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Nursing Competencies for Multiple Modalities of Connected Health Technologies

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Abstract. An overview of the rapid and diverse number developments in health information technologies (HIT) in recent years are described in this chapter and the move towards more integrated and connected health is described. The evolution of HIT is described as it has increased in complexity, diversity, connectivity, and more recently, the move towards multiple modalities. Examples of developments in various settings are represented from clinical settings, at home, and in low-resource settings. The implications of the move towards multiple modalities for nursing competencies and the move towards personalized and connected health are discussed, highlighting important areas for consideration and development in the future.

Keywords. eHealth, mHealth, uHealth, integrated care, connected health, IoT

1. Introduction

Connected health as a concept has been integrated into development and change in producing health care services. In recent decades several technologies have been introduced to help the transition in practice from physical to virtual and from manual to digital actions in health care [1]. Thus, connected health is linked not only to technologies, but also to management, and social aspects of providing timely, continuous and high quality care.

Changes in patient profiles, care contexts and costs are challenges for delivery of nursing care globally. The growth in the amount of elderly citizens and complexity of their care needs and services is seen as a driving force to focus on integration at professional, organizational, regional and national level. Early discharge and on the other hand demand for cost-effective services emphasize to provide additional home care beside hospital care [1, 2].

This chapter gives an overview and examples of the diversity of what is considered "connected health" and discuss some of the implications of connected health for nursing competencies. First, the focus will be on providing basic definitions (e.g., eHealth, mHealth, and pHealth) of the diverse terminology related to advanced technologies (e.g., Internet of Things). Next, case examples of connected health will be presented divided by setting (e.g., clinical, home, low-resource settings), with the aim

of illustrating the growth towards multiple modalities. Finally, considerations and implications for nursing informatics competencies will be discussed.

2. The evolving field of connected health

Connected health is close to the concept integrated care highlighting the role of patients, collaboration among professionals, and coordination of health care services at multiple levels with advanced technologies. Sharing care information and focusing on the continuum of health care delivery are the key components of integrated care to ensure high quality, safe and efficient care to patients and populations with disabilities or chronic diseases across settings and organizations [1, 3]. Both integrated and connected health are premised on use of advanced technologies with aims on access, sharing, analysis, and use of health data through applications and information systems. Further, the premise of connected health also includes potential cost-effectiveness provided by creative and novel ways of delivering health care, compared with traditional face-to-face care [1].

Technologies that can be seen as encompassed under the broader term of connected health has grown in diversity in recent decades, signaling evolution in the field towards multiple modalities. The adoption of various terms e.g., eHealth, uHealth, mHealth, pHealth, and Internet of Things (IoT) have been connected not only to technologies used in health care but also to describe the practical consequences of advantages as well as disadvantages of the usage. More recent developments are exploring the potentials of wearable electronic devices that can monitor physical and physiological changes in the body and "smart" spaces that incorporate environmental biosensors and facilitate pervasive monitoring [3-5].

Figure 1 illustrates the ecosystem of connected health supported by advanced technology, focusing on continuum of services and service providers. In the ecosystem, mHealth describes the actors of the service system who are connected to services and service providers through mobile technology. One of the main advantages mHealth provides is the independence of location and timing to access and use information and services [1, 6]. In the ecosystem, pHealth represents the continuum of personal health data content/items from disease to wellness which are stored and shared through eHealth applications [1]. It also includes the growing field of personalized health, where treatment of diseases is adjusted to specific personal characteristics [7] Finally, the ecosystem should provide accessible connections with various means and technologies when and where ever needed (uHealth) as well as connect to recent advances in technologies in various formats and be able change and share data and information (IoT).

To aid in providing clarity around terminologies and modalities under the umbrella of connected health, the following sections provide brief definitions of some common terms.

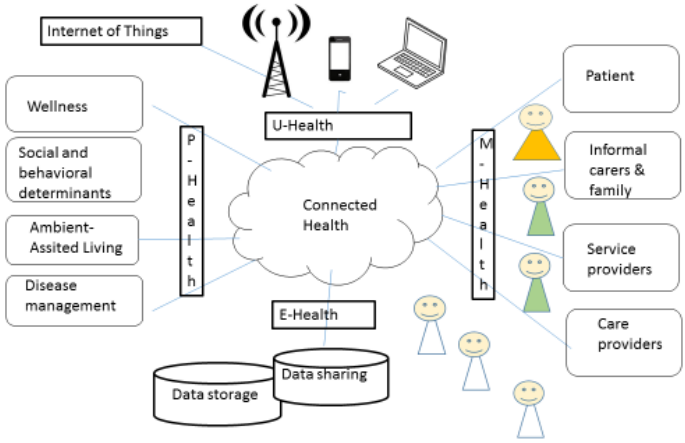

Figure 1. Connected health ecosystem.

2.1 From eHealth to uHealth

The concept of eHealth was introduced in the beginning of 2000's [8] and the number of studies focusing on various aspects of eHealth adoption in health care has grown extensively since then [9]. A remarkable growth of research is especially seen since 2010, based on reviews [1, 4]. The vast amount of eHealth definitions have a lot of commonalities in regard to use of technologies in support health and health-related fields by electronic means and to improve the availability, quality and efficiency of health services [9-10]. eHealth as a concept has been regarded as an umbrella term for the use of Information and Communication Technology (ICT) in healthcare. The outstanding definition by Eysenbach describing the meaning of "e" as not only electronic but far more important aspects of the vowel e.g., education, empowerment, ethics [8]. In terms of connected health eHealth focuses on methods providing safe information management.

Almost parallel to concept eHealth the term uHealth started to appear in the literature in the mid 2000's (e.g., NI2006 proceedings) [11]. Information and communication technology was regarded to have ubiquitous possibilities for use in health care (uHealth). For instance, within the proceeding of the 9th International Congress on Nursing Informatics, a track for submissions focused on ubiquitous computing. Papers and posters presented at this conference described Intranet, Internet, websites, wireless and mobile terminals use in clinical practice and education. On the other hand, Internet and videoconferencing were topics already in the 6th International Congress on Nursing Informatics in 1997. This verifies that nurses, researchers and educators have been early adopters of advanced technology. Overall, uHealth provides wide insights to multiple use of technology in connected health especially highlighting the flexibility of use.

2.2 From telehealth to mHealth

The introduction of the concept mHealth occurred slightly after the concept eHealth. However, mHealth has its origin in telemedicine which has its potential to provide asynchronous communication between care provider and patients. For instance, telemedicine and telehealth can be seen as initial forays into connected health. Telemedicine is described as using electronic communications to facilitate medical information exchange and telehealth can be viewed as a further expansion to include the participation of consumers by providing access to health education resources and support for self-management through the use of the Internet [1, 4].

With advances in technologies came the rise of mobile health that accompanied the rapid proliferation of the use of cellular phones and mobile devices [1]. Within mHealth, we have seen the delivery of health information and facilitating the work of health care providers through short message services on basic cellular phones, to the delivery of sophisticated medical functions and decision support for health providers, given the introduction of smart phones with access to the Internet. mHealth is also regarded more consumer-centered in terms of providing support and information sharing both to patients and professionals. Interestingly, based on previous studies more facilitating than restraining factors were revealed in m-health adoption. However, it seems that external factors for instance human and organizational environment have challenges to overcome [4]. mHealth has advantages to connect citizens, patients, relatives, and care providers with the use of technology to improve especially co-operation in terms of care coordination, information flow and exchange [7].

2.3 From pHealth to IOT

The various definitions focusing on personal health information management highlight the role of an individual and his/her rights on accessing, managing and sharing electronic information in a confidential, secure, and technically sound environment [4]. The number of applications and software developed to maintain personal health information is expanding yearly. The size of devices, connectivity, and mobility enables various groups of citizens and patients to maintain their health data easily, even continuously if needed. pHealth services tend to be highly distributed from virtual environment independent of location and time. Services are individually tailored to diagnose, care, prevent, and provide lifestyle services [12]. The use of sensors and sensor systems have abilities to monitor a variety of activities not only for wellness and lifestyle assessment. With the advances of wearable systems they have a huge potential for clinical use as well as home care based on the patients' signs and symptoms to be monitored and assessed. [4].

The amount of data, diversity of technology in use and multiplicity of actors in health care demands effective and interoperable systems for data exchange. The term Internet of Things (IoT) appeared in the literature in 2010's to highlight the not only the technology but also the networks required to connect the devices and people even the devices with themselves. Internet of Things has been defined as "things belonging to the Internet" involving sensor based data collection, data management, data mining and World Wide Web. The vision to interact anything and anytime is especially appealing in remote care [13, 14].

3. Case studies

The definitions provided in the previous section highlight the continual development of technologies and concepts as related to connected health. In this section, we describe examples from the literature to illustrate the diversity in modalities of connected health available today, from clinical settings, to the home, and within low-resourced settings.

3.1 From clinical settings

In clinical and acute settings, there have been efforts to improve communication among nursing and other health care professionals through the use of technology, beyond static computer stations and electronic health records. Among these efforts include exploring the potentials of mobile devices, environmental sensors, and in particular, the use of radio-frequency identification (RFID – a wireless Automatic Identification and Data Capture technology). As components of 'smart' hospital rooms, RFIDs enable ubiquitous computing and the collection of ambient data to inform and support the work of clinicians.

One example of such a study explored the use of RFID tags and readers worn by patients, healthcare workers, and placed in surrounding objects, as a means to track movement of persons and objects in real-time, as well as a means of collecting and using real-time data to support the work of health care providers and systems [15]. Multiple uses of RFID in a "smart hospital environment" were described. First, the ability to track and manage valuable assets such as expensive hospital equipment is made possible, reducing time spent searching for equipment and allowing for the ability to forecast requirements of future inventory. Another application is the ability – through wearable RFID tags and readers placed in the environment – to locate and track the positions, movement, and identities of health care workers and patients. This tracking function, combined with the ability to track certain physiological and biomedical patient data (e.g., heart rate, oxygen saturation, temperature, blood pressure, step count, etc.) serves as a powerful information source that can inform built systems of emergencies or adverse events. For example, an ambulatory patient whose movement is seen to abruptly stop combined with abnormal physiological conditions can trigger an emergency rescue process system, identifying the closest available health care worker who can attend to the patient. Similarly, Ariffin and colleagues proposed a system and provide recommendations for implementing a system that uses RFID tags and readers as an affordable way to monitor patients in a psychiatric ward, in an effort to reduce the numbers of patients who left without permission or formal discharge [16].

Other areas of interest in the acute care setting centers on the use of innovative communication technologies to facilitate communication and workflow among nurses and other members of the health care team, including telephones, various mobile technologies (e.g., pagers, mobile phones, personal digital assistants), and increasingly, wearable hands-free communication devices [17]. For example, Pemmasani and colleagues evaluated the use of a hands-free mobile voice communication system and assessed nurses' perceptions of advantages and disadvantages of this technology [18]. Results of the study were mixed. Although it was found that the technology successfully reduced the average distance that staff walked during a shift by nearly 20% -- in line with findings of other studies [19-22] – participants nevertheless expressed challenges and limitations related to signal reception and voice recognition [18]. Findings of this study suggests that hands-free communication

technologies, with further development and refinement, have potential to free up nursing time and improve communication in inpatient acute care settings, although issues related to quality of the technology and connectivity need to be carefully considered [18].

Numerous studies suggest a positive potential in leveraging ICTs to support better communication in acute settings, however, limitations of past studies need to be considered in interpreting results. For instance, a systematic review of studies from 1996 to 2010 on ICT adoption among clinicians suggest that many studies were of lower quality; there remains limited evidence for improvement in communication effectiveness as a result of ICT adoption and the need for more robust evaluations [17].

3.2 *At home: Gerontechnology*

A recent review provided a narrative account of the of newly developed and implemented technologies in gerontechnology – "a term born in Europe just prior to the 1990s as a composite of a two words: 'gerontology,' the scientific study of aging, and 'technology'" [23]. Gerontechnology is concerned with research on the biological, psychological, social, and medical aspects of aging, exploiting the potentials offered by the progress of technology. [24]. The review sought to gain an understanding of technologies developed and implemented for older adults' home use, as well as to examine whether there is evidence to support the premise that these technologies can support independent living [25]. Of the 184 publications included in the review, the authors categorized devices as having three key target functions that addressed: (1) social isolation; (2) loss of autonomy and functional decline; and (3) cognitive disorders and behavioral and psychological symptoms of dementia. Many studies attempted to address specific health problems and limitations, with a dominance of issues related to chronic obstructive pulmonary disease, diabetes, heart failure, and other chronic conditions [25]. Currently, there is very limited evidence and few articles addressing the needs of the frail older person nor on upstream technologies that aimed to prevent physical disability or decline [25].

The review highlighted the diversity of technological approaches and devices being explored in gerontechnology. For instance, studies leveraging technology to address social connectedness of older adults employed the use of cell phones, computers, and innovative "sociometric" devices that can monitor interpersonal interactions and detect social isolation. One example was a wearable pendant that by detecting the presence of other pendants and analysis of the users' tone of voice, could quantify the quality and frequency of personal interactions of wearers [26]. Other approaches leverage tracking capabilities of mobile phones to determine patterns of movement and mobility as a way to quantify social networks.

Technological developments related to alarms and personal emergency response systems were a focus in gerontechnology studies [25] with the aim of monitoring risks, detecting acute and adverse events, and providing a sense of security for those living alone [27]. The use of various sensors were prominent ways of monitoring physical activity and abnormalities in movement. For example, the use of pressure sensors in "smart carpets", infrared sensors, and increasingly, wearable systems that make use of accelerometers, gyroscopes and inclinometers, were incorporated in devices to monitor falls and provide alerts to caregivers [28-30]. Other examples of developments to address functional and cognitive decline included: exploring the use of robotic systems to support the rehabilitation of disabled people [31], providing support for activities of

daily living and provide companionship [32]; "intelligent" mobility aids with built-in safety features [33], that can facilitate the avoidance of obstacles and provide navigation [32, 34]; and computerized devices that use artificial intelligence to prompt and guide individuals through activities of daily living [35].

3.3 In low-resource settings: Liga Inan project in Timor Leste

In countries where penetration of more traditional communication technologies, such as telephone lines and broadband internet, are low, m-health in particular has been seen as a mechanism for connecting with patients who previously had limited access to the healthcare system [36]. One such example is the Mobile Moms, or Liga Inan project in Timor Leste. This project combines pregnancy stage-based text messages to expectant and new mothers with a means of requesting a call back from an on-call midwife as well as a clinical tool that midwives use for registering patients and tracking care [37]. Midwives reported overall job satisfaction with the tool including a perceived increase in communication with patients and a perceived increase in the use of skilled birth attendants. Midwives' perceptions of an innovative mHealth technology's impact on their work and job satisfaction Patients have given positive feedback about the program with 96% reporting satisfaction with the content of the messages [38]. The increase in demand in services, however, presented a challenge, as midwives reported being unable to arrange for transportation for patients to healthcare facilities [39].

Research on the impact of mHealth in low resource settings is showing improvements in delivery of care and access to the healthcare system to many challenges to successful implementation and sustainability remain [36]. While mHealth and other forms of connected health pose great promise towards strengthening and connecting patients with providers, new challenges can develop where staff lack the resources or the competencies to meet with new patient demands.

Table 1. Case study summary illustrating the variety of technologies described in these case studies in clinical, home, and low-resourced settings.

Setting	Technology
Clinical	Use of mobile devices, environmental sensors, and radio frequency identification (RFID) to collect real-time and ambient patient data, mobile technologies (pagers, mobile phones, personal digital assistants) and hands-free devices to support inter-team communication.
Home	Various sensors to monitor physical activity and abnormalities in movement, robotic systems to support the rehabilitation, communication devices to facilitate companionship, "intelligent" mobility aids with built-in safety features, navigation, and can avoid obstacles, computerized devices that use artificial intelligence to prompt and guide individuals through activities of daily living
Low-resource settings	Bi-directional text messaging to support communication, care coordination tools between community health workers and facility-based nurse managers

4. Competency recommendations and implications on the expected roles of nurses

The evolution of connected health technologies are moving towards multiple modalities and are taking innovative and diverse approaches to support health care workers, health systems, and patients, as illustrated in the above examples. Ultimately, the overarching intention of these diverse and innovative HIT developments is to support and deliver interventions and health care services that are better connected,

integrated, and personalized. Unsurprisingly, these developments in connected health are accompanied by numerous implications for the provision of nursing care and require some new competencies of nurses to best make use of connected health technologies.

For one, the goal of having HIT facilitate patient-centered care, integrated care, and health care teams' communication can shift care team dynamics and patterns of care provision. For example, studies implementing HIT have described clinician concerns related to shifts in team dynamics and uncertainties as to whether the new technology should be adopted as a standard of practice or whether its use is up to the discretion of the health care provider [40]. In the same vein, new tasks and functionalities that are made possible with HIT also have the potential to restructure existing care models, support task shifting among various health care providers, and highlight the need for new and different ways of providing patient care [1]. For instance, a wider adoption of RFID tags and sensors in hospital settings will arguably change nursing workflows. For example, creating systems that are capable of continuous individual patient monitoring and aggregated data displayed in central nursing stations, the amount of time nurses need to spend physically checking on patients may be reduced. For such systems and new workflows to be successful however, the need to develop different nursing competencies and capabilities are made apparent. In the system described above, for example, nurses will need to have competencies related to data literacy in order to interpret and make use of ambient data that are collected. In the case of adoption of ambient sensing technology in smart homes, the ways that expectations and competency requirements of home care and community nurses need to similarly be thoughtfully considered. For instance, do nurses need to be more knowledgeable about mobility in the home, if the smart home is capturing data on obstructions that may cause increased risk for falls?

The rapid development and increasing diversity of connected health technologies will arguably influence patient expectations, which will have direct implications for nurses. For instance, rapid developments in HIT may create and promote patients' perceptions of extended provider capacity that may be unrealistic. The increasing push and marketing of innovative HIT, the public's increased and rapid access to HIT development news, and the "selling" of connected health technologies as being able to do more and more [1], may not be in line with actual levels of maturity and sophistication of connected health technologies. The mismatch between what HIT is purported to accomplish and what it is realistically able to achieve may be something that nurses may need to contend with, as related to patient expectations. Further, as HIT increasingly aims to facilitate ubiquitous connectivity, an important expectation that all health care providers will need to contend with is the potential expectation of 24/7 availability of health services.

Navigating the diversity and rapid development of technologies may be overwhelming for nurses in terms of learning and adopting technologies for their own work, as well as providing guidance for patients using HIT. These relate to two key aspects: 1) the actual use of new technologies; and 2) managing and make sense of the data produced. With regard to the first point, competencies that may need further development among nurses might be related to broad technological literacy and a foundational understanding of health and clinical informatics. The use of advanced technologies demands nurses to be familiarized with both synchronous and asynchronous messaging in terms of technology, psychology, and nursing aspect. It will be impossible for an individual nurse to know and master each piece of technology

they come across. However, there may be fundamental aspects of all HIT hardware and software that can be identified as a foundational knowledge base. For instance, this may include the ability to recognize when the technology does not address end-user needs and understanding how this would ultimately influence decision-making around the appropriateness of HIT use and impacts on health outcomes. Another example may be the nurse's ability to identify when help is needed and knowing how and where to access additional resources to troubleshoot. Considering the increasing diversity of HIT, perhaps a goal in the future is to advocate for core features across all HIT devices (e.g. universally recognizable help button) to be incorporated in future HIT designs.

Finally, competencies related to managing and making sense of the masses of data produced by various HIT will be crucial for nurses. In addition to supporting the nurse's own work, it may be the case that nurses' responsibilities related to teaching and supporting patient self-care (e.g. diabetes management at home) will expand to include supporting patients' ability to navigate, use, and make sense of the data produced by HIT that they use. A crucial point of importance will be nurses' competencies around educating and guiding patients on privacy, confidentiality, safe data sharing, and ownership of data.

5. Conclusion

The challenges for nurses to provide connected health care services will focus on the environment where services are provided, which will vary based on patients' conditions and equipment and tools available. This means that nurses must have knowledge and skills to work with multiple technologies. As competencies, this involves basic understanding of data acquisition, information flow and exchange as well as archiving in nursing practice. In relation to connected technologies used in the context of nurses' own work, additional skills include the ability to use decision support systems in practice, data-based planning and decision making through the utilization & synthesis of HIT system data, quality assurance using technology, and the ability to articulate the application and significance of HIT to clinical practice. As HIT are increasingly taken up by patients, nurses require additional competencies to support patient teaching and self-care around connected health technologies and being able to make sense of the data produced. This includes the ability to synthesize data from more than one source and understand its relevance to practice, demonstrating awareness of and ability to access data and information from multiple sources, understanding of patient rights related to HIT and computerized patient data, and a conceptual understanding of data quality issues for HIT. Competencies related to understanding and interpreting research will also be important, as understanding the supporting literature and evidence upon which technologies are based on will serve as additional sources of knowledge to inform decision-making around HIT use and adoption.

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