

Digital transformation of integrated care: Literature review and research agenda

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Abstract: Ambient assisted technologies have the potential to prolong the life of older adults with declining functional capacities in the community, which is of key importance in ageing societies. It also facilitates work and improves work outcomes in care systems. Currently, in European Union member states, many older adults seek acceptance to nursing homes too early. Current capacities of available nursing homes are in several member states insufficient to cater to increasing demand from the ageing population. How to prolong living in the community and postpone the reallocation to the nursing home is a major challenge in the European ageing society. According to the Web of Science, in the last 20 years, there has been growing research interest in ambient assisted living. Until now, the field of nursing and the field of social care in many member states are not integrated sufficiently, resulting in increased expenditures for nursing and social care on one hand and lack of services provided for a growing number of older adults with declining functional capabilities on the other hand. This paper aims to review the literature on the ambient assisted living and introduce the multiple decrement model for the measurement of efficiency of developed ambient assisted living technologies that are incorporated into the systems for management and control of long-term care services. Based on the proposed model, the future research agenda is outlined.

Keywords: Social care, health care, ambient assisted living, silver economy, ageing.

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1. INTRODUCTION

The recent trend of ageing in Slovenia and Europe has already resulted in a significant increase in the number of older adults with declined functional capacities. Development of sustainable supply and service networks for this population is mayor challenge for EU member states. Digital transformation of supply chains and service networks reduces delays in production and supply chains and also in care services (Bogataj, Aver & Bogataj, 2016; Bogataj & Bogataj, 2004; 2007; Bogataj & Grubbström, 2012) and soon after retirement require long-term care and better facilities, appropriately located, for servicing the older adults and improving designs of supply chains adapting to ageing population (Drobne & Bogataj, 2015; Kovačić & Bogataj, 2013), based on supply policy (Campuzano-Bolarin et al., 2019). Population ageing will increasingly strain Slovenia's and other European Union (from now on EU) member states production and supply systems, healthcare and long-term care systems. Especially the financing is not prepared to face the projected increases in expenditures from population ageing. More specifically, public spending on health and long-term care accounted for 8.5% of gross domestic product (from now on GDP) in the EU in 2015 and is expected to reach close up to 12.5% of GDP in 2060 (Organisation for Economic Co-operation and Development [OECD], 2016). Wolff, Starfield, and Anderson (2002) hypothesized that the demographic and economic trends of long-term care create an impossible

future unless new solutions are found and implemented to care for the elderly. In the opinion of Nagode et al. (2014), long-term care is composed of social care and nursing services. The boundary between health care and social care in long-term care was set up by the OECD, Eurostat, and the World Health Organization in 2006. There is no commonly accepted distinction between health care and social services. We use long-term medical and nursing care, personal care, and assistance with necessary daily activities as part of health care services. All other services related to only help with daily support tasks fall under the category of social care services in long-term care. We present the boundary between health care and social care services in long term care in Figure 1.

Demarcation	Medical and nursing care	Basic daily activities	Daily support activities	Other social care services
Long-term care - health care				
Long term care - social care services				
Partially outside the demarcation of long-term care				

Fig. 1: Demarcation between health care and social care

Source: Adapted from Nagode et al. (2014).

2. LITERATURE REVIEW

One of the possible solutions of how to improve in the field of long-term care is the development of information-communication support. Similarly, Van Grootven and van Achterberg (2019) believed that the primary issues related to promoting healthy ageing are providing support to

quality of care in times of shrinking resources and limited informal and professional care availability. Also, in their opinion, digital transformation could offer such solutions. There are restrictions and high demand for professional care. Therefore, information communication technologies can potentially contribute to improve the existing efficiency or to provide a viable alternative to professional care. Despite their potential, information communication technologies have not yet frequently been used in gerontology (Van Grootven & van Achterberg, 2019).

Digital transformation has the potential to reorganize and improve the provision of long-term care services (Dugstad et al., 2019; Hill & Shaw, 2011; OECD, 2016). In the past, Slovenian institutions already engaged in different projects with an emphasis on digitally supporting health care and ambient assisted living. Also, the number of publications in the field of integrated care is increasing, as presented in Figure 2 (Clarivate Analytics, 2019).

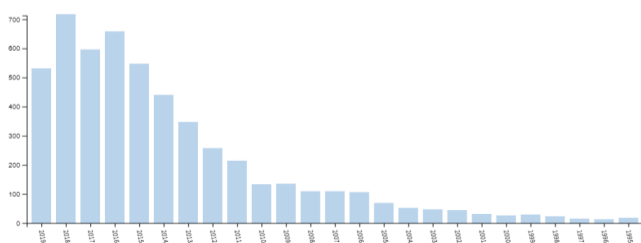


Fig. 2: Number of publications according to Web of Science on integrated care (Source: Clarivate Analytics, 2019).

Ambient assisted living intends explicitly to help people primarily in their natural environment (Calvaresi et al., 2016). Similarly, Ferreira, Teles, and Vieira-Marques (2019) posit that economic and societal challenges that are a result of the contemporary phenomenon of population ageing have been continuously explored by policies that are intended to promote healthy and independent ageing at home. As a field, ambient assisted living also evolved at a fast pace and in different directions in the past decade (Calvaresi et al., 2016). Furthermore, ambient assisted living solutions have gained a distinguished place among strategies that discuss ageing and that address societal challenges in countries where population ageing is an issue (Ferreira, Teles & Vieira-Marques, 2019). In general, ambient assisted living focuses on a variety of different stakeholders, namely social services, relatives, patients, health workers, and care agencies (Calvaresi et al., 2016). Information-communication technologies in the context of ambient assisted living are used mainly as a tool to provide remote care services (Sun et al., 2009). Moreover, ambient assisted living is a core focus of the emerging field of gerontechnology, which deals with technological innovation in the field of health care, social services, which lead to an improvement in the wellbeing of the population in general, but especially for older adults. Such innovations could support individuals to remain longer in the community. Program of healthy and active ageing aims at enabling continued participation of older adults in the

community, supporting their activities, and social engagement, while improving the cost-effectiveness and quality of provision of health and social care services. An essential characteristic of such technologies is also its ability to predict and respond to the ever-changing needs of older adults (Blackman et al., 2015). Due to the availability of all information about their users, such systems can decide which services to provide and to whom, how, and when they should be provided (Queiros et al., 2015). Queiros et al. (2015) further explained that ambient intelligence deals with new paradigms where wireless sensor networks and computing devices are connected with the internet of things and spread everywhere to enable natural and intelligent interactions between individuals and the physical environment. The authors went on to clarify that ambient assisted living provides a digital environment that focuses on allowing autonomous life at home, boosts the self-confidence of individuals, their mobility, health, and functional capabilities and promotes a healthy lifestyle, and prevents social isolation, enhances the feeling of safety, supports caregivers and at the same time enhances the efficiency and productivity of resources.

Several authors provide additional recommendations when discussing the involvement of ambient assisted living solutions in care services. One of them is that information communication technology could indeed occupy the role of a facilitator of health and wellbeing interventions. However, it cannot be its primary driver (Patel, Asch & Volpp, 2015). Moreover, information communication technology solutions cannot function on their own. While self-management programs are gaining in importance, the role of professionals is still integral as they need to teach individuals new skills, equip them with confidence, provide them with self-management tools and help them deal with challenges and identify their accomplishments (Bodenheimer, Lorig & Kolman, 2002). Another important aspect is that information communication solutions should be designed in a way that they can fit into the everyday life of the individual to be used to their full effect. Also, they should require minimal effort to use and be as relevant as possible in the perception of the user (Martin, Kelly & Kemohan, 2008). The end goal of such efforts is to provide a sustainable system of help and enhance the development of new forms of care integrated with healthcare services and supported by digital technologies, aimed mainly to the target population, the elderly. According to the European Commission (from now on EC) (2018), reforms of health and care systems are crucial for the sustainability of public finances. Innovative solutions and digital transformation of health and care have the potential to improve the resilience, accessibility, and efficiency in providing quality care services to an increasing number of older adults. Especially digital solutions are expected to increase the wellbeing of millions of individuals. Moreover, they will radically change the provision of health and care services if they are designed with a clear purpose and are delivered cost-effectively. Also, digitization is expected to promote health and prevent disease in the workplace. This digital transformation can also contribute toward the transition to

new care models that are more focused on the needs of the individual and are examining the possibility to move away from traditional hospital-centered systems to more desirable community based and integrated care structures. With the help of digital tools, we as a society will be able to utilize scientific knowledge in a way so that individuals can remain in good health, thus preventing them from becoming patients. Another significant advantage of digital tools is that they provide the opportunity to better use health data for research and innovation purposes with the end goals of better health interventions in the context of personalized health care with the aim of more effective health and social care systems (EC, 2018). As explained by the EC (2018), personalized medicine is an emerging approach that relies on data gathered by new technologies. The appropriate dissemination of data enables us to better understanding the specific characteristics of an individual and deliver the right care to him or her at best possible time. Furthermore, new technologies allow more extensive use of genomic and other information that supports doctors and scientists in their quest to understand diseases better and serve as potential input to predict better, prevent, diagnose and treat. On the example of residents in nursing homes, Dugstad et al. (2019) argued that the implementation of real-time monitoring by ambient assisted technologies is considered beneficial both for improving the safety of the services users and the overall quality of care. Moreover, it also positively influences the workflow of care providers. According to authors Rada (2015) and Lorenz et al. (2017), digital monitoring is gaining in importance and recognition among health care information technologies in long-term care, namely in residential care for persons who have dementia. However, Dugstad et al. (2019) warned that the successful implementation of novel digital solutions in the care service context has to be understood as a complicated and time-consuming process. Even more concerning, as indicated by Lorenz et al. (2017) and Ienca et al. (2017), many healthcare professionals and service organizations have a negative perception and attitude towards the introduction of such technologies. Typical reasons for such a reluctance include ethical considerations, fear that technology will have a detrimental effect on the built relationships, and a general lack of skills and knowledge in the use of digital technologies (Creswell & Sheikh, 2018; Nilsen et al., 2016). Moreover, some social workers argued that the use of digital technologies in their everyday activities results in the de-professionalization of social work practices (Parrott & Madoc-Jones, 2008). Contrary, in their research, Deusdad and Ricco (2018) reported that professionals believe that digitalization is an appropriate solution in long-term care, especially as a way to speed up and simplify administrative processes. Moreover, the negative stereotypes about technology can be reduced or eliminated when technology can reduce bureaucratic burdens when it facilitates contact with carers and, at the same time, improves coordination among professionals. In such a case, digital technologies can be perceived as practical tools that aim to help cope with the increasing bureaucratic burden. This is particularly eye-opening for individuals as it allows them to devote more time to the

care recipients' needs, especially in comparison with the time necessary to tackle administrative tasks (Deusdad & Ricco, 2018). To conclude, it is hypothesized that we will need to change our mindset and the underlying assumptions that underpin existing models of care if we wish to engage in a successful transformation of health and social care (Ham, Dixon & Brooke, 2012). Therefore, efficiency improvements and overall progress in the social innovation field of health care and long-term care are both possible and desirable. Moreover, population ageing accompanied by the increasing complexity of needs among the elderly indicates that the development of a delivery system that can integrate the fields of health and social care and can rely on new information communication technology solutions is of paramount importance. With such an order, we would also be able to achieve overall improvements in the wellbeing and health of the EU population. If we want to be able to choose the most efficient ambient assisted technologies, we need to develop a model to understand the patterns of improvement of the functional capacities due to the deployment of ambient assisted technologies in the health and social care context and their influence on the older adults tenure in the community and delayed relocation to the nursing home.

Ambient assisted living technologies provide real-time context information about older adults and the environment (Bernardos et al., 2010). An essential dimension of ambient assisted living is fall detection, where a wearable wireless accelerometer device is applied, and communication with care holders and relatives of assisted persons is available in real-time (Lombardi et al., 2009). Wireless Sensor Networks are vital enablers of ambient assisted living services (Martin et al., 2009). Radio Frequency Identification (from now on RFID) tags can log care events whenever a continuous data link is not desirable, and interactions between RFID wearable device. The carer's usage of mobile devices can improve the quality and quantity of relevant information (Lopez-de-Ipina et al., 2010). The current multiple decrement models only consider healthcare - nursing needs (Rogelj et al., 2019). Moreover, the current model of long-term care uses a hospital institutional approach, where nursing services are prioritized in comparison with social care services. If we want to keep older adults engaged in the community and support active and healthy ageing also the equal importance of nursing and social care should be promoted. This approach considers the balanced approach of both aspects mentioned above. During our literature review, no indexed Web of Science paper exists that would jointly model disability thresholds for both needs and both disability thresholds. Our paper adds to state of the art presented in Abtoy, Touhafi, and Tahiri (2018) and Singh et al. (2017).

3. THE FUTURE RESEARCH AGENDA: THE MULTIPLE DECREMENT MODEL

The basic actuarial multiple decrement models were already developed by Bogataj et al. (2015; 2016), Deshmukh (2012), Promislow (2015) as well as Rogelj and

Bogataj (2018) and Rogelj et al. (2019). However, in the existing multiple decrement models, social care has not been considered as equivalent to nursing services when defining categories of care. In this paper, we use standard actuarial notations. The majority of older adults who are over the age of 65 do not expect to move to the nursing home well after the historically determined retirement age due to the shortage of available beds in nursing homes. For example, in Slovenia, current demand exceeds available capacities for more than 50%. A similar situation is also in other new member states, like Bulgaria or Rumania, Czech Republic, and Poland. With ageing, older adults experience decay of cognitive functions (Prakash et al., 2009), physical capacities (Lindberg et al., 2009) as well as encounter visual problems (Bucur, Madden & Allen, 2005). Physiological declines influence the ability of the performance of activities of daily living. There is a disability threshold, at which older adults are no longer able to perform daily activities in their current environment and need a relocation to the nursing home. Ambient assisted technologies allow real-time communication and observation between nursing and social work professionals and the user living in the community. The dynamics of the physical and cognitive functional capacities of older adults is shown in Figure 3.

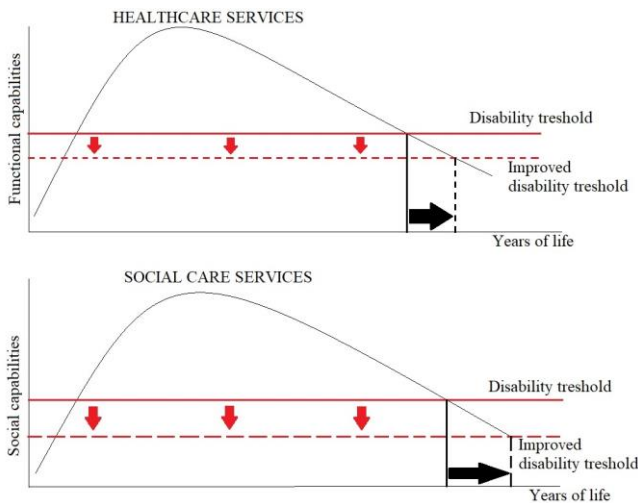


Fig. 3: Healthcare and social care services – functional and social capabilities declines and dynamics in long-term care

The older adults may move among the various category of care, such as fully functional older adult; older adult in need of social care; older adult in need of nursing services; older adult in need of memory care; older adult in need of a combination of nursing and social services, nursing home resident and dead. The model enables us to study how we can postpone the relocation to the nursing home with ambient assisted technologies. In multiple decrement models that have m different states for older adults with declining functional capabilities, there are $m + 1$ states for the transition from one category of care to another (the second usually being more dependent on the help of others). We denote with C the set of different states of a person with different categories of care. We denote the initial state of the fully-functioning person as state 0 and

decrease of functional capabilities, accompanied with a certain level of assistance and care with j ($j = 1, 2, \dots, m$). There are known probabilities of transition from state 0 to state $j \in C$. All paths to j determine the dynamics of integrated care at decreasing functional capabilities, showing a variety of exits from the community to nursing home or death (Bogataj et al., 2015; 2016; Deshmukh, 2012). The seniors move along different paths of the graph to death ($j=m$). We denote senior x years old, living previously in the community in a current category of care $i \in C$ by $T_i(x)$. Therefore, $x + T_i(x)$ will be the age when the senior exits out of the current category of care i and enters a new category of care $j, j \in C$. The future service period in the category of care i , $T_i(x)$, is a random variable with probability distribution function:

$$G_i(t) = \Pr(T_i \leq t), t \geq 0 \quad (1)$$

The function $G_i(t)$ represents the probability that the older adult will die or transfer to a different category of care j within t years, for any fixed t . $G_i(t)$, is calculated from the given national statistics. $G_i(t)$ is continuous having probability density $g_i(t) = G_i'(t)$. Thus, we can write the probability that the senior will transfer from the category of care i in the time interval from t to $t+dt$:

$$g_i(t) dt = \Pr(t < T_i < t + dt, j \in C) \quad (2)$$

Therefore, the probability that an x years old person in the category of care i will transfer into a category of care j within t years, denoted by ${}_i q_x(i, j)$ is:

$${}_i q_x(i, j) = G(i, j; t) \quad (3)$$

and the probability that an x year old senior will remain there at list t years:

$${}_i p_x(i) = 1 - G(i, j; t) \quad (4)$$

Forecasting the future care structure of seniors S in the multiple decrement model ($i \rightarrow j; i \in C, j \in C$) is described by the following transition equations:

$$S_{x+1, \tau+1} = S_{x, \tau} P_{x, \tau} = \left[S_x^{(0)} S_x^{(1)} S_x^{(2)} S_x^{(3)} S_x^{(4)} S_x^{(5)} S_x^{(6)} S_x^{(7)} \right]_{\tau}^*$$

$$* \begin{bmatrix} p_x^{(0)} & q_x^{(0,1)} & q_x^{(0,2)} & q_x^{(0,3)} & q_x^{(0,4)} & q_x^{(0,5)} & q_x^{(0,6)} & q_x^{(0,7)} \\ 0 & p_x^{(1)} & q_x^{(1,2)} & q_x^{(1,3)} & q_x^{(1,4)} & q_x^{(1,5)} & q_x^{(1,6)} & q_x^{(1,7)} \\ 0 & 0 & p_x^{(2)} & q_x^{(2,3)} & q_x^{(2,4)} & q_x^{(2,5)} & q_x^{(2,6)} & q_x^{(2,7)} \\ 0 & 0 & 0 & p_x^{(3)} & q_x^{(3,4)} & q_x^{(3,5)} & q_x^{(3,6)} & q_x^{(3,7)} \\ 0 & 0 & 0 & 0 & p_x^{(4)} & q_x^{(4,5)} & q_x^{(4,6)} & q_x^{(4,7)} \\ 0 & 0 & 0 & 0 & 0 & p_x^{(5)} & q_x^{(5,6)} & q_x^{(5,7)} \\ 0 & 0 & 0 & 0 & 0 & 0 & p_x^{(6)} & q_x^{(6)} \end{bmatrix}_{\tau}$$

$$= [S_{x+1}^{(0)} S_{x+1}^{(1)} S_{x+1}^{(2)} S_{x+1}^{(3)} S_{x+1}^{(4)} S_{x+1}^{(5)} S_{x+1}^{(6)} S_{x+1}^{(7)}]_{\tau+1} \quad (5)$$

The quality of digitally supported integrated care is influencing the intensity of transitions (Rogelj & Bogataj, 2018).

4. FUTURE RESEARCH AND CONCLUSIONS

The significant gap that was found in the literature is that no model would forecast healthcare – nursing and social care needs simultaneously and measure their social value. This study brings essential benefits as (1) it can improve the sustainability of long-term care systems and designing supply chains where seniors are customers or workers (Bogataj & Usenik, 2005; Kovačić et al., 2015; Kovačić,

Usenik & Bogataj, 2017; Usenik & Bogataj, 2005); (2) it explains that transitions in Slovenia and many other countries, from institutional care to community care are not performed successfully because the community care facilities are not developed enough (Rogelj et al., 2019); (3) it elaborates on the fact that contribution rates and expenditures for long-term care are expected to double or in some EU member states even triple in the next 40 years; and (4) it argues that at the moment, the organizational capacities of community care and investments in ambient assisted technologies are deficient. However, this is still seen as a possible solution to improve older adults' health and longevity. Finally, (5) The proposed model and collection of national or regional health statistics will allow a better understanding of patterns of functional capabilities of older adults and demand for long-term care services. Moreover, using the model presented in our paper can support policymakers in evaluating national pension and long-term care policies (Bogataj, Vodopivec & Bogataj, 2013) and supply (Campuzano-Bolarin et al., 2019), which influence transition probabilities.

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