Exploring the Impact of IoT Adoption on Elderly Non-Communicable Disease Patients: Attitudes, Subjective Norms, and Perceived Behavioral Control in Malaysia

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Abstract:

This research examines the impact of IoT adoption on elderly non-communicable disease (NCD) patients in Malaysia, focusing on their attitudes, subjective norms, perceived behavioral control, perceived innovativeness, and intentions towards IoT technologies. Through primary data collection using a quantitative approach, survey questionnaires were administered to a representative sample of elderly NCD patients. SmartPLS will examine the links between the key variables and the behavioural intention to use IoT among elderly NCD patients. For examining IoT adoption intention, this study developed a framework based on the theory of planned behaviour (TPB). This research will help older adults and healthcare practitioners understand the significance of IoT in healthcare. The findings of this study are expected to produce meaningful insights that could raise awareness and educating patients about the benefits of IoT adoption, involving social networks for support and encouragement, enhancing self-efficacy and technological skills, integrating IoT devices into existing healthcare systems, and implementing supportive policies.

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SECTION I.
Introduction (INTERNET OF THINGS (IOT) AND NON COMMUNICABLE DISEASES)

In recent years, the rapid development of technology has facilitated the emergence of pioneering solutions across diverse sectors, encompassing healthcare. In healthcare, the Internet of Things (IoT) exhibits considerable promise, particularly in non-communicable disease (NCD) management for elderly individuals. Comparable to numerous other nations, Malaysia is experiencing a significant change in demographics, characterised by a rapid rise in the proportion of elderly individuals within its population. The incidence of non-communicable diseases (NCDs), including cardiovascular diseases, diabetes, and chronic respiratory conditions, is increasing, presenting substantial obstacles for healthcare providers and policymakers. Implementing Internet of Things (IoT) technologies offers a potential avenue for tackling these challenges and enhancing the standard of care for elderly individuals with non-communicable diseases (NCDs).

Non-communicable diseases are the leading cause of death worldwide, accounting for 74% of all fatalities. Non-communicable diseases include cardiovascular disease, cancer, diabetes, and chronic respiratory illnesses. These non-communicable illnesses all share major behavioural risk factors that can be modified, such as tobacco products, an unhealthy diet, a lack of participation in physical exercise, and the dangerous use of alcohol. These factors can eventually result in sickness, including but not limited to overweight and obesity, high blood pressure, and high cholesterol. They remain a significant public health problem in every country, especially in low- and middle-income countries, responsible for more than three-quarters of the deaths caused by non-communicable diseases. In addition, they continue to be a significant public health problem in every country [1].

According to a report the WHO issued in 2015, Non-communicable diseases (NCDs) were the cause of death for an estimated 41 million people worldwide. According to the findings of a study that the World Health Organization carried out in 2021, non-communicable illnesses were the cause of three out of every four deaths in Malaysia [1]. Consequently, the Ministry of Health in Malaysia has positioned the prevention and control of non-communicable diseases (NCDs) as a top priority. This is evidenced by the country's National Strategic Plan for NCD 2016-2025 and its complementing national programs to reduce the risk factors associated with NCDs [2].

Non-communicable illnesses account for around 70 per cent of the illness burden and 71 per cent of all premature deaths in Malaysia, according to the National Health and Morbidity Survey (2019) [3]. Non-communicable diseases (NCDs) cost the Malaysian economy more than RM 9.65 billion annually in hospitalizations, medical examinations, medicines, and primary care consultations, according to a new report titled Direct Healthcare Cost of Non-Communicable Diseases in Malaysia, which was published by the Ministry of Health of Malaysia and the World Health Organization [4].

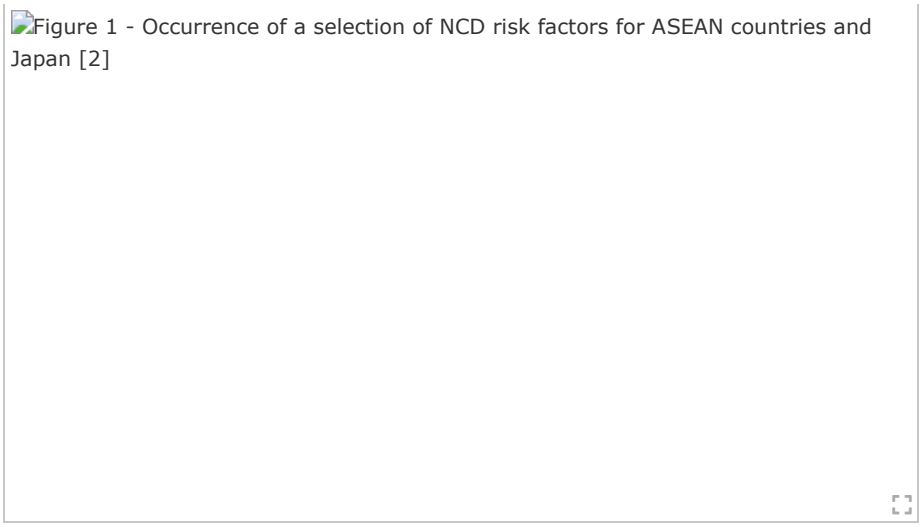

Figure 1
Occurrence of a selection of NCD risk factors for ASEAN countries and Japan [2]

The tectonic shifts that have taken place in the socioeconomic environment of health are essentially to blame for the rise of non-communicable illnesses as the leading cause of mortality in Malaysia and elsewhere worldwide. The impact that diabetes has on culture and society should not be underestimated. The shocking finding that hypertension patients were responsible for almost 55% of the deaths caused by COVID-19 researchers made it from Malaysia's National Institutes of Health (NIH), which includes the Institute for ClinicalResearch(ICR)[5].

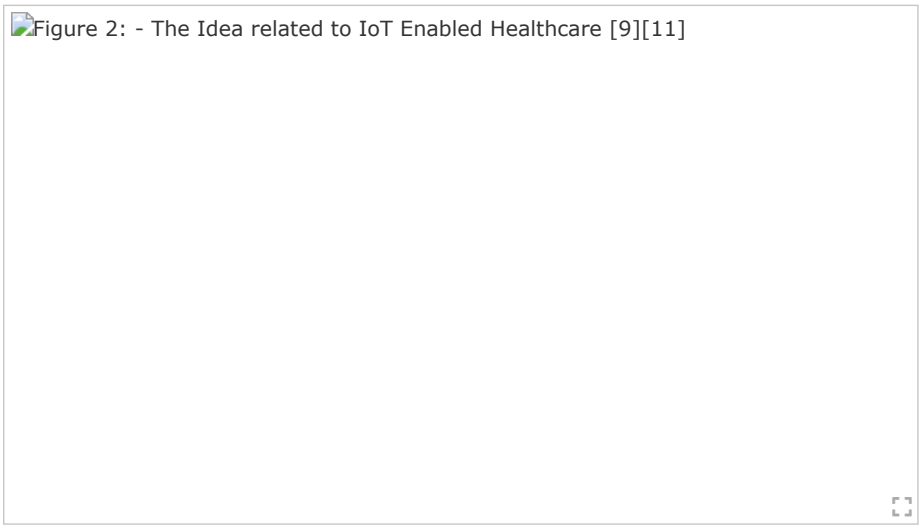

Figure 2:
The Idea related to IoT Enabled Healthcare [9] [11]

"Utilizing the wearable devices in IoT enables a range of health products and services from telemedicine to self-diagnosis and monitoring, which results in cost reduction and significantly drives the insurance business for IoT adoption [12]. Utilizing wearable devices in IoT enables a range of health IoT-enabled healthcare that should be able to provide the essential values that help patients and encourage the overall healthcare organization to build an organism of health services [13]. As a result, this research aims to investigate IoT adoption's impact on elderly NCD patients in Malaysia.

SECTION II.
Literature review

A. Behaviour Intention to use IOT

The behaviour intention to adopt IoT among elderly NCD patients refers to their willingness and intention to embrace and utilize IoT technologies for managing their Non-communicable diseases. Several factors influence their behaviour intention, and understanding these factors is crucial for promoting successful adoption.

B. Attitudes of Elderly NCD Patients Towards Iot Adoption in Healthcare

Positive feelings about IoT adoption can significantly impact whether or not older people with NCDs are willing to use these technologies and integrate them into their daily lives. When older patients have a positive outlook, they are more interested in and curious about IoT gadgets. Suppose older people think about the benefits of IOT, such as real-time health monitoring, medication reminders, and access to personalised health data. In that case, it will lead to better disease control and a higher quality of life [15]. Individuals with positive attitudes are more willing to demonstrate their readiness to adopt and utilise Internet of Things (IoT) devices. They believe in the potential of these technologies to address their health challenges and are motivated to take the necessary steps to acquire and incorporate them into their daily routines. Elderly patients with positive attitudes actively engage with the devices, adhering to recommended health practices and treatment plans. Through the seamless integration of Internet of Things (IoT) technologies into their daily routines, individuals can experience advantages such as continuous health monitoring and assistance, ultimately contributing to enhanced results [16] [17] [14].

In conclusion, positive attitudes towards IoT adoption play a vital role in shaping the willingness of elderly NCD patients to engage with these technologies and seamlessly incorporate them into their daily lives. By fostering positive attitudes through education and awareness, and highlighting the potential benefits, healthcare providers and policymakers can encourage greater acceptance and utilisation of IoT devices for effective NCD management among this population.

C. Subjective Norm Aspect by Investigating the Influence of Social Factors on the Adoption of IOT among Elderly NCD Patients

Social impact significantly affects how older people with NCD feel and what they plan to do about adopting IoT. The advice and thoughts of family, friends, healthcare professionals, and peers can significantly affect their choice to use IoT technologies. Since family members are involved in the day-to-day lives and healthcare choices of elderly patients, they may support IoT adoption by pointing out the possible benefits and encouraging their loved ones to look into and use these technologies. Positive feedback from trusted family members can help them see how valuable and essential IoT devices are for managing NCDs [9] [18].

Similarly, the support and endorsements from healthcare professionals, including doctors, nurses, and other caregivers, can influence the adoption of IoT among elderly NCD patients. Social influence affects the perceptions of elderly NCD patients by providing social norms and standards of behaviour. When they observe that individuals in their social network, including family members, friends, healthcare professionals, and peers, have embraced IoT devices for NCD management, it creates a perception that such adoption is acceptable and appropriate. On the other hand, if negative thoughts or doubts are common in their social circles, they may be unwilling to accept IoT [19] [20].

D. Perceived Behavioural Control, which refers to the Individual's Perception of their Ability to Adopt and Use IOT Technologies for NCD Management

The concept of perceived behavioural control is significant in shaping an individual's intentions and actual adoption of Internet of Things (IoT) technologies for non-communicable disease (NCD) management. It pertains to an individual's perception of their capability to adopt and utilise these IoT devices. Assessing critical factors in this context involves evaluating the self-efficacy, technological skills, and perceived ease of use of IoT devices among elderly patients. Self-efficacy pertains to an individual's confidence in their abilities, and higher levels of self-efficacy can have a favourable impact on the intentions and actual utilisation of IoT technologies among elderly patients. Individuals who possess a strong sense of self-assurance in effectively operating and handling Internet of Things (IoT) devices are more likely to adopt and accept these technologies to manage non-communicable diseases (NCDs) [21]. Elderly patients with excellent technological proficiency are likelier to perceive that they have control over adopting and utilising IoT technologies. Proficiency in using devices, familiarity with relevant applications, and familiarity with interfaces enhance their perceived behavioural control [10]. By addressing barriers, providing appropriate support, and enhancing their confidence and skills, healthcare providers can facilitate the successful adoption and utilisation of IoT technologies for effective NCD management among the elderly [22] [23].

E. Perceived Innovativeness among Elderly NCD Patients, which refer to their Willingness to Try and Adopt New Technologies

Perceived innovativeness among elderly NCD patients refers to their willingness to try and adopt new technologies. Elderly patients perceived as innovative and open to new ideas are likelier to exhibit positive attitudes towards IoT adoption. Their curiosity and interest in exploring novel healthcare solutions drive their willingness to embrace IoT devices for NCD management. This perceived innovativeness plays a significant role in shaping their adoption behaviours [24]. When elderly patients are open to innovation, they are more likely to seek out information about IoT technologies actively, learn about their potential benefits, and overcome potential barriers [25] [24]. Elderly patients with high perceived innovativeness are more likely to be motivated to continuously explore and integrate IoT technologies into their daily lives [24]. This sustained engagement enhances the potential for long-term usage and benefits of IoT devices for NCD management. Understanding and assessing the role of perceived innovativeness among elderly NCD patients can inform strategies to promote IoT adoption [24].

F. Sustainable Healthcare System

It is essential to construct a sustainable healthcare system to treat elderly Non-communicable disease (NCD) patients to satisfy this population's rising healthcare needs while optimising resource utilisation. A sustainable strategy combines preventive measures, an integrated care approach, telemedicine and remote monitoring technologies, patient empowerment and self-management, multidisciplinary care teams, health information systems and data analytics, and policy and funding support [26]. Prioritising health promotion programs, routine screenings, and awareness campaigns promote healthy lifestyles, early diagnosis, and prompt intervention. The healthcare system can effectively reduce the long-term expenses associated with advanced NCD management by emphasising prevention. This decreases the frequency of hospital visits, improves patient convenience, and optimises the allocation of healthcare resources [27] [28] [29]. By integrating these strategies, it is possible to establish a sustainable healthcare system that effectively meets the requirements of elderly NCD patients.

SECTION III.
Theoretical underpinning

The Theory of Reasoned Action (TRA) underwent a name change in 1980, becoming the Theory of Planned Behavior (TPB), to predict an individual's intention to engage in a specific behaviour at a particular time and location. The primary component of this model is the construct of behavioural intent, which is influenced by one's attitudes towards the probability of behaviour leading to the desired outcome, as well as a subjective evaluation of the associated risks and benefits of that outcome. The Theory of Planned Behavior (TPB) has demonstrated efficacy in predicting and elucidating diverse health behaviours and intentions, encompassing substance use, breastfeeding, utilization of health services, and smoking.

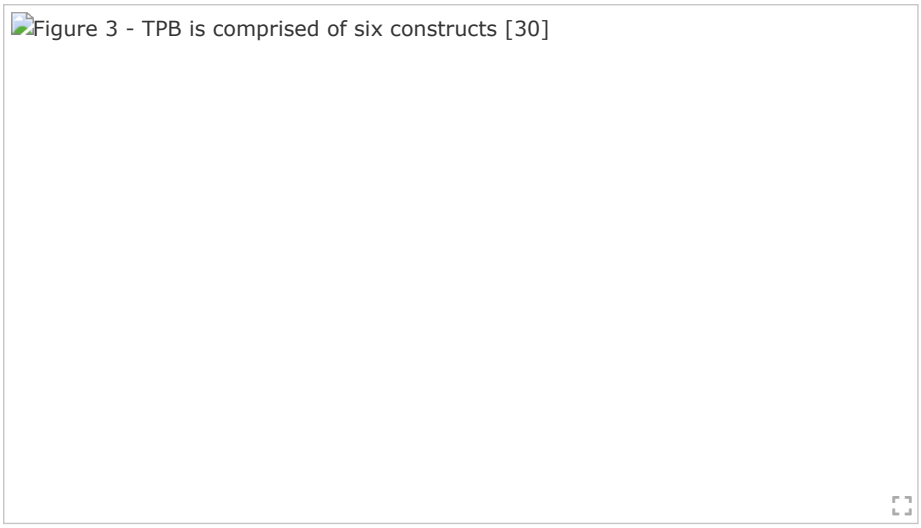

Figure 3
TPB is comprised of six constructs [30]

With social cognitive theories such as TPB, health-related behaviours influenced by social and psychological factors can be comprehended more comprehensively. These theories help guide interventions that attempt to change people's ways of living and can be applied in various contexts.

According to the TPB's proposal, three variables influence behaviour: perceived consequences of behaviour change (attitude), perceived expectations of others (subjective norm), and perceived facilitators or barriers to the ability to change (perceived behavioural control). Attitude, subjective norm, and perceived behavioural control are the components that make up a person's behavioural purpose. The behavioural purpose is the immediate antecedent of behaviour. People's intents and actions can be changed, to some extent and possibly even completely, depending on their attitudes, subjective norms, and how much behavioural control they believe they have. To develop successful interventions, one must first conduct an exhaustive assessment of a person's attitudes and subjective norms and the amount of control they believe they have over their behaviour [30].

SECTION IV.
RESEARCH FRAMEWORK

The expected hypotheses of this study are as follow:

H1: There is a significant positive association between the intention to use IoT and the attitude of elderly NCD Patients in Malaysia.

H2: There is a significant positive association between the intention to use IoT and the subjective norm of elderly NCD Patients in Malaysia

H3: There is a significant positive association between the intention to use IoT and Perceived Behavioural Control of elderly NCD Patients in Malaysia

H4: There is a significant positive association between the intention to use IoT and the perceived innovativeness of elderly NCD Patients in Malaysia

H5: There is a significant positive association between actual behaviour and intention to use IoT among elderly NCD Patients in Malaysia

Figure 4:
Proposed Research Framework

SECTION V.
Research methodology

A. Data Analysis (Primary Data)

For this research on the impact of IoT adoption on elderly NCD patients in Malaysia, a proposed research method is to collect primary data using a quantitative approach. This method involves gathering numerical data to analyse and draw statistical inferences about attitudes, subjective norms, perceived behavioural control, perceived innovativeness, and intentions towards IoT

adoption. Designing and administering structured survey questionnaires to a representative sample of elderly NCD patients in Malaysia allows for data collection on various aspects of IoT adoption. For this study, random sampling will be used to ensure the inclusion of diverse elderly NCD patients from different regions and healthcare settings. The current study's sample size will be calculated using a statistical technique proposed by earlier researchers. The survey will have both in-person and digital components. There will be three parts to the questionnaires. In the first section, some will be asked basic questions on the demographics and background of the study's participants. In the second section of the survey, participants will be asked questions designed to assess their familiarity with and willingness to take action to prevent Non-communicable diseases (NCDs) like cardiovascular conditions, cerebrovascular incidents, diabetes, and cancer. The final portion will survey attitudes, subjective norms, perceived behaviour control, perceived innovativeness, and actual behaviour intention towards IoT usage for treating NCDs. All survey questions will be graded on a Likert scale, with one representing "strongly disagree" and five representing "strongly agree." All the statistical analysis will be carried out using SEM and Smart PLS. SPSS will be used to analyse the collected data's descriptive statistics, test assumptions for normality and reliability analysis, and PLS will be used for the structural modelling. As a result of this research, we can raise awareness about the benefits of technology through this survey.

B. Data Analysis (Secondary Data)

The researcher gathers secondary data from past studies and is likely for other purposes [31]. Compared to primary data, researchers would be able to get secondary data far quicker and faster. This study will employ secondary data for independent variables such as technology and NCD for dependent variable. Secondary data will be collected from the Ministry of Health, Malaysia, the World Health Organization (WHO), and the World Bank. This secondary data will be employed to investigate the determinants of IOT on NCD patients in Malaysia. The model estimation for this is shown below:

$$\mathrm{NCDt} = f(\mathrm{IOTt})$$

View Source

where NCDt is the non-communicable disease in Malaysia (dependent variable), while, and Internet of things which proxies number of internet users in Malaysia (IOTt) is the independent variables.

All variables are expressed in the natural logarithms and the logarithmic form of functional regression model is written as follows:

$$\mathrm{LNCDt} = \beta 0 + \beta 1 \mathrm{IOTt} + \mu$$

View Source

For this paper, will adopt annual data of time series from 1990 to 2022.

C. Empirical Model

This study will use ADF (Augmented Dickey-Fuller) and PP (Phillips-Perron) unit root tests to test the stationary of NCD and IOT variables. Cointegration exists when the variables are integrated in the same order with a stationary linear combination.

D. Johansen and Juselius Multivariate Cointegration Test

Furthermore, this paper will use the Johansen and Juselius Multivariate cointegration test to investigate whether there is a long-run relationship between the dependent variable (LNCD) and independent variables (LIOT) using trace and maximum eigenvalue statistics. This technique is superior to the bivariate cointegration test because it can be applied to multiple variables and fully capture the equation's underlying time series data.

E. Granger-Causality test within Vectors Error-Correction Modelling (VECM)

VECM test will conduct if there is a long-run relationship between the variables involved in the study. The Johansen and Juselius cointegration test can determine the long-term relationship. The next step from here is to proceed with the Granger causality test within VECM to examine the causal

links among the variables in this paper. Below is the Granger Causality test within VECM:

$$\Delta \ln NCD = a_1 + \sum_{i=1}^{k} \varphi \quad 1\mathrm{i} \quad \Delta\mathrm{NCD} \quad \mathrm{t}-\mathrm{i} \quad +$$
$$\sum_{i=1}^{k} \quad \theta 1\mathrm{i}\Delta \ln \mathrm{IOTt}-\mathrm{i} \quad \lambda 1 \ \varepsilon t-\mathrm{i}+\mu 1\mathrm{t}$$
$$\Delta \ln IOT = a_2 + \sum_{\mathrm{i}=1}^{\mathrm{k}} \varphi \quad 2\mathrm{i} \quad \triangle \ \mathrm{NCD} \quad \mathrm{t}-\mathrm{i} \quad +$$
$$\sum_{\mathrm{i}=1}^{\mathrm{k}} \theta \quad 2\mathrm{i}\Delta \ln \mathrm{IOTt}-\mathrm{i} \quad \lambda 2\varepsilon \mathrm{t}-\mathrm{i}+\mu 2\mathrm{t}$$

View Source

where LNCD*t* is the logarithmic form of non-communicable disease in Malaysia at time *t*, LIOT*t* is the logarithmic form of Internet of things of Malaysia at time *t*, α is the intercept, θ, ϕ, β and δ are the coefficients

SECTION VI.
Expected Result and Discussion

The expected results for primary data obtained through a quantitative research approach, specifically a questionnaire survey, are first for the attitudes towards IoT Adoption. The quantitative data analysis may reveal many elderly NCD patients' positive attitudes towards IoT adoption. The survey responses can indicate their recognition of the benefits of IoT devices for NCD management, such as improved monitoring, increased convenience, and enhanced control over their health. Moreover, for the variable Subjective Norms, the data analysis may demonstrate that subjective norms significantly impact the intentions of elderly NCD patients to adopt IoT technologies. Furthermore, quantitative analysis can provide insights into the perceived behavioural control of elderly NCD patients regarding IoT adoption. In addition, perceived innovativeness, the data analysis may indicate the level of perceived innovativeness among elderly NCD patients regarding IoT adoption. The survey responses can provide insights into their willingness to try and adopt new technologies, curiosity about healthcare innovations, and interest in novel solutions for NCD management. Finally, in behaviour Intentions and adoption, the quantitative data analysis can examine the behaviour intentions of elderly NCD patients towards adopting IoT technologies. The expected results derived from the quantitative analysis of the primary data will provide more precise and measurable insights into the attitudes, intentions, and potential adoption behaviour of elderly NCD patients towards IoT technologies in Malaysia. These findings can contribute to a better understanding of the factors influencing IoT adoption and inform strategies to promote successful implementation and utilisation among this population. However, the expected result for secondary data of this research is that the Internet of Things (IoT) has a negative correlation with Non-communicable diseases in both the short-term and long-term (45), (46) and (47). This implies that a rise in the Internet of Things adoption rate in Malaysia is associated with a decrease in the prevalence of non-communicable diseases in the country. The utilisation of data derived from Internet of Things (IoT) devices can facilitate medical practitioners in determining the optimal course of treatment for patients, thereby ensuring the attainment of desired outcomes.

SECTION VII.
Conclusion and recommendation

In conclusion, this research on the impact of IoT adoption on elderly NCD patients in Malaysia has provided valuable insights into the attitudes, subjective norms, perceived behavioural control, perceived innovativeness, and intentions towards IoT adoption. The study emphasizes the need for a sustainable healthcare system incorporating preventive measures, an integrated care approach, telemedicine, patient empowerment, multidisciplinary care teams, health information systems, and policy support. Moreover, healthcare providers should focus on raising awareness and educating elderly NCD patients about the benefits of IoT adoption for their disease management. Furthermore, efforts should be made to enhance the self-efficacy and technological skills of elderly NCD patients. Training programs and resources that teach them how to use IoT devices effectively and address any barriers or challenges they may face can improve their perceived behavioural control and increase their confidence in adopting and using these technologies. Policymakers should support adopting IoT technologies by incentivizing their use, allocating resources for

infrastructure development, and ensuring data privacy and security. By implementing these recommendations, healthcare systems in Malaysia can foster the successful adoption and integration of IoT technologies among elderly NCD patients, ultimately improving their health outcomes, enhancing their quality of life, and promoting a more sustainable healthcare system for the ageing population.

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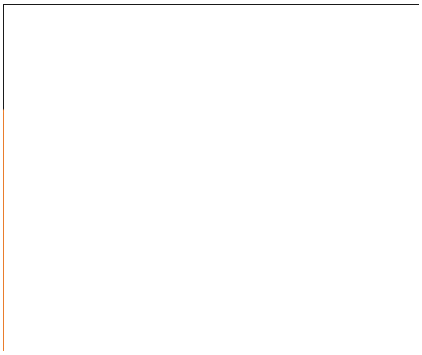

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