การทบทวนวรรณกรรมอย่างเป็นระบบ: อุปกรณ์สวมใส่อัจฉริยะสำหรับการตรวจสอบสุขภาพและ การประยุกต์ใช้ในประเทศไทย

Systematic Review: Wearable Devices for Health Monitoring and Their Application in Thailand

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บทคัดย่อ

ประเทศไทยกำลังก้าวเข้าสู่สังคมผู้สูงอายุอย่างเต็มรูปแบบ โดยคาดว่าประชากรอายุ 60 ปีขึ้นไปจะเพิ่มเป็นร้อยละ 31 ภายในปี 2040 กลุ่มนี้มีแนวโน้มเผชิญกับโรคไม่ติดต่อเรื้อรัง (NCDs) เช่น ความดันโลหิตสูงและเบาหวาน ซึ่งส่งผลต่อคุณภาพชีวิตและเพิ่มภาระต่อระบบสาธารณสุข อุปกรณ์สวมใส่เพื่อสุขภาพ (wearable devices) ซึ่งสามารถเชื่อมต่อกับระบบ telehealth จึงกลายเป็นนวัตกรรมที่มีศักยภาพในการติดตามอาการและจัดการโรคได้แบบเรียลไทม์ งานวิจัยนี้มีวัตถุประสงค์เพื่อประเมินประสิทธิภาพของอุปกรณ์สวมใส่ในการดูแลสุขภาพผู้สูงอายุ วิเคราะห์ปัจจัยที่ส่งเสริมหรือเป็นอุปสรรคต่อการใช้งาน และศึกษาความเหมาะสมของการประยุกต์ใช้ในบริบทประเทศไทย โดยใช้การทบทวนวรรณกรรมอย่างเป็นระบบตามแนวทาง PRISMA จากฐานข้อมูล PubMed, Scopus, ThaiJo และ Google Scholar ในช่วงปี ค.ศ.2019-2023 ซึ่งพบว่าอุปกรณ์สวมใส่ช่วยเพิ่มประสิทธิภาพในการติดตามสุขภาพและจัดการโรคเรื้อรัง เช่น เบาหวานและโรคหัวใจ และสามารถลดความถี่ในการเข้ารับการรักษาในโรงพยาบาลเมื่อนำไปใช้ร่วมกับระบบ telehealth อย่างไรก็ตาม ยังมีอุปสรรคสำคัญ ได้แก่ ความไม่แม่นยำของอุปกรณ์ ราคาที่สูง ความไม่คุ้นเคยกับเทคโนโลยี และความไม่สะดวกในการสวมใส่ โดยเฉพาะในกลุ่มผู้สูงอายุ

ที่อาศัยอยู่ในพื้นที่ชนบท ดังนั้น แม้อุปกรณ์สวมใส่จะมีศักยภาพในการส่งเสริมสุขภาพผู้สูงอายุ แต่ยังจำเป็นต้องพัฒนาในด้านต้นทุน เทคโนโลยี และการส่งเสริมความรู้ด้านดิจิทัล เพื่อให้เกิดการใช้งานอย่างแพร่หลายและยั่งยืนในบริบทของประเทศไทย

คำสำคัญ : อุปกรณ์สวมใส่, การติดตามภาวะสุขภาพ, สังคมผู้สูงอายุ, ประเทศไทย, โรคไม่ติดต่อเรื้อรัง

Abstract

Thailand's rapidly aging population, projected to reach 31% by 2040, faces increasing rates of non-communicable diseases (NCDs) such as hypertension and diabetes, which place significant strain on the healthcare system and diminish quality of life. Wearable health monitoring devices present a promising solution for early detection and chronic disease management, particularly when integrated with telehealth services. This review aimed to evaluate the effectiveness of these devices in elderly health monitoring, explore factors that facilitate or hinder their adoption, and assess their suitability for use in Thailand. Using the PRISMA framework, 35 empirical studies published between 2019 and 2023 were analyzed from databases including PubMed, Scopus, ThaiJo, and Google Scholar. The findings indicate that wearable devices contribute to improved health tracking and management of chronic conditions, especially diabetes and cardiovascular diseases, and offer added value through real-time monitoring and telehealth connectivity. Nonetheless, several barriers hinder widespread use, including device inaccuracy, high costs, limited digital literacy, and discomfort during use-issues that are particularly pronounced among elderly individuals in rural areas. To unlock the full potential of wearable health technologies in Thailand, it is essential to address economic, technological, usability, and infrastructure challenges through targeted interventions and inclusive policies that promote equitable access and adoption among older adults.

Keywords : Wearable Devices, Health Monitoring, Elderly Population, Thailand, Non-Communicable Disease

Introduction

Thailand is undergoing a major demographic transition into a fully aged society. In 2023, over 20% of the population was aged 60 or above, and this figure is expected to rise to 31% by 2040, reflecting an urgent societal transformation that will reshape healthcare needs nationwide.[1-2] Aging is naturally accompanied by a rising burden of health challenges, particularly non-communicable diseases (NCDs)-such as hypertension, diabetes, cardiovascular disease, and cognitive decline-which now account for over 70% of all deaths in Thailand.[3-4] These chronic conditions not only diminish the quality of life among elderly individuals but also impose substantial demands on caregivers and healthcare infrastructure, especially in rural areas where medical access is limited.

The increasing prevalence of NCDs among older adults raises critical questions about how to ensure adequate, continuous care while maintaining patient independence. Studies have shown that NCDs such as type 2 diabetes affect more than 1 in 4 elderly Thais, while nearly 50% of those aged 60 plus suffer from hypertension.[3] Many of these individuals require long-term monitoring, early symptom detection, and personalized management to prevent complications and hospitalization. However, traditional healthcare delivery models often fall short due to limited manpower and fragmented access to care.

Wearable health monitoring devices-such as smartwatches, biosensors, and fitness trackers-offer a promising alternative. These tools enable real-time tracking of vital signs like heart rate, blood pressure, sleep quality, glucose levels, and physical activity. When integrated with telehealth platforms, wearable devices facilitate proactive disease management, encourage healthy behavior, and allow for timely interventions, especially for patients living with chronic conditions.[5-7] Studies conducted both internationally and within Thailand support the value of these technologies. For instance, Likasittananon et al. in 2024 found that Thai individuals aged 15-70, though aware of smartwatches and health apps, had low utilization rates, mainly due to limited support systems, device cost, and digital literacy barriers[8]. Another study by Moore et al. in 2021 emphasized that elderly users reported greater confidence and autonomy in managing their conditions when using wearable health tools[5].

Given the expected growth of Thailand's elderly population and the chronic disease epidemic, the adoption of wearable

devices may offer a scalable solution to promote active aging and reduce the healthcare burden. However, questions remain about their effectiveness, usability, and real-world implementation within the Thai context. This systematic review was therefore conducted to evaluate the global and local evidence on wearable health monitoring devices, identify barriers and enablers to their use, and assess how these technologies can be applied to support elderly care in Thailand.

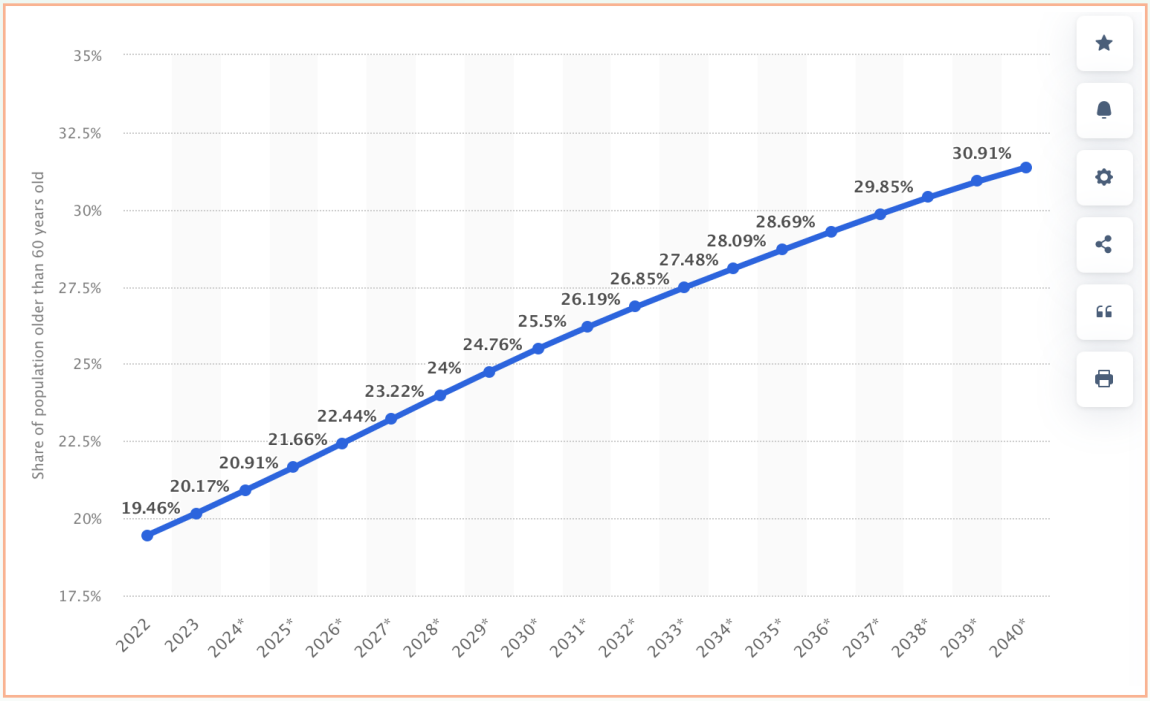

Fig. 1. A line graph that shows the trajectory of the increasing percentages of elderly people from 2022-2040

Objectives

1. Evaluate the global effectiveness of wearable devices in health monitoring.
2. Identify barriers and facilitators to wearable device adoption globally and in Thailand.
3. Provide recommendations for integrating wearable health technologies into Thailand's healthcare framework.

Methodology

This systematic review followed PRISMA guidelines to assess the effectiveness and applicability of wearable health monitoring devices for elderly care in Thailand. Literature was searched from 2019 to 2023 using Google Scholar, PubMed, Scopus, ThaiJo, and open-access sources such as Statista. Keywords included “wearable devices”, “health monitoring”, “elderly”, “chronic disease” and “Thailand”. Inclusion criteria were: empirical studies on wearable health devices involving elderly or chronically ill populations, published in English or Thai. Exclusion criteria included non-empirical works or irrelevant topics. From 148 initial records, 35 studies were selected based on title, abstract, and full-text screening by two independent reviewers. Data extracted included study details, device types, outcomes, and barriers to adoption. Study quality was assessed using the Cochrane Risk of Bias Tool for RCTs and the GRADE framework for non-randomized studies. A narrative synthesis summarized findings by device type, health outcomes, and contextual challenges.

Results

1. Types of Wearable Devices for Health Monitoring

1.1 Skin based wearable devices

Skin based HWDs, as the name implies, uses skin as the medium of communication to diagnose diseases through the analysis of skin secretions, like sweat. They are non-invasive and continuous, meaning that they can provide data in real-time. Skin based HWDs can be classified into 3 main categories: Textile based HWDs, Epidermal based HWDs and those that do not fit into either category.[6]

1.1.1 Textile based HWDs

Textile based HWDs are disguised into clothing items, like shirts or trousers. Sensors are integrated into the clothing, which tracks essential and vital signs such as heart rate, body temperature and respiration rate. This makes it comfortable for the users to wear.[7]

1.1.2 Epidermal based HWDs

Epidermal based HWDs are embedded into the skin and are made of biocompatible and flexible materials. A prime example of this is the graphene electronic tattoo, consisting

of bilayer substrate of graphene and polymethylmethacrylate (Gr/PMMA).[9] Sensors are integrated into the material, and are capable of monitoring various physiological signals.

1.2 Electronic based wearable devices

These can include wearable vests, smart watches, skin patches and implantable HWDs. Each device will have its own sensors hidden somewhere inside the device which can detect substances in the body using electronic circuitry.[9] Devices under this category are capable of detecting range of motion and vital signs without any invasiveness. Nowadays, movement is easily detected by using gyroscopes, accelerometers and magnetometers.[10]

2. Effectiveness of Wearable Devices in Health Monitoring

2.1 Telehealth integration

Wearable devices have revolutionised health monitoring by integrating telehealth services which help facilitate real-time tracking of vital health metrics such as heart rate, glucose and blood pressure levels. This allows for early detection of potential health issues, reducing the frequency of hospital visits and any associated costs. By providing continuous feedback, wearable devices encourage patients to manage their health conditions more effectively, improving their awareness and understanding of disease symptoms.[11]

In managing chronic diseases like diabetes, heart disease and hypertension, wearable devices offer great benefits. Continuous glucose monitoring helps patients maintain optimal glucose levels, while cardiovascular monitoring assists patients with heart conditions in managing their health. Data collected by wearable devices can be transmitted to healthcare providers via telehealth platforms, allowing for personalised care along with timely interventions that improve patient outcomes.[12]

2.2 Customizability of WDs

Wearable devices can be customized to monitor specific health metrics that are most relevant to a patient's conditions or health goals. For instance, a user with diabetes might prioritise the continuous tracking of glucose in the blood while a patient with a history of heart disease may want to use the tracking of heart rate variability and electrocardiogram (ECG readings). This personalised approach to health monitoring ensures that users receive targeted feedback, which can lead to better health outcomes.[13]

3. Barriers to Adoption

3.1 Inaccuracy

The accuracy of readings from wearable devices are crucial, especially when monitoring vital signs such as heart rate. As of right now, wearable devices tend to report inaccurate data at times, which can be misleading and potentially catastrophic for the user. For example, if a wearable device underestimates a user's heart rate, it could suggest that the user isn't exercising intensely enough. This causes the user to overexert, which increases the risk of cardiovascular events such as arrhythmias and heart attacks.[14]

3.2 Awareness of benefits regarding WDs

Elderly users of HWDs may not fully recognise the diverse applications and benefits of wearable devices, missing out on innovative technology and the many benefits HWDs can provide, leading to underutilization. Barriers such as unfamiliarity with technology, perceived complexity and age-related challenges all hinder the adoption of these devices.[15] Well-tailored support and user-friendly design can minimise the effects of these hindrances on adoption.

3.3 Uncomfortability

Some types of wearable devices such as smart watches and ankle braces may be uncomfortable to wear, especially during fitness exercises.[16] Materials such as latex, rubber or silicone which are often used in wearable devices may trigger allergic reactions in some individuals, resulting in contact dermatitis.[17] Furthermore, recent studies have identified high concentrations of perfluoroalkyl substances (PFAS), known as "forever chemicals," in certain smartwatch bands, particularly those made from fluoroelastomers, which may pose additional health risks.[18]

4. Application of Wearable Devices in Thailand

Current State:

Wearable devices are increasingly used in Thailand's healthcare sector. Not only do they assist with healthcare monitoring but also with chronic disease management and wellness tracking. Hospitals all over the country are gradually integrating these devices with telehealth services for real-time monitoring.[19]

Devices like the Apple Watch, Garmin and Fitbit are adopted by many Thai consumers, especially in Bangkok and other urban areas. The fitness tracker market in Thailand is projected to grow by 6.31% between 2024 and 2029, reaching a market volume of approximately $308.80 million by 2029.[20]

Barriers Specific to Thailand:

However, most of the high-quality wearable devices remain costly, meaning that rural and low-income populations will have very limited access to them. The same people also lack awareness of the potential benefits and applications of wearable technology in management of health.[21]

Aside from this, there is limited legislation addressing the privacy and security of data, raising concerns about the protection of sensitive health information. Cost, technology and human factors remain key barriers to increasing rates of adoption of wearable devices.[22]

Opportunities for Adoption:

A study conducted about investigated the awareness and attitudes of Thai individuals aged 15 to 70 regarding the use of smartwatches and health applications in managing chronic diseases. This was done through a survey, which assessed the knowledge levels and perceptions of the participants. They found that while there was general awareness of the technology, the rates of actual utilization were low. By increasing the educational initiatives and demonstrating the practical benefits wearable technology holds, the adoption of wearable devices for chronic disease management could increase.[8]

Recommendations for effective utilization of wearable technology and future research

Device manufacturers can be collaborated with to produce affordable wearable devices tailored to the elderly population in order to assist lower income groups.[23] Subsidies and/or financial assistance programs can also be implemented to further aid seniors to purchase wearable devices.[24] Furthermore, a robust digital health infrastructure can be developed to support the integration of wearable device data into Thailand's healthcare system.[25]

To support future research, long-term studies can be conducted to evaluate the efficacy of wearable devices in improving health outcomes, thereby reducing hospitalizations among the elderly.[23] User-centered design is a key field to critically

research into. This can be done by exploring design preferences such as comfort, screen size and intuitive interfaces.[26]

For example, a study conducted by Suksawat and Keawpromman focused on analyzing factors influencing individuals and their decisions to purchase smartwatches. The study identified that some health monitoring features such as heart rate monitoring and activity monitoring were significant motivators. However, concerns such as cost and privacy deter some users from purchasing. By addressing concerns through transparent data policies, varied pricing strategies and user-friendly designs could increase adoption among consumers.[27]

Discussion

The findings of this systematic review highlight the significant potential of wearable devices in enhancing health monitoring, particularly in the context of Thailand's aging population. Wearable technologies, such as fitness trackers, smartwatches, and biosensors, have demonstrated their effectiveness in real-time monitoring of vital signs, chronic disease management, and promoting preventive care.[5, 11] However, the adoption of these technologies faces several barriers, both globally and specifically in Thailand, which must be addressed to fully realize their benefits.

Effectiveness of Wearable Devices

Wearable devices have proven to be highly effective in health monitoring, particularly in the management of chronic diseases such as diabetes, hypertension, and cardiovascular conditions.[11-12] The integration of wearable devices with telehealth platforms has enabled continuous tracking of health metrics, reducing the need for frequent hospital visits and lowering healthcare costs.[11] This is especially relevant for Thailand, where the aging population and the rising prevalence of non-communicable diseases (NCDs) place a growing burden on the healthcare system.[3-4] The ability of wearable devices to provide personalized feedback and support early detection of health issues aligns well with the needs of elderly individuals, who often require ongoing monitoring and timely interventions.[5]

Barriers to Adoption

Despite their potential, several barriers hinder the widespread adoption of wearable devices. Inaccuracy in data readings, particularly for vital signs like heart rate, remains a significant concern.[13] Inaccurate data can lead to misguided health decisions, posing risks to users, especially the elderly. Additionally, lack of awareness about the benefits of wearable technology, particularly among older adults, contributes to underutilization.[14] Many elderly individuals are unfamiliar with these devices or perceive them as too complex, which limits their adoption. Discomfort associated with wearing certain devices, such as smartwatches or ankle braces, further discourages use, especially during physical activities or for extended periods.[15-19]

In Thailand, these barriers are compounded by economic and infrastructural challenges. High costs of wearable devices make them inaccessible to low-income and rural populations, who could benefit the most from these technologies.[20] Limited digital literacy and inadequate healthcare infrastructure in rural areas further exacerbate the issue.[21] Moreover, the lack of robust legislation addressing data privacy and security raises concerns about the protection of sensitive health information, which could deter users from adopting wearable devices.[22]

Opportunities for Thailand

Thailand has made strides in integrating wearable devices into its healthcare system, particularly in urban areas where devices like the Apple Watch and Fitbit are increasingly popular.[19-20] The projected growth of the fitness tracker market in Thailand indicates a growing interest in wearable technology.[20] However, to ensure equitable access, targeted interventions are needed. Affordable wearable devices tailored to the needs of the elderly, coupled with subsidies or financial assistance programs, could make these technologies more accessible to low-income groups.[23-24] Additionally, educational initiatives aimed at increasing awareness and digital literacy among elderly users could enhance adoption rates.[8]

The development of a robust digital health infrastructure is crucial to support the integration of wearable device data into Thailand's healthcare system.[25] This includes improving internet connectivity in rural areas and establishing clear policies on data privacy and security. Collaboration between device manufacturers, healthcare providers, and policymakers will be essential to address these challenges and create an enabling environment for wearable technology adoption.

Future Research Directions

Future research should focus on long-term studies to evaluate the efficacy of wearable devices in improving health outcomes, particularly among the elderly.[23] Research into user-centered design is also critical, as it can help address issues related to comfort, usability, and accessibility. Exploring the impact of wearable devices on reducing hospitalizations and improving quality of life for elderly individuals could provide valuable insights for policymakers and healthcare providers. Additionally, studies on the economic impact of wearable technology adoption, particularly in low-resource settings, could inform strategies for scaling these technologies in Thailand and other similar contexts.[23,25]

Conclusion

Wearable devices hold immense potential to transform healthcare delivery, particularly in aging societies like Thailand. By enabling continuous health monitoring and supporting chronic disease management, these technologies can enhance the quality of life for elderly individuals and reduce the burden on healthcare systems. However, addressing barriers such as high costs, limited awareness, and data privacy concerns is essential to ensure equitable access and widespread adoption. With targeted interventions and collaborative efforts, Thailand can leverage wearable technology to create a more inclusive and sustainable healthcare system for its aging population.

แนะนำการอ้างอิงสำหรับบทความนี้

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