and websites that were searched and randomized did not give an explicit definition of either e-health or m-health. This suggests, as Oh et al. [14] concluded, that there might be a tacit understanding of what e-health and m-health entail. Perhaps this is why several of the included resources in the current study did not define e-health and m-health, but had an open attitude, signalling that the subject is of importance and lies in the future, as several institutions and studies have suggested [37,44].

Several of the definitions of e-health and m-health are similar. They differ mainly in that the concept is defined in detail or is linked to the given context. A significant difference between the definitions from the PubMed and SpringerLink compared to Google is that, from the latter, potential or tentative evidence for e-health and m-health is more often presented. It is of no surprise but must be stated to be in the nature of these websites because they have a broader target group.

2. Use of e-Health and m-Health

The results suggest that e-health is useful for seeking information about ill-health or for increasing the possibility for self-care or the use of point of care. However, there is a risk that healthcare personnel are pushed away when individuals can search for information themselves. This study has shown that e-health is a concept that consists of both social and material interactions. E-health cannot, therefore, replace human actors, but must be used in interaction with traditional care that is not based on the digital world [4]. Practitioners, through their application of e-health, can provide patients with adequate and customized information to increase their knowledge of e-health use, which, in turn, can lead to increased self-care and empowerment, thereby developing or enhancing person-centred care [1,5].

The results of the study, and primarily the three-level model, provide an understanding of how different types of e-health and m-health can be put into practice, and the effects or consequences of using them, which may be either positive or negative. This study can be used to create opportunities for improved conceptual understanding and use, namely semantic interoperability, between individuals and organizations using e-health. Through knowledge of opportunities and limitations with e-health, communication between various professions can be facilitated, which creates increased patient safety and better care. In nursing and medical programs, or related disciplines, the study can be used to increase teachers' and students' understanding of e-health and m-health.

To be mobile and flexible is not only important for m-health but also for e-health. Five keywords that characterize the definition of e-health and m-health are the following:

health, mobile, use, information, and technology. This also indicates that the definitions are less geared towards the "commercial" but focus rather on promoting health compared with 15 to 30 years ago, indicating a change of direction and attitude. The health impacts on the individual of this change should be studied. E-health or m-health cannot replace human actors because e-health and m-health consist of social and material interactions. Using e-health and m-health is, thus, about developing healthcare without compromising native relics.

Conflict of Interest

No potential conflict of interest relevant to this article was reported.

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Supplementary Materials

Supplementary materials can be found via https://doi.org/10.4258/hir.2020.26.2.119.

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