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Defining and Delimitating Telemedicine and Related Terms - An Ontology-Based Classification

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Abstract. The way health care is delivered changes continuously and is increasingly supported by digital technologies, such as telemedicine. Many terms in that context exist, which are not defined consistently and therefore used ambiguously. This makes it difficult to assess the evidence base. Ontologies bring structure and clarity to the discourse around telemedicine and related terms. We use this tool to provide definitions of relevant terms and show their interrelations. The results provided will be applied to different case studies to show their applicability. We aim to provide a more evidence-based understanding of relevant terms in digital health.

Keywords. Ambient assisted living, digital health, ehealth, integrated care, ontology, telemedicine

1. Introduction

Demographic change is one of the big challenges health care systems currently face [1], as it leads to a rise in chronic non-communicable diseases. In response to these developments, the World Health Organization (WHO), in its Ottawa Charta, has demanded a stronger focus on prevention instead of treatment. [2]. Prevention, especially of chronic diseases, is a task for a multi-disciplinary care team, predicated on strengthening measures of integrated care [3]. However, it also demands active health behaviour change from any individual targeted by preventive measures, which is, in turn, based on a patient empowered by feelings of self-efficacy [4]. eHealth as a broad term came with the promise of enabling patient empowerment and therefore shared decision making [5], among others. As it also aids in overcoming geographic distances [6],

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eHealth not only ensures access to care, but also helps to interconnect health care providers involved in chronic care [7]. Thus, it enables integrated care [8] and thereby helps to deliver health care more effectively. Telemedicine in particular, another term in the eHealth context, is already used in many countries [9], e.g. to monitor patients in their home or connect health care professionals and patients via the internet to improve access to and quality of health care [10]. Mobile telemedicine applications allow for individualized tailoring of both preventive messages and interventions [11], and thus are especially suited for behaviour change measures [12]. Yet, in order to implement digital applications in preventive behaviour change as well as in integrated chronic care, a common and unambiguous understanding of terms in the domain is essential. Many ambiguous and overlapping terms surrounding telemedicine exist [13], and they are not defined consistently [14,15]. As the "digital health market" is a constantly evolving field, existing approaches to classify the field of telemedicine and related terms are neither exhaustive nor comprehensive [16]. Ontologies are an appropriate tool in terms of a scheme for structuring domain entities and explaining their relationships [17]. They can provide and share a common understanding of a domain and relating concepts [16]. We aim to apply an ontology-based approach to structure and clarify the telemedicine discourse, including (1) the definition of relevant terms and (2) their interrelations as well as (3) a description of specific application types of telemedicine. This will improve the understanding of relevant terms and working with the related concepts consistently. This paper provides a revision and extension of a previously developed ontology [16]. In order to demonstrate the applicability of the ontology, we will apply the presented approach to case examples.

2. Method

According to a typology of reviews provided by Grant and Booth, literature reviews are an apt method to examine current literature from a wide research field. Owing to the diversity of such wide research fields, literature reviews do not warrant comprehensive searching [18]. Such, we deemed a literature review the most appropriate method for systemizing somewhat conflicting terms.

Starting from the term "telemedicine", the review was conducted to collect all relevant concepts, their definitions and interrelations. Identification of relevant concepts was primarily done by screening research papers as well as official communication of national and international associations (e.g., European Commission (EC), U.S. Food and Drug Administration (FDA), and WHO). Terms were included as far as they represented a concept in the area of digitization in health care and described the context of their application or underlying technology. Results of the search were first synthesized in a narrative manner, as common for literature reviews [18]. Afterwards, and also in line with the methodology, we conceptually analysed the interrelations and delimitations of the terms reported in the results. To further illustrate the variability of the concept of telemedicine as one example, telemedicine application types were analysed, derived from a taxonomy based on quantitative content analysis [19]. Using selected examples of digital health innovations applied in common chronic conditions, the developed ontology was applied and checked for applicability.

3. Conceptual Understanding

The ontology provided consists of terms (displayed in bold in the following text) describing health technology applications or their underlying technological concepts, as well as terms describing the care delivery and location context of these applications. Each of these groups (underlined) is separately introduced in the following.

Telemedicine, as the core term of our investigation, as well as closely related health technology applications (telehealth, mHealth, eHealth, digital health, health IT) are defined. Sood et al. [10], who reviewed 104 articles defining **telemedicine**, conclude that the delivery of health care services and/or medical education over distance using information and communication technology (ICT) are main characteristics of telemedicine solutions. This is in line with the WHO's definition, who further add that "all health care professionals" [20,p.10] can be involved in the health care service delivery. Telemedicine is a subclass of the concept **telehealth** [10]. As the WHO states in its constitution, "health is a state of complete physical, mental and social well-being and not merely the absence of disease or infirmity" [21]. Accordingly, telehealth broadens the concept of telemedicine by including the aspect of well-being into health service delivery and such also encompasses preventive and health promotion measures. While health care professionals are explicitly involved in both telemedicine and telehealth, **mHealth** adds a further dimension by additionally including the individual as executing person for the service [22] into the "use of mobile communications for health information and services" [23,p.1]. Such, mHealth explicitly incorporates the active and empowered patient targeted by preventive measures.

The three introduced concepts telemedicine, telehealth, and mHealth are partly related to each other. Furthermore, each of the terms independently forms a subclass of the term eHealth [10,23,24 as cited in 16]. In 2015, the European Commission defined **eHealth** on their website [24 as cited in 16], which is now replaced by an almost word-identical definition of **digital health (and care),** describing "tools and services that use information and communication technologies (ICT) to improve prevention, diagnosis, treatment, monitoring and management of health and lifestyle" [25]. This is in line with the observation by Scott and Mars that only from 2016 onwards the usage of digital health as term increased [15]. Similarly to telehealth, digital health encompasses both "health services delivery and personal health and wellbeing" [26]. As the FDA underlines, mHealth, telehealth and telemedicine as well as health IT are also subclasses of digital health [27], which supports the interchangeable use of the terms digital health (and care) and eHealth. **Health IT**, as fourth subclass of digital health within the scope of our chapter, describes "the application of information processing involving both computer hardware and software that deals with the storage, retrieval, sharing, and use of health care information, data and knowledge for communication and decision making" [28,p.38].

The common underlying technological concepts are ICT and digitization. Digital health as well as its subclasses use ICT as technological basis [10,16,23,25]. **ICT** is defined as "all technical means used to handle information and aid communication. This includes both computer and network hardware, as well as their software" [29] and, e.g., telephones, smartphones, audio and video recording. Furthermore, ICT enables the diffusion of **digitization** in every area of society. Not only in health care but also in other areas of life, digitization changes the work processes from using analogue to digital signals, which broadens the usage and possibilities of technological systems [30].

When applied in care delivery processes, digital health affects different care models, especially integrated care as connecting professionals mainly relies on technological solutions. Generally, digital health affects care models by "complement[ing] and enhanc[ing] existing health service delivery models" [31,p.1] and enabling new ones [32]. **Care models**, i.e. a blueprint for health care provision, which is characterized by existing standards and evidence-based practice [33], can also be represented by **integrated care** [34]. In integrated care, the "inputs, delivery, management and organization" [35,p.7] of health and care services are combined along the continuum of health provision to improve different outcomes of these services (e.g., quality or efficiency) [35]. When applied in the context of professional care provision, eHealth and therefore digital health can support integrated care, especially for people with multimorbidity [36]. The potential of digital health to "strengthen integrated, people-centred health services" [31,p.1] was just recently highlighted by the seventy-first World Health Assembly in Geneva.

Another context in which digital health services can be applied is the living space, i.e. location context, of people, no matter if they are patients or individuals. Concepts related to location context are Health Smart Homes as special types of Smart Homes and Ambient Assisted Living. Equipping the living space of people with special needs for health care purposes is called **Health Smart Home** (HSH) [37,38]. As the name implies, it represents a health-focused **Smart Home** (SH) [37], which in turn generally describes the equipment "of a living space […] with electronic devices and communications infrastructure" [38,p.166]. In both cases, the aim is to increase the safety of occupants by enabling "monitoring and control of the immediate physical environment" [38,p.166], in general or related to their health status. Further related to SH are also **Ambient Assisted Living** (AAL) technologies, which extend the SH environment towards the health care domain [39]. Even though AAL also represents a health technology application, it was not previously explained as it is strongly dependent on the location context. In contrast to HSH, AAL explicitly describes assistance applications, i.e. "technological concepts, products and services for situation-dependent and unobtrusive […] assistance of people with special needs in daily life" [40,p.11].

AAL and HSH, both representing health-related SHs, are closely linked concepts. Vacher et al. described this connection by stating that "one of the great challenges in Ambient Assisted Living is to design health smart homes that anticipate the needs of its inhabitant while maintaining their safety and comfort" [41,p.35]. As the Association for Electronic and Information Technologies (VDE) states, AAL systems are "integrated into people's living environments" [40,p.11], i.e. are integrated into HSHs. Based on the definitions above, it can also be said that AAL uses ICT [40] and can incorporate digital health (and care) solutions, as they focus not only on health but also on lifestyle [25]. Increasing the comfort, safety and quality of life is a goal inherent to all three concepts, SH, HSH and AAL, framing the terms [37,38,40]. A complete overview of the terms included and their interrelations is given in Figure 1.

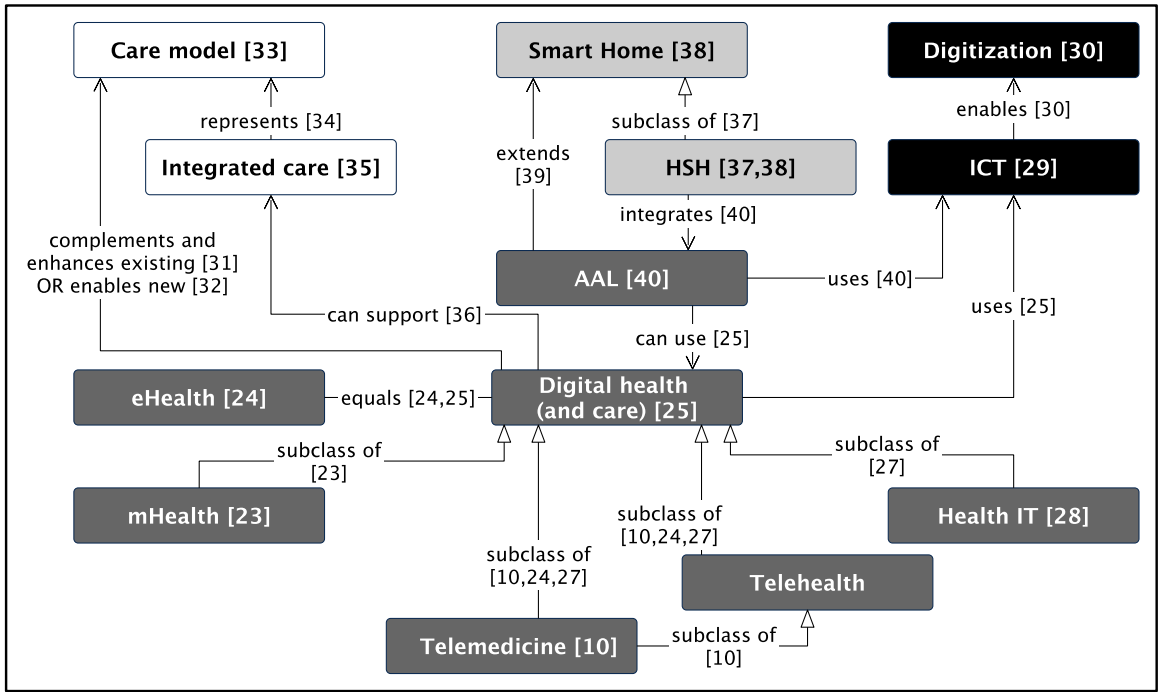

Figure 1. Ontology for telemedicine and related terms (Note: [24] refers to [24 as cited in 16]) – Legend: dark grey describes health technology applications, white terms are related to care delivery, light grey terms describe the location context and black refers to underlying technological concepts. Characteristics of classes are passed on to subclasses.

To facilitate the understanding and delimitations of the terms, Table 1 shows important differentiation characteristics and their specification for the terms related to health technology applications.

Table 1. Delimitation of terms related to health technology applications – "x": characteristic is always fulfilled, "(x)" characteristic can be fulfilled.

Delimitation \ Term	Health IT	mHealth	Tele-medicine	Tele-health	Digital health	AAL
Use of ICT	x	x	x	x	x	x
Across distances	(x)	x	x	x	(x)	(x)
Mobile		x	(x)	(x)	(x)	(x)
Medicine	x	x	x	x	x	x
Well-being	x	x		x	x	x
Professional involvement	x	(x)	x	x	(x)	(x)
Living space						x

The presented ontology helps define the included terms and delimitate them from each other. However, the definitions are quite broad and can cover various combinations of specific services or people involved. This can be seen using the example of telemedicine. Telemedicine projects have different characteristics (e.g. application type, personnel involved or setting), shown in previous work where a taxonomy was applied to a German telemedicine project database [42]. Regarding the ontology provided, the application types of telemedicine are particularly relevant as they represent the different phenotypes to be subsumed under the concept of telemedicine. A telemedicine project or

initiative can be either *tele-consultation*, *-ambulance, -diagnosis*, *-monitoring*, *-rehabilitation*, *-health education, digital disease-management* or a combination of them [19].

4. Application of the Ontology

In the light of this primarily theoretical perspective on the delimitation of relevant terms, the following two case studies illustrate their application in different chronic patient cohorts: (I) patients with diabetes and (II) patients with stroke. Due to the need for intensive, individualized and continuous support and care, patients with chronic diseases are seen as the ideal target group to develop and implement telemedicine strategies [43,44]. The presence of multi-morbid conditions further requires the attention of more than one medical specialist, which is why chronic diseases are also the ideal target for integrated care interventions.

(I) According to the American Diabetes Association, patients with diabetes require "[e]ffective diabetes self-management education and support [, that] should be patient centered, may be given in group or individual settings or using technology, and should help guide clinical decisions" [36,p.38]. In their consensus report, the European and American diabetes associations summarize that applying **telemedicine** in patients with diabetes is associated with a modest improvement in glycaemic control [45], e.g. through *tele-monitoring*. Output data on HbA1c and times spent below, in and above range can be quantified, explained and visualized in a patient's application in real time [46]. Furthermore, health care providers can easily give feedback on each value and respond quickly in case of dramatic and potentially life-threatening changes [47]. Such, based on a monitoring of the transferred clinical outcomes, the responsible health care professional (e.g. physician, diabetologist, or diabetes educator) is able to provide individualized telemedical care [48] and *digital self-management* support [49] from a distance. Moreover, as feedback on the values can be tailored to the individual patient due to her/his preferences and disease history [50], they enable the patient to adjust her/his health behaviour accordingly [51]. This is achieved by tailored *tele-health education*, which can also be delivered via web-sites and mobile phones [52].

The number of available lifestyle apps promoting physical activity and healthy diet in the App Store or Google Play Store is continuously increasing [53,54]. When looking for applications targeting patients with diabetes or diabetes-associated risk factors like unhealthy diet, obesity or low levels of physical activity, the identified apps cover different functions and features. For example, there are apps exclusively delivering educative content on the disease itself (including its pathogenesis, diagnosis or treatment options) in plain language, digital diaries to monitor eating habits, or educative motivational videos to improve physical activity. Consequently, our ontology would qualify them as **mHealth** or **telehealth** (depending on the devices used).

(II) Another example for potential **telemedicine** support is stroke. For example, *tele-diagnosis* can support the early detection of a potentially life-threatening condition due to a stroke [55] by linking emergency care units (tele-ambulances [56]) and hospitals. Reducing the time between onset and diagnosis may lead to faster emergency measures in *tele-ambulance* [57]. Apart from emergency settings, *tele-consultation* is a useful tool in stroke care to enable primary physicians in remote or rural locations to contact experts and such enable **integrated care**. Experienced neurologists can examine the patient remotely through live video feeds or study a computed tomography, thereby assisting the

primary physician in giving the accurate diagnosis and determining the appropriate treatment [58]. Tele-consultation can also be used by the patient directly, in order to gain access to remote physicians, even more so in case of immobility [59]. Furthermore, *tele-rehabilitation* has proven to be an effective tool to support improved limb and cognitive function [60].

5. Discussion

The present manuscript provides an updated overview of terms and concepts in the area of telemedicine. The definition of terms and their interrelations was based on scientific literature or insights from national and international associations. Therefore, the systematisation of relevant terms in a consolidated ontology and their application in specific use cases have the potential to improve the understanding of relevant terms.

Some interrelations were not included explicitly as they are implicitly represented in the provided ontology. One example is the connection between integrated care and HSH. Rialle et al. [37] state that HSHs can be part of integrated care. This connection is implicitly given by the ontology provided. Here, HSHs integrate AAL, which in turn use digital health, which can support integrated care. As only the AAL/digital health part of the HSH is related to care delivery, this interrelation mirrors the Rialle et al's statement.

Additionally, other terms related to the ones already included, exist, e.g., telecare, wearables, e-prescriptions, teleprevention, robotics, or internet of things. Telecare, for example, is seen as another subclass of eHealth [61], while virtual care is seen as part of telehealth [62] and wearables and e-prescriptions are specific components within the domain described. Nevertheless, these concepts did not add much information to the knowledge base. Potential changes to the ontology in the future could also arise from the growing use of telemedicine applications based on artificial intelligence, such as Amazon Alexa. On the one hand, they can help improve accurate tele-diagnosis and monitoring, for example in blood pressure management [63]. As for preventive care, automated interactive voice response systems have shown the potential to support health behaviour change, for example uptake of screening or immunisation measures [64].

A consolidated understanding of telemedicine-related terms and their scope is important for the evaluation and standardisation of digital health solutions [65,66]. Therefore, newly developed digital health interventions and applications can make use of this consolidated ontology, which may also inform the evidence base needed for successful implementation [67]. For example, the evidence standards framework for digital health technologies by the National Institute for Health and Care Excellence differentiates three evidence tiers, with simple digital health applications such as Electronic Health Records being on the lowest tier where no clinical effectiveness has to be proven [67]. The ontology provided can serve as a starting point for this regulatory process and guide the clear definition of concepts and services.

Though being grounded in existing literature and evidence, the present work has several limitations. The selection of terms was applied by the listed authors and is therefore prone to selection bias. As such, no systematic procedure was chosen and additional terms could be missing. Nevertheless, the consolidated ontology should be seen as a terminological basis to be reviewed and updated continuously. Established high-quality literature provided by national and international associations as well as scientific papers should be used to update the terminological basis for the proposed ontology in the future.

6. Conclusion

Based on a literature search, we provide an updated ontology for telemedicine and related terms and support the overall understanding with specific application types. With the help of use cases, we highlight the applicability of the proposed ontology and outline how developers of digital health interventions, regulatory bodies or funding agencies can make use of this terminological resource. Due to the emerging development of subcategories and trends in digital health, continuous updates of the terminological nomenclature are needed to ensure its contemporary validity.

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