ISBN: 978-981-18-7950-0
2023 the 13th International Workshop on Computer Science and Engineering (WCSE 2023)
doi: 10.18178/wcse.2023.06.028

Internet of Things Based Patient-Centered Care Model for Elderly Healthcare: A Conceptual Model

Nur Hani Zulkifli Abai+, Saira Nawaz and Mawarny Md Rejab

School of Computing, Universiti Utara Malaysia, Sintok, Malaysia

Abstract. The increase in elderly population escalates the challenges in the elderly healthcare service. To increase the quality of healthcare service for elderly, patient-centered care approach has been proposed. However, there are few issues need to be highlighted. Among the issues are the need of continuous monitoring that requires continuous clinical data collection. This involves huge labor and increase medical service cost. Apart from that, most elderly patients have multimorbidity that requires health services from multiple care providers and multiple care environments. Transmission between care providers and care environment require more efficient health information sharing method. To overcome these problems, the use of the Internet of Things has been introduced to help in terms of data collection and data transmission. This paper presents a conceptual model on Internet of Things based Patient-Centered Care for elderly healthcare monitoring. It comprises the Internet of Things layer, two principles from Patient-Centered Care Model and Comprehensive Geriatric Assessment Process.

Keywords: Internet of Things, Software Engineering, Smart Healthcare, Patient Centered Care, Elderly

1. Introduction

The provision of health and social care to the growing elderly population is one of the greatest challenges for society in the coming decades. This is due to the increase of elderly population all over the world over the decades. Elderly healthcare has become one of major concern since they are usually unable to care for themselves that lead to the important of Patient-Centered Care (PCC) approach. PCC allow caregivers to identify and manage common elderly health problems appropriately. It incorporates the important of family and friends' participation and highlight the importance of patient preferences.

In current era, there are various efforts to use system-based elderly care technologies. Most of them are primarily restricted application to assist the elderly needs (e.g. health protection, safety control, etc) and relying on physicians to evaluate patients conditions. However, current solutions have many challenges regarding data integrations and information sharing across different care providers and care environments and therefore does not support the concept of PCC [1]. One of the most critical areas is in clinical data collection. Since health monitoring is one of important aspect in elderly healthcare, it is very important to have continuous clinical data collection of the elderly. Manual data collection is time consuming [2] and require huge amount of labour and traveling time for patient for physical examination. It also have high risk in human error, missing information [3,4] and low data quality [5] that might lead to clinical errors caused patient health deterioration and, in some cases, death [6].

Furthermore, in PCC implementation, patient' clinical data needs to be captured not only inside care environment (e.g., hospitals, clinics) but also outside care facilities. However, current technologies lack the support of documenting patient's data (e.g., physical exams, laboratory tests) both inside (e.g., hospitals) and outside of care environments (e.g., at home) [7]. Moreover, PCC implementation also require the integration of Patient Generated Data (PGD) regarding patients' beliefs, behavior, environment [2] and other variables (e.g., physical activity, sleep patterns, self-reported sign and symptoms, blood sugar levels, or behavior tracking) [8]. PGD data collected directly from patient [8], can be useful in personalized treatment decisions and optimizing PCC implementation [2, 8]. However, current solutions lack in contextual data support for

+ Corresponding author. Tel.: +6049285164; fax: +6049285067.
E-mail address: nurhani@uum.edu.my.

Patient Generated Data (PGD) [2, 7] and thus are insufficient for coordination in treatment decisions and planning [9].

In this situation, the Internet of Things (IoT) is a promising solution to offer continuous, objective, and holistic monitoring, alleviating the burden of human caregiver effort and supporting clinical decision making. The goal is to help this large group of elderly people to live safely in their homes as far as they can and to prevent unnecessary further hospitalization in the future. Rapid networks and the emerging sensor technology will also play an important role in meeting the needs of an increasing population. This research paper presents a conceptual model of IoT health care solutions that incorporate important elements from patient-centered care perspective. The conceptual model has been developed based on three different perspectives that are elderly healthcare monitoring, patient-centered care approach and internet of things.

The paper is structured as follows. Section 2 presents previous work related to this study related to IoT, PCC and elderly healthcare. Section 3 presents research methodology that has been used to develop the proposed conceptual model. Section 4 presents the conceptual model of IoT based patient-centered care for elderly healthcare. Meanwhile final section presents conclusions of this paper.

2. Previous Works

2.1. Elderly healthcare

The distribution of the world's elderly population (age 65 and above) structure estimated to growth from 10% in 2017 to 22% by 2050 [10]. This phenomenon is highly noticeable in Europe as it is projected that the proportion of the elderly population would reach 35% by 2050 [10]. Longer lives offer numerous incentives, but the magnitude of the chances of improved survival would, however, mostly depend on one main factor: the health [11]. WHO study in 2014 shows that while serious disabilities for older people might have decreased significantly, no substantial improvements in less extreme disabilities have been observed over the last 30 years (that include support from another person over simple tasks such as eating and washing) [12]. Geriatric syndromes, multimorbidity, and disability are closely interrelated and prevalent among ageing population [11]. Many of such Geriatric conditions had been categorized by [13] as show in Fig. 1.

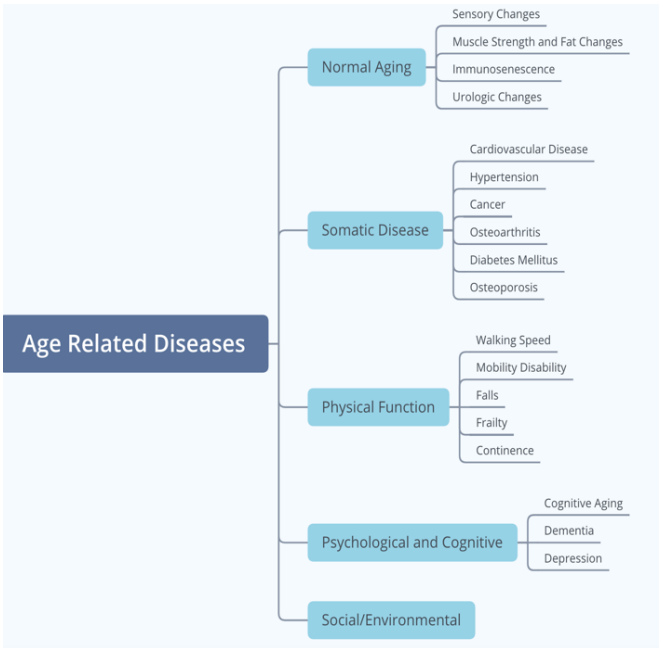

Fig. 1: Age related diseases[12]

Identifying geriatric conditions by performing a geriatric assessment can help clinicians manage these conditions and prevent or delay their complications. This is important especially to isolate someone who actually has infectious disease such as COVID-19 and avoid placing lots of people under risk[14]. Therefore, a multi-dimensional, cross-diagnostic method for determining the medical, psychological and cognitive capacities of a vulnerable elderly person also known as Comprehensive Geriatric Assessment (CGA) had been proposed for this study. CGA is not only a full diagnosis to identify frailty, but also a clinical roadmap

to human multidisciplinary optimization of a fragile patient [15]. CGA's potential advantages include improving the diagnosis precision, optimising patient treatments, enhancing prognoses, restoring maintenance, supporting lack of choice and autonomy and improving the quality of life [16]. Figure 2 shows the CGA processes.

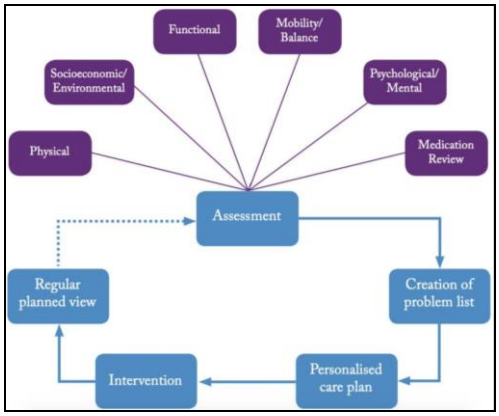

Fig. 2: Comprehensive geriatric assessment [15]

2.2. Patient centered care

Picker's Patient Patient Centered care (PCC) is a model of health care which offers a holistic approach to patient care. This covers physical treatment, emotional care, environmental (hospital or home) and self-care [17]. It comprises listening to patients, educating them, and involving them in their treatment. It is a personalized care approach that helps health professionals to develop patient-specific care plans. PCC is defined as: "providing care that is respectful of and responsive to individual patient preferences, needs, and values and ensuring that patient values guide all clinical decisions" [17].

PCC is a term used by healthcare providers to define the level of interaction between patients and healthcare professionals that has an effect on patient treatment [18]. It promotes the relationships in which physicians and patients share information in a two-way manner, discuss patients' values and preferences, assist patients and their families in making treatment choices, facilitate access to adequate treatment, and allow patients to stick with the often difficult behavioural improvements required to sustain or improve health [19]. A summarised view of Picker's eight principles by [20] are discussed as below:

- Respect for patients' values, preferences includes an understanding of quality-of-life issues, participation in decision-making, integrity, and commitment to patient wishes and autonomy.
- Information and education on clinical status, progress, prognosis, and processes of care in order to facilitate autonomy, self-care, and health promotion.
- Physical comfort including pain management, help with activities of daily living, and clean and comfortable surroundings.
- Emotional support and alleviation of fear and anxiety about such issues as clinical status, prognosis, and the impact of illness on patients, their families and their finances.
- Involvement of family and friends in decision-making and awareness and accommodation of their needs as caregivers.
- Access to care with attention to time spent waiting for admission or time between admission and placement in a room in the inpatient setting, and waiting time for an appointment or visit in the outpatient setting
- Coordination and integration of care across clinical, ancillary, and support services and in the context of receiving frontline care
- Continuity and transition as regards information that will help patients care for themselves away from a clinical setting, and coordination, planning, and support to ease transitions

This study is focused on proposing a solution that solves the healthcare coordination and transition issues among multiple care providers and care environments, therefore, the scope of study will focus on two principles from Pickers' PCC model that are Coordination and Integration of Care and Continuity and Transition.

2.3. Internet of things in elderly healthcare

The IoT is described as a network of information developed by RFID and communications technologies [21]. It can be defined as a networked interaction of physical objects or devices that can coordinate themselves, exchange knowledge, data and resources, respond and act in situations and environmental changes [22]. The foundation of IoT architecture [23] is composed of three fundamental elements. The first element is hardware that includes sensor nodes, its integrated communication and interface circuitry. The second element is middleware that comprises of network communication, data process and analysis. Meanwhile the third element is presentation that consists of effective visualization platforms, compatible with various systems for various applications, and present data in an accessible way to end-users. Physical objects, sensors, cloud servers, developers, actuator layers, customers, business layers, and IoT protocols all play a role in IoT architecture. There is no single consensus on a standardised IoT architecture because of the broad variety of Internet objects. Most researchers see traditional IoT architecture as being at three levels: Perception Layer, Network Layer and Application Layer [24](Jabraeil Jamali et al., 2020).

Some of the previous studies aim on accuracy and reliability of clinical data [25]. Meanwhile other study focuses on remote monitoring [25, 26, 27], clinical data collection [25, 26, 28], data transmission and sharing [25, 26, 27] behavioural monitoring [29, 30], rehabilitation and recovery [30] and mobility monitoring [31]. Some of the studies were carried out with concern about cost effectiveness [26,28].

3. Research Methodology

The first step in this was to study was to understand the concept of PCC, IoT and elements required to build IoT based PCC conceptual model. The references comprised of books, journals, referenced and non-referenced white papers, reports, thesis and public policy. The literature review was intensively and systematically reviewed and analysed with important content in tabular form to give a broader understanding of each aspect studied. The study was focused on elderly healthcare context and understanding of current issues within the context of the study. The next step was aimed at identifying important elements necessary for conceptual model development based on IoT, PCC and elderly healthcare domain. All identified elements had been extracted from literature has been analysed to identify groups of elements in each domain. Final step is to study the relation between elements and develop the conceptual model.

4. The Conceptual Model of IoT based PCC for Elderly Healthcare

In this section, a conceptual model of patient centred care is being proposed. As shown in Fig. 3, the conceptual model focuses on three domain that are IoT, PCC and elderly healthcare monitoring. Two principles from PCC have been chosen related to identified problems that are Coordination and Integration of Care; and Continuity and Transition. Based on these principles key elements needs to be considered to achieve PCC in healthcare has been identified that are clinical data and participants data. Participants data contain information of patient, multiple care providers (e.g., healthcare professionals, family, and patient) and multiple care environments (e.g., hospital, nursing facilities, home, primary and special care offices).

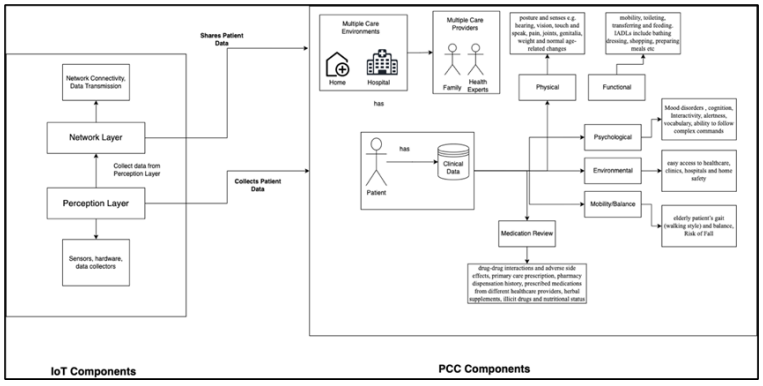

Fig. 3: IoT based PCC for elderly healthcare conceptual model

In order to understand the clinical data requirements for elderly healthcare monitoring, Comprehensive Geriatric Assessment(CGA) process has been adapted as a base foundation. CGA proposes data collection related to patient's functional, physical, socioeconomic/environment, mobility, psychological factors need to

be collected and assessed to create specialized care plans for elderly. Therefore, in the conceptual model, clinical data has been linked to CGA data requirements. For the purpose of inducing IoT to assist in data collection and data sharing in elderly healthcare, layers in IoT architecture has been linked to support both PCC elements. In IoT architecture, Perception layers is directly linked with data collection, while network layer is linked with data access and transmission.

5. Conclusion and Limitations

Elderly healthcare require technology empowerment to increase its efficiency, affordability, and quality of life. Main concern that had been highlighted in this paper is the issue in data collection and data sharing of elderly healthcare monitoring. Current practice in elderly healthcare monitoring is not time efficient, require high labour that contribute to high medical service cost and low data quality. This paper proposed a conceptual model of IoT based Patient-Centered Care for elderly healthcare. The model is based on three main domains that are Internet of Things, Patient-Centered Care principles and Comprehensive Geriatric Assessment that specifically for elderly healthcare monitoring. This study used qualitative data analysis methodology based on previous literature. However, empirical study will be executed to gather a complete and verified element dan sub element for the model based on real elderly healthcare monitoring environment.

6. Acknowledgement

This research was supported by Ministry of Higher Education (MoHE) of Malaysia through The Fundamental Research Grant Scheme for Research Acculturation of Early Career Researchers (RACER/1/2019/ICT04/UUM/3)

7. References

[1] L.S.Sulmasy, T.A.Bledsoe, P.Acp Ethics, and C.H. Rights, (2019). American College of Physicians Ethics Manual: Seventh Edition. 2019.

[2] J.M.Butler, J. M., B.Gibson, L.Lewis, G.Reiber, H.Kramer, R.Rupper, J.Herout, B.Long, D.Massaro, and J.Nebeker. Patient-centered care and the electronic health record: Exploring functionality and gaps. JAMIA Open. 2020, 3(3):360-368.

[3] F.Magrabi, M.S.Ong, W.Runciman and E.Coiera. An analysis of computer-related patient safety incidents to inform the development of a classification. Journal Am Medical Information Assoc. 2010, 17(6): 663-670.

[4] Kaur, A., & Kumar, Y. (2021). Healthcare data analysis using water wave optimization based diagnostic model. Journal of Information and Communication Technology, 20(4), 457-488.https://doi.org/10.32890/jict2021.20.4.

[5] V.Ehrenstein, H.Kharrazi, H.Lehmann, and C.O.Taylor. Obtaining Data from Electronic Health Records. 2019.

[6] M.O.Kim, E.Coiera, and F.Magrabi. Problems with health information technology and their effects on care delivery and patient outcomes: a systematic review. 2017,24:246-250.

[7] R.J.Holden, S.A.McDougald , P.L.Hoonakker, A.S.Hundt, and P.Carayon. (2015). Data collection challenges in community settings: insights from two field studies of patients with chronic disease. Qual Life Res. 2015, 24(5): 1043-1055.

[8] M.Winge, P.Johannesson, E.Perjons, and B.Wangler. The coordination hub: Toward patient-centered and collaborative care processes. Health Informatics Journal. 2015,21(4): 284-305.

[9] United Nations. World Population Ageing 2017 Highlights. Retrieved from www.unpopulation.org. 2017.

[10] J. R. Beard et al. The World report on ageing and health: A policy framework for healthy ageing. The Lancet. 2016.

[11] E. Jaul and J. Barron. Age-Related Diseases and Clinical and Public Health Implications for the 85 Years Old and Over Population. Front. Public Health. 2017,5.

[12] S.Y.Chang, J.Son, S.M.Park, B.S.Chang, C.K.Lee, and H.Kim. Predictive Value of Comprehensive Geriatric Assessment on Early Postoperative Complications Following Lumbar Spinal Stenosis Surgery: A Prospective Cohort Study. Spine. 2020, 45(21), 1498-1505.

[13] J.Blumenthal, and S.R.Gambert. Comprehensive geriatric assessment. AAPS Advances in the Pharmaceutical

Sciences Series. 2016.

[14] M. Sahinoglu and H. Sahinoglu. Consequences and Lessons from 2020 Pandemic Disaster: Game-Theoretic Recalibration of COVID-19 to Mobilize and Vaccinate by Rectifying False Negatives and False Positives. International Journal of Computer Theory and Engineering. 2022, 14(3): 109-125.

[15] Institute of Medicine. Crossing the Quality Chasm: A New Health System for the 21st Century - Institute of Medicine. 2001

[16] J.M.Lusk, and K.Fater. A concept analysis of patient-centered care. Nurs Forum. 2013, **48**(2), 89-98.

[17] R.M.Epstein, K.Fiscella,C.S.Lesser and K.C.Stange. Why the nation needs a policy push on patient-centered health care. Health Aff (Millwood). 2010, 29(8):1489-1495.

[18] D.Shaller. Patient-centered care: What does it take? Common Wealth Fund. 2007.

[19] C.L.Zhong, Z.Zhu, and R.G.Huang. Study on the IOT Architecture and Access Technology. 2017.

[20] S. Naveen and S.Hegde. Study of IoT: Understanding IoT Architecture, Applications, Issues and Challenges. International Journal of Advanced Networking & Applications. 2016.

[21] G.Verma, and S.Prakash. A Study towards Current Trends, Issues and Challenges in Internet of Things (IoT) based System for Intelligent Energy Management. 2019.

[22] M.A. J.Jamali, B.Bahrami, A.Heidari, P.Allahverdizadeh and F.Norouzi. IoT Architecture BT - Towards the Internet of Things: Architectures, Security, and Applications. 2020.

[23] J.H.Abawajy, and M.M.Hassan. Federated Internet of Things and Cloud Computing Pervasive Patient Health Monitoring System. IEEE Communications Magazine. 2017, 55(1):48-53.

[24] A.Al-Adhab, H.Altmimi, M. Alhawashi, H.Alabduljabbar, F.Harrathi, and H.Almubarek. IoT for remote elderly patient care based on Fuzzy logic. 2016.

[25] L.Mainetti, L.Patrono, A.Secco and I.Sergi. An IoT-aware AAL system for elderly people. 2016.

[26] S.Pinto, J.Cabral and T.Gomes. We-care: An IoT-based health care system for elderly people. 2017.

[27] J.C.Liau and C.Y.Ho. Intelligence IoT(Internal of Things) Telemedicine Health Care Space System for the Elderly Living Alone. 2019.

[28] W.L.Chen, L.B.Chen, W.J.Chang and J.J.Tang. An IoT-based elderly behavioral difference warning system. 2018.

[29] S.Enshaeifar, S., Barnaghi, P., Skillman, S., Markides, A., Elsaleh, T., Acton, S. T., Nilforooshan, R., & Rostill, H. The Internet of Things for Dementia Care. IEEE Internet Computing.2018, 22(1), 8-17.

[30] P.Pandey, and R.Litoriya. Elderly care through unusual behavior detection: A disaster management approach using IoT and intelligence. IBM Journal of Research and Development. 2020, 64(1).

[31] D.Perez, S.Memeti, and S.Pllana. A simulation study of a smart living IoT solution for remote elderly care. 2018.