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Review Article

Emerging Technology for Healthy Lifestyle of the Middle-Age and Elderly: A Scoping Review

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Abstract

Background: Emerging technology research focusing on promoting healthy lifestyles for the middle-aged and elderly is paramount in recent literature. However, limited evidence is available for the middle-aged population. This paper reviews how emerging technologies can help in promoting a healthy lifestyle for the middle-aged and elderly.

Methods: A scoping literature review method was employed. Articles were extracted from online databases published within 2010–2021. Overall, 3,152 articles related to the topic were obtained and 2979 articles were archived via different search procedures. Moreover, 173 articles that met the inclusion criteria underwent qualitative synthesize for conclusive inferences.

Results: Most studies focused on people aged 60 and up, leaving the middle-aged population under-studied and unprepared to age. Older adults have high technology anxiety and resistance to change. Limited studies are available to support technology-based healthy lifestyle promotion for middle-aged people. The emerging technologies that are useful in promoting healthy lifestyle behavior among middle-aged people include: robotics, virtual reality, wearables, artificial intelligence, smart textiles, as well as centralized health information systems.

Conclusion: This review sets as a pace-setter for future research on how emerging technologies can aid in the development of healthy lifestyles for the middle-aged and elderly population, allowing them to live a quality life as they age.

Keywords: Emerging technology; Technology; Elderly; Healthy lifestyle; Middle-aged; Scoping review

Introduction

There will be a drastic increase in the percentage of elderly people over 65 yr of age, from 10% as recorded in 2000 to 24% by 2030 (1). Based on the United Nations' report, it is projected that by 2050, the rate of elderly people (ages>60) will expand beyond double the contemporary statistics, escalating to a total of 2 billion people globally (2). The

rise in the elderly population, together with middle-aged people, has a great impact on the health care systems, comprising of care costs as well as increased usage of health-care facilities (3-7). The health outcomes of the middle-aged persons, who will eventually become elderly within a couple of years, is not only affected by physical challenges but also psychological factors (2, 8). These health issues could eventually lead to psychological burdens such as loneliness and social isolation, which would exacerbate the negative impact of the overall health of these people when they grow older (9).

Emerging technology is defined as a "radically novel and relatively fast-growing technology" characterised by a certain level of coherence that persists over time and has the potential to exert a significant influence on the socio-economic domain(s) based on the composing actors, institutions, and interactive patterns, as well as associated knowledge production processes (10).

This paper examines how emerging technologies can aid in the provision of a healthy lifestyle for the middle-aged and elderly according to recent research and provides a broad perspective on this area while considering the challenges and issues that must be addressed. Our main research questions are: 1) How to formulate a framework for emerging technologies for a healthy lifestyle of middle-aged people? 2) What are the components of a healthy lifestyle with regard to emerging technology for the middle-aged and elderly? In order to have a clear overview of the work in this paper, an emerging technology architecture for the healthy lifestyle of middle-agers is presented in Fig. 1.

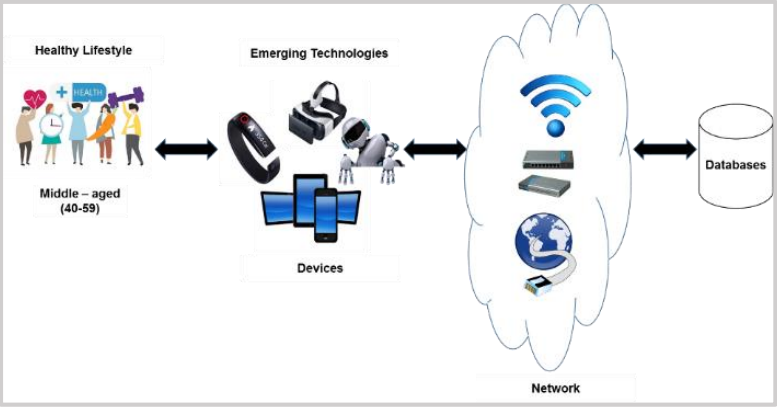

Fig. 1: Emerging technology architecture for healthy lifestyle of the middle-aged and elderly people

Methods

Study Design

A critical scoping review was conducted in this study based on the framework proposed by Arksey and O'Malley (11). The purpose of performing a scoping review is to synthesize the available information that lies in the existing literature, which acts as an initial indication as well as the possible size of the literature body, focusing on an emerging topic or field (11, 12).

Scoping Review Strategy

We adapted a scoping review strategy as recommended by researchers (13-16). In order to ensure relevance of the reviewed articles, we limited the initial screening of publications from 2010 to 2021. This scoping review was undertaken via dual methods of searching, including controlled and uncontrolled searches. Controlled search was adapted through systematic literature reviews as it helps in reducing biases or incomplete evidence from the study (12). Through this search techniques, we could have standardized results and op-

timal mapping of the literature (17,18). The control search was performed on IEEE Xplore and PUBMED databases. Meanwhile, the second search strategy was conducted through uncontrolled searches, done to extensively explore the subject's area and to extract a larger range of articles within the defined scope of emerging technology domain. Here, we gathered and screened records from more open and generic databases such as Google Scholar, Science Direct, PLOS, Springer, ACM, and Web of Science. This process helped to identify the documents of interest based on the occurring terms in the title, abstract, as well as main body text of the respective papers screened. A sample list of searched terms used in this scoping review is presented in Table 1.

Table 1: A sample of search terms used

Searching Terms	***Search Explore Databases***
Search terms	• Technolog*
	• "technology acceptance"
	• iot
	• sensors
	• "emerging technology"
	• "healthy lifestyle"
	• "healthcare"
	• elder* or older
	• adult*
	• middle-age*

Wildcards and Boolean operators were used for the searches

Inclusion and Exclusion Criteria

The search procedure was done in an iterative manner, which helped us to capture the essential articles irrespective of their research designs, quality, or methods employed (12, 17). We only selected articles in English and explicit references in the domain of emerging technologies and their applications to the healthy lifestyle of the middle-aged and elderly. In fact, some publications discussed both age groups together due to the fact that middle-aged people fall into the category of ageing adults (19, 20). In order to justify the reliability, the critical procedures taken in examining the databases, and extraction of the final studies for qualitative synthesis, a Preferred Reporting Items for Systematic Reviews and Meta-Analysis (PRISMA) protocol was used (13, 21), and its usage is necessary to strengthen the advanced scoping review (13, 18).

Article Screening & Selection

We employed a three-phase search process comprised of: article collection, title and abstract scanning, and full text reading. At least two reviewers (FF and SH) scrutinized each article to ensure adherence to the inclusion criteria and the accuracy of the extracted data. In a case where two reviewers face divergence, another reviewer (ZJ) will intervene. Overall, 3,152 articles were obtained in the first sub-phase from the databases, with 590 duplicated articles detected. Thereafter, all articles were examined by analyzing and carefully reading the titles and abstracts to ascertain their eligibility. Specifically, at this stage, articles were assessed based on the availability of full text or abstract, its language, and the level of data relevance or data sufficiency, in which 2,479 articles were excluded. In the next stage, the full text was screened and read, and 200 articles were removed due to issues such as: not focusing on technology, not related to

healthy lifestyles, or not focusing on the elderly or middle-aged. The articles that met our inclusion and exclusion criteria were finalized (n = 173). Importantly, during this search and screening process, extraction of data from various articles was gathered, thereby providing insights as well as propelling determination of the final review format. The PRISMA diagram for this scoping review is depicted in Fig. 2. In addition, in this study, we did not employ the quality assessment process as it is not indicated for scoping review (12, 18).

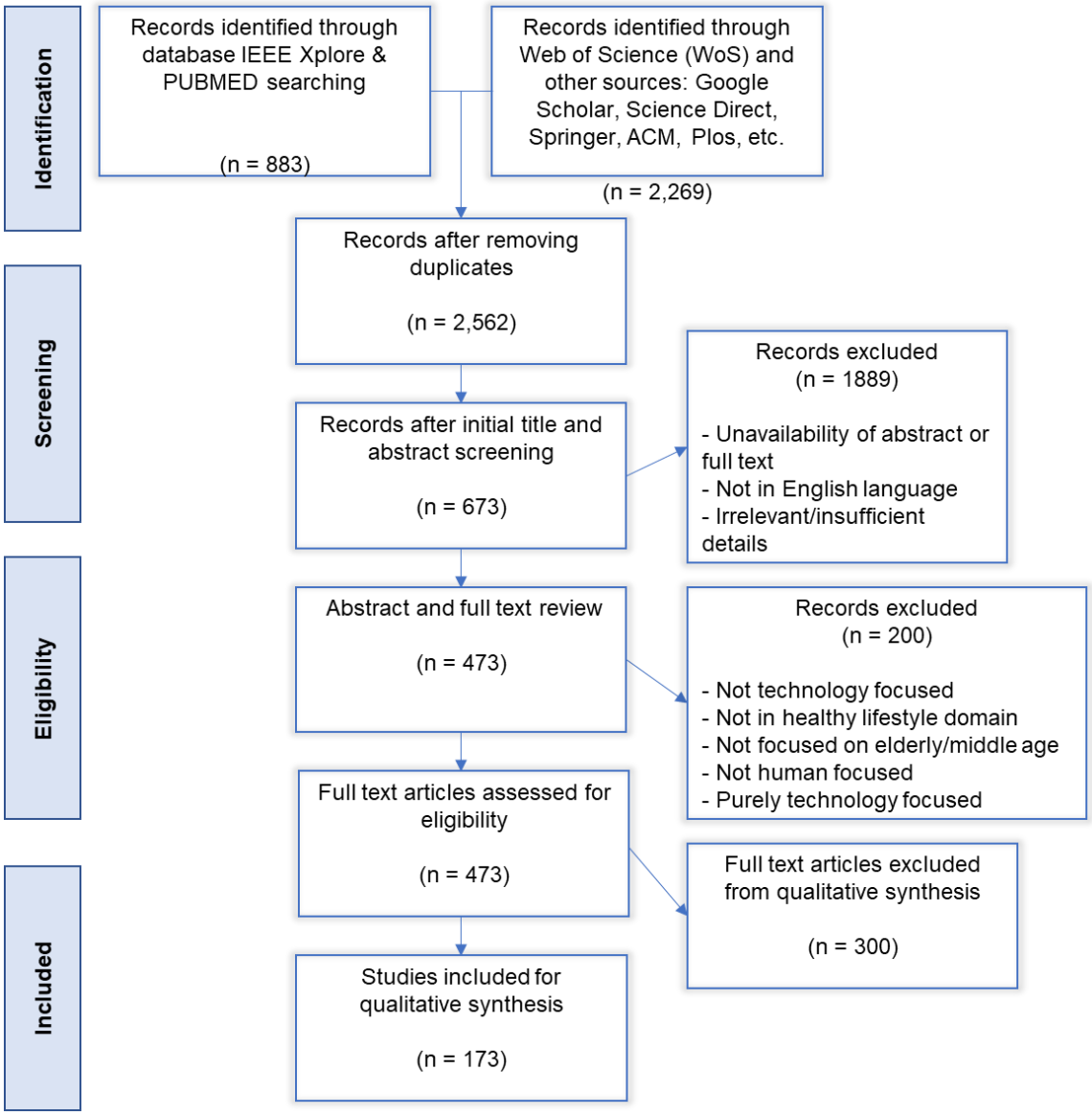

Fig. 2: PRISMA flow diagram for emerging technology literature search

Data Analysis Method

All of the selected full texts were added to EndNote referencing software, and an Excel spreadsheet was used to summarize the findings, synthesize the important themes, and make conclusive inferences. In this study, we employed thematic analysis, qualitative synthesis, and content analysis.

The purpose of conducting this analysis was to identify essential characteristics that help to classify the findings into several themes. The themes were derived in an inductive manner whereby each of the created themes contained information that focused on specific areas related to emerging technologies for the healthy lifestyle of the middle-aged or elderly. The identified themes were later validated in terms of functionality, acceptability, and attributes of the technologies targeted at the studied population.

Results

Based on the literature and to answer the research questions, the conceptualization of the healthy lifestyle framework is presented by discussing the taxonomy presented in Fig. 3, under three sections: 1) Emerging Technology Categories 2) Healthy Lifestyle Attributes 3) User Acceptance. Related studies from the literature employed different techniques such as surveys, proposed systems, models, and frameworks. Fig. 3 presents a taxonomy of the emerging technologies for a healthy lifestyle for the middle-aged and elderly people.

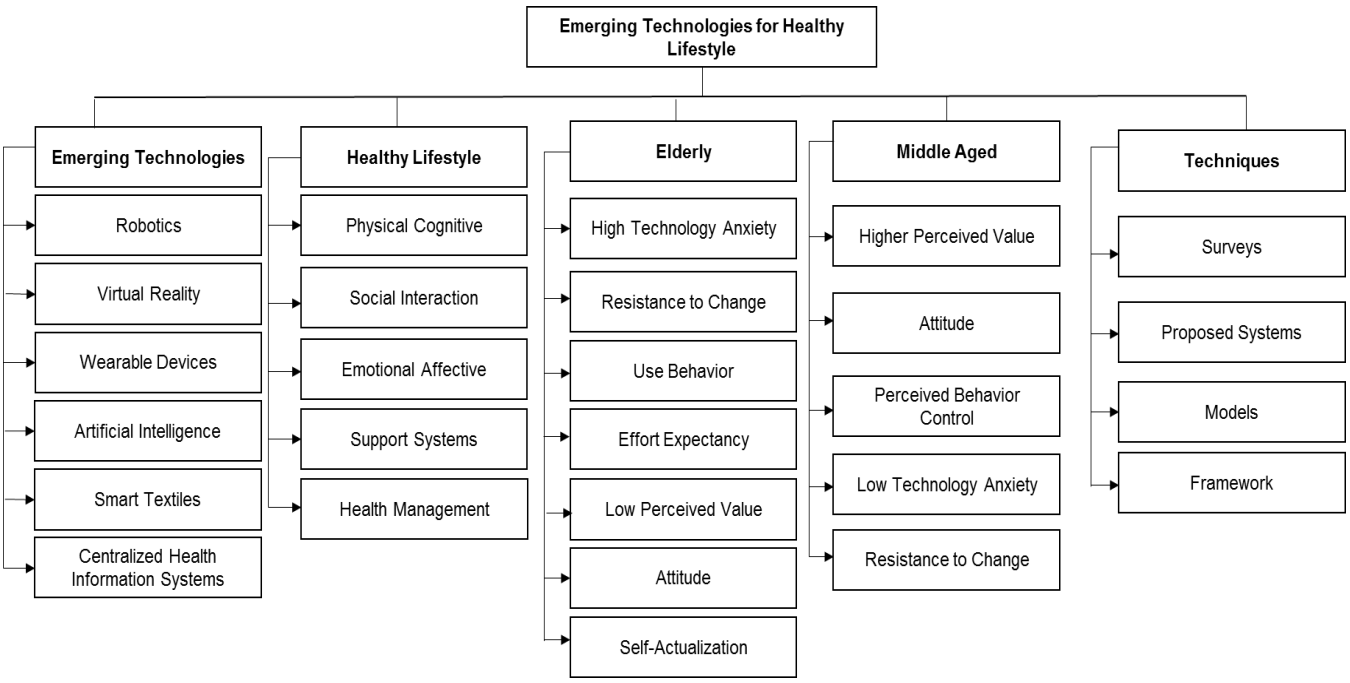

Fig. 3: Emerging technologies taxonomy for healthy lifestyle

Emerging Technologies Categories

This section discusses different categories of emerging technologies based on the aforementioned healthy lifestyle taxonomy and tries to bridge a gap in the middle-aged group. The emerging technology categories are discussed in six themes derived from emerging technology literature. The emerging technologies that will be useful in promoting the healthy lifestyles of middle-aged people include: robotics, virtual reality, wearables, artificial intelligence, smart textiles, as well as, centralised health information systems.

Robotics: Robotics is the branch of technology concerned with the design, construction, operation, and application of robots. Most robotics researchers introduce robotic technology on a broad scale, with the perception that it could lessen loneliness as well as cause a rise in the independence of elderly people (22). Furthermore, the elderly and middle-agers would benefit similarly from smart home technologies, wherein robots can be

used in designing (23).

Virtual Reality: This refers to a similar or completely different simulated experience from the real world. Its applications comprise purposes meant for education as well as entertainment. Apart from just exercising their brains, virtual reality also gives room for the middle-aged elderly to travel across the globe as well as help in relieving their memories amidst the walls of a nursing home or retirement home (24). There are several ways in which emerging technologies developed via virtual reality can help in improving the health of middle-aged people, thus preparing them for a more enjoyable old age. As specified in the literature, a person's psychological state as well as the visible signs of facial expression can be relatable to the pathogenic diseases that are clinically relevant to the wellbeing of a person. Some researchers tried to use the analysis of facial expressions for the purpose of self-management as well as for the monitoring of wellbeing on a person via the application of virtual reality (25). This application helps researchers collect images and signals using an emerging multisensory device. The device is able to extract quantitative features of individual facial expressions related to stress, fatigue, and anxiety. This data can be subsequently mapped computationally and used to describe the expression of an individual's face (24, 26, 27). Apparently, such devices can help middle-aged people monitor their health personally and also encourage a healthy lifestyle. Moreover, personalized advice and coaching messages will support users to keep adopting healthy behaviors and counteract any potentially harmful behaviors (24).

Wearables & Smart Textiles: This is referred to as a segment of technology devices which can be worn by end-users (in this case, the elderly) and could include fitness and health-related tracking information. Smart textiles are an emerging technology that has the ability to track different parameters on a daily basis (28). More so, there would be a drive towards a change in the models of delivering healthcare coupled with the relationship that exists between healthcare providers and patients (29, 30).

Artificial Intelligence: AI applications can help as a reminder to middle-agers about the time to take their medications, appointments with physicians, and even time to take their meals, thus helping to eliminate the confusion and anxiety faced by most elderly people (31).

Centralized Health Information Systems: This refers to a centralized computing system that has the ability to manage, store, and provide access to the medical information of patients, thus enabling both medical personnel and patients to have rapid access to critical patient information via the network, Internet, or mobile devices (32, 33).

Healthy Lifestyle Attributes

A healthy lifestyle refers to a lifestyle that assists in improving and maintaining an individual's health and wellbeing (4). The diversity of healthy living includes eating healthy foods, participating in physical activities such as exercise, and managing stress and weight. Based on scoping reviews of past literature, healthy lifestyles are split into different components:

Physical Cognitive: Emerging technology plays a complex role in physical activities. On one hand, it contributes to the epidemic of sedentary behavior and physical inactivity. However, other innovative technologies have been increasingly used in promoting physical and cognitive activities (34).

Social Interaction: This is most often associated with a person(s) participation in activities, allowing them to interact with other users. An automated analysis of social interaction on the basis of visual cues, exists in literature. However, there is a limit in the contributions regarding the analysis of social interaction with regards to healthy lifestyle (35).

Emotional Affective: Refers to the consideration of well-being on an emotional level explicitly. This is closely related to the idea of Affective Computing (AC), an area concerned with the interactions of emotions with and via computers (36).

Support Systems: A support system provides the tools and technologies that can enable the powerful leveraging of a human's thinking capacity as well as problem solving. Thus, it enhances as well as augments distinct mental capabilities, which comprise computation, memory, visualization,

analysis, reasoning, evaluation, and representation (37).

Table 2 gives a summary of the literature review on emerging technologies for the healthy lifestyle of the middle-Aged, which focuses on the common goals, factors considered, and gaps that future work can address.

Table 2: LR Summary on Emerging Technology for Healthy Lifestyle of the Middle-Aged

Healthy Lifestyle	*Common goals*	*Factors of Consideration*	*Gaps*	*Reference*
Health Management	- Investigated how older and middle-aged citizens adopt health services via ICT/mobile.	- Perceived value, attitude, perceived behavior control, technology usefulness, level of intrusiveness and resistance to change are predictors of the intention.	- Limited generalizability - Existing User interfaces, need improvement. - Lack of practical trials.	(5, 6, 38, 39)
Social Interaction	- Explored how technology is/can be used to combat social isolation and increase social participation among elderly.	- Technologies utilize social network services & touch screen technologies. - Social outcomes are often ill-defined/not defined.	- Limited methodologies to evaluate interventions. - Insufficient attention to key social concepts.	(24, 35, 40-42)
Emotional Affective	- Evaluated degree of acceptance/implementation of different technologies.	- Video cam and screen usage were influenced by level of income and caregiving. - Most elderly persons don't use the Internet frequently.	- More programs and measures are necessary for real life implementation.	(41, 43, 44)
Physical Cognitive	- Review how exergames help to motivate the elderly to exercise, focusing on possible social interactions via online exergaming & persuasive technologies.	- Elderly suffers from loneliness. - Mobile applications can enhance the health of older adults by teaching them to exercise from home.	- No specific age groups. - Gamification can be combined with existing exercising apps.	(1, 41, 45-49)
Support Systems	- Design and development of technological frameworks that can support assistance to the elderly.	- Multi-agent systems, safe communication, federated information management. - Emotional Attachment, cues to use, proficiency to use, need compatibility, resources input, and support.	- Need for careful analysis of socio-economic & ethical issues. - No link between digital literacy and user participation. - Need to improve context information.	(39, 42, 50-54)

Emerging Technology & the Elderly

From the literature, several factors have been identified as being responsible for the acceptance of emerging technology by the elderly. The factors are defined below:

Technology Anxiety: Technology anxiety refers to

the apprehension of an individual when they are faced with the possibility of trying out a new technology.

Resistance to Change: Resistance to change is an essential factor in technology adoption (55) and it is perceived as the degree to which a person considers employing a specific technology or system. Elderly people will have a change in their habits as well as lifestyle restructuring, instead of just adopting novel technologies (34). They have the tendency to manifest different behaviors towards the use of new technologies; thus, it is rather important to ensure that this factor is being investigated prior to the development of such technologies, especially for middle-aged people's use.

Effort Expectancy: Is the degree of ease associated with the use of a system or technology. From previous studies (33), effort expectancy has the potential to strongly influence the intention of users to adopt or accept technology, especially health-related information systems.

Perceived Value: This refers to the customers' merits of a product or service and its ability to meet their needs and expectations. Researchers have used perceived value in describing the perceptions of the elderly towards adopting mobile health services and discovered that it had significant effects on the attitudes and behavior intentions of both middle-aged and older users (56).

Attitude: This refers to the way an individual feel about a particular idea or situation. The personal attitude as well as the willingness of aged individuals to confront technological devices (emerging technology) is undoubtedly amongst the biggest obstacles to introducing emerging technological innovations (57).

Self-Actualization: Self-actualization is a significant predictor of behavioral intentions to adopt the use of wearable healthcare technology by the elderly (58). Self-actualization is an essential factor to be considered when studying the antecedents of technology acceptance by middle-agers.

Emerging Technology and the Middle-Agers

Emerging technology usage is typically influenced by diverse experiences in life. Though middle-agers might be familiar with basic technologies including mobile phones and the Internet, alongside other digital devices such as television and radio, the majority of them are not quite familiar with such technologies as compared to young adults who were born at the advent of the emerging technologies (59). Furthermore, additional motivations for middle-agers to use emerging technologies in their daily life might comprise the need to feel safe with others as well as a way of supporting a healthy lifestyle (60). This review nevertheless focuses on how emerging technology can be used by middle-agers to promote their healthy lifestyle.

A study by Kuoppamäki et al. (61), was conducted towards digital domestic technologies in the lives of late middle-agers alongside young adults, hence comparing the two age groups' need for using technologies, as well as trying to detect if it's for a risk to privacy or a need for security. From their findings, young adults interpreted digital technologies via notions such as privacy, time management, and self-control. However, for middle-agers, the conceptualization of technology was in relation to factors such as security, personal skills, and social relationships (61, 62). Invariably, middle-agers have the possibility of making good use of emerging technology for improving healthy lifestyles as well as enhancing quality of life, if they are well harnessed with its benefits as well as its usage early enough.

Discussion

In this scoping review, most studies focused more on older people aged 60 and above, leaving the middle-agers under-studied, leaving them unprepared to age. Older adults have high technology anxiety and resistance to change, with most studies focusing on hospital monitoring and management as benefits of emerging technologies. Limited studies are available to support technology-based healthy lifestyle promotion for other populations, especially the middle-aged.

Deng Mo investigated how older and middle-aged citizens adopted mobile health services (63). The targeted population were middle-aged people and

the elderly, all within the age range of 40 years and above. The middle-age-group intention to use mobile health services was predicted by their resistance to change, perceived behavior control, and perceived value, coupled with attitude.

From the literature, the determination of ICT was based on computer accessibility and support, followed by health, age, education, and marital status. However, health moderated the effect of age, indicating that the elderly people who were healthier had a more likely chance of using computers as compared to their counterparts.

Particularly worrying from previous studies (64), are the health effects associated with emerging technologies and the fact that the elderly people are not inclined to share their experience of how ICT can significantly affect their quality of life. Health-related ICT for the elderly needs to be kept simple and should demonstrate substantial benefits. Moreover, special attention should be placed on support as well as training, all of which should be based on precise cultural and personal traits.

Research Challenges & Future Directions

A lot of great promises are being offered by technology for elderly care. However, such potential is hindered by diverse factors as explained above, as well as other human factors and challenges (35, 65). The challenges from the review of emerging technology for the healthy lifestyle of the elderly population are summarised below.

- Limited Generalizability: Regarding sample size, most empirical studies were conducted as pilot studies, with just a few looking into a large sample of elderly people (34, 63).
- Age: Most of the studies focused on the elderly and there is a lack of studies relating to middle-aged people, who are closer to becoming elderly.
- Limited Factors Studied: Literature focused on acceptance and adoption of technologies by the elderly, leaving a gap in how technology can impact the elderly's needs (6). Careful analysis of the socio-economic and ethical issues of emerging technologies is needed (31), alongside how this could affect the middle-aged persons.
- Lack of Practical Trials by the Elderly: Many technology-based studies are abstract, hence the need for initial results to be followed by practical trials.
- Lack of Healthy Lifestyle Component: From the reviewed studies, it appears there is an absence of the connection between emerging technologies and the healthy lifestyle of the elderly. Most of the studies either focus solely on technology use, or on health technology or mobile health, without finding relationships between both (31).

Conclusion

Through this scoping review, we were able to formulate a framework for emerging technology for healthy lifestyles of the middle-aged and elderly and identify the components of a healthy lifestyle relating to emerging technology. Finally, as the bedrock of all technological efforts, the implementation of emerging technology use on the middle-aged and elderly should be tailored to the component of how it affects their healthy lifestyle. The topic emerging technology is conceived between the onyxes of healthy lifestyle and the middle-aged and elderly people. Regarding healthy lifestyle, the relevant factors identified are: physical cognitive/physical activity, social interaction, emotional affective support systems, and health management/monitoring. The affecting factors for middle-aged people using emerging technology include: high technology anxiety, resistance to change, use behavior, effort expectancy, low perceived values, attitude, and self-actualization. It is paramount to put the needs of the middle-aged and elderly into critical consideration when developing emerging technologies that can help foster a positive and healthy lifestyle among this group of people. Therefore, if a middle-aged person grows up with an acceptance of technology, their later years will be more appreciative.

Journalism Ethics considerations

Ethical issues (Including plagiarism, informed consent, misconduct, data fabrication and/or falsification, double publication and/or submission, redundancy, etc.) have been completely observed by the authors.

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Conflict of interest

The authors report no conflicts of interest.

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