

Remote Monitoring Solutions for Homebased Healthcare Services for Elderly.”- A Literature Review

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Abstract

With the extraordinary rise in human longevity during the 20th century, population aging has now spread throughout the world. There are a lot of people in populous countries like India who are 60 years of age or older. In India, the number of people over 60 has tripled in the past 50 years and is expected to rise steadily soon. The United Nations Department of Economic and Social Affairs (UNDESA) released data in 2015 indicating that there were about 116.6 million elderly people in India. According to their projections, the percentage of Indians who are 60 years of age or older will increase from 8.9% in 2015 to 19.1% in 2050. Despite increases in life expectancy, aging is linked to a multitude of co-morbidities. Furthermore, as people age, mental health conditions such as anxiety disorders, dementia, and depression are frequently noted in the Indian population. To meet the requirements of the aged in the nation, non-governmental organizations, the government, hospitals, and family caregivers are the available resources. Although there are laws in place, they do not adequately cover the social benefits that the senior population is entitled to. The way we provide healthcare services has changed because of developments in technology and medicine. Research indicates that the use of remote monitoring or home telemonitoring systems can assist avoid medical emergencies and reduce the likelihood of recurrent hospital stays. The objective of the study is to identify the recent advances in remote health monitoring devices and assistive devices for the elderly.

Methods

A literature review was conducted using ScienceDirect, PubMed, Google Scholar and ProQuest. Publications related to older people's care, elderly people's perception and acceptance, healthcare service seeking behavior and assistive technologies and solutions were included in the study.

Results and Conclusion

In this paper remote monitoring device application in home-based healthcare service delivery and elderly people's perceptions towards services are reviewed by investigating 50 published articles that met the inclusion criteria. Firstly, by analyzing the related works, the theoretical concepts of remote monitoring devices and major remote monitoring systems for home-based healthcare services are presented. Later, the acceptance and use of those solutions by the elderly is discussed.

Keywords: *Elderly, Home-based Health care, Aged, Remote Monitoring, Telemonitoring, mHealth, Robotic solutions for healthcare.*

Introduction

A WHO study states that in 2017, 962 million people worldwide were 60 years of age or older, making up 13% of the world's population. This percentage is predicted to rise by about 3% annually, so that by 2050, more than 25% of people on all continents—aside from Africa—will be older than 60 [1]. As the population ages, so does the prevalence of chronic illnesses including cancer, congestive heart failure, dementia, and Alzheimer's disease, which calls for greater medical attention [2]. It is possible to view the home as a significant healthcare environment that reorients treatment toward individuals and their communities rather than traditional clinical settings. By 2045, there will be more senior citizens than children and young adults due to a rise in the old reported in recent demographic surveys. However, the cost of caring for the elderly will rise due to a global lack of nursing assistants and home healthcare providers [3][4]. In a rapidly aging population, it has become important to develop assistive technology for independent living at home as socio-technical innovation [5]. The initial introduction of information and communication technology (ICT) into the healthcare sector aimed to reduce expenses and boost efficiency. With its locating capabilities and the advent of mobile devices, m-health leverages the worldwide availability, immediacy, and monitoring of e-health. The notion of smart health, or s-health, has been evolving recently and is based on the utilization of both Internet of things (IoT) and smart cities. "Systems in smarter cities are instrumented, linked, and intelligent."The advancement of smart home technology has improved the standard of healthcare support services and allowed seniors to lead more welcoming lives at home instead of in hospitals. By enhancing healthcare services for patients at home or in distant areas outside of hospitals, smart home automation systems can reduce the likelihood that patients would experience depression because of feeling alone in hospital wards. In addition to prescribing medication and viewing measured vital health data for a remote diagnosis, healthcare providers can monitor patients from their offices. Patients, particularly the old or disabled, can now easily operate some home appliances from smartphones, tablets, laptops, the internet, and other devices thanks to the quick advancement of software and technology in the smart home healthcare system [6]. A smart home healthcare environment is one that is widespread because it consists of multiple computer devices that take proactive actions on behalf of people. Thus, user context and preferences are some of the essential factors to be considered for decision making in a smart home healthcare setting so that the user can select any option that piques their interest among the resources and services that are available in any given scenario [7].

Following this introduction, the article analyses the literature in terms of remote health monitoring solutions. After that it assess the smart-health potential through home intelligent service, smart treatment, and telemedicine. The results provide a thematic description of home-based e-health-care services experiences and propose a substantive model of e-care system acceptance and use. In discussion, we articulate the relevance and importance of our study findings for research and practice as well as consider some potential avenues for future research that could overcome this study's limitations. The last section concludes with some summarizing remarks.

Materials and Methods

In this paper home-based healthcare service delivery and elderly people's perceptions towards services are reviewed by investigating 50 published articles that met the inclusion criteria. A mixed method of literature review was used first the grey literatures are selected by PRISMA analysis and then further the selected literatures are analyzed in a narrative way. Using keywords- Elderly, Home-based Healthcare services, and Remote Monitoring devices. A variety of synonymous terms were combined using Boolean logic, and a combination of three groups of keywords— (1) elderly, (2) home care, and (3) Remote monitoring—was selected as the keywords. To include all relevant publications, their thesaurus equivalent words and associated

Medical Subject Headings terms- aged, telemonitoring, home health care, independent living, ambient assistive living, smart home solutions, IoT devices, and artificial intelligence (AI) in older people's care—were also included in the search in Google Scholar, PubMed, ProQuest, and ScienceDirect databases. Firstly, by analyzing the related works, the theoretical concepts of remote monitoring devices and major remote monitoring systems for home-based healthcare services are presented. Later, the acceptance and use of those solutions by the elderly is discussed.

Inclusion and Exclusion Criteria

Quantitative, qualitative, and mixed method peer-reviewed publications and published conference papers were included. Last 10 years publication data have been considered. Research articles and case reports related to assistive technology assessment for elderly care, set in homes, smart homes, experimental settings, nursing homes, and rehabilitation settings were selected.

Inclusion criteria

- Published after January 2014 in English language.
- Peer-reviewed journal articles and published conference papers.
- Studies that focused on the latest technological, artificial intelligence, and IoT for elderly. care and Remote monitoring solutions and assisted living devices.
- Publications related to older people's care, independent living, and novel assistive technologies.

Exclusion criteria

- Published before January 2014 in languages other than English.
- Literature reviews and systematic reviews.
- Book chapters, dissertations, theses, magazine articles, reports, wire feeds, position papers, editorials, white papers, and working papers.

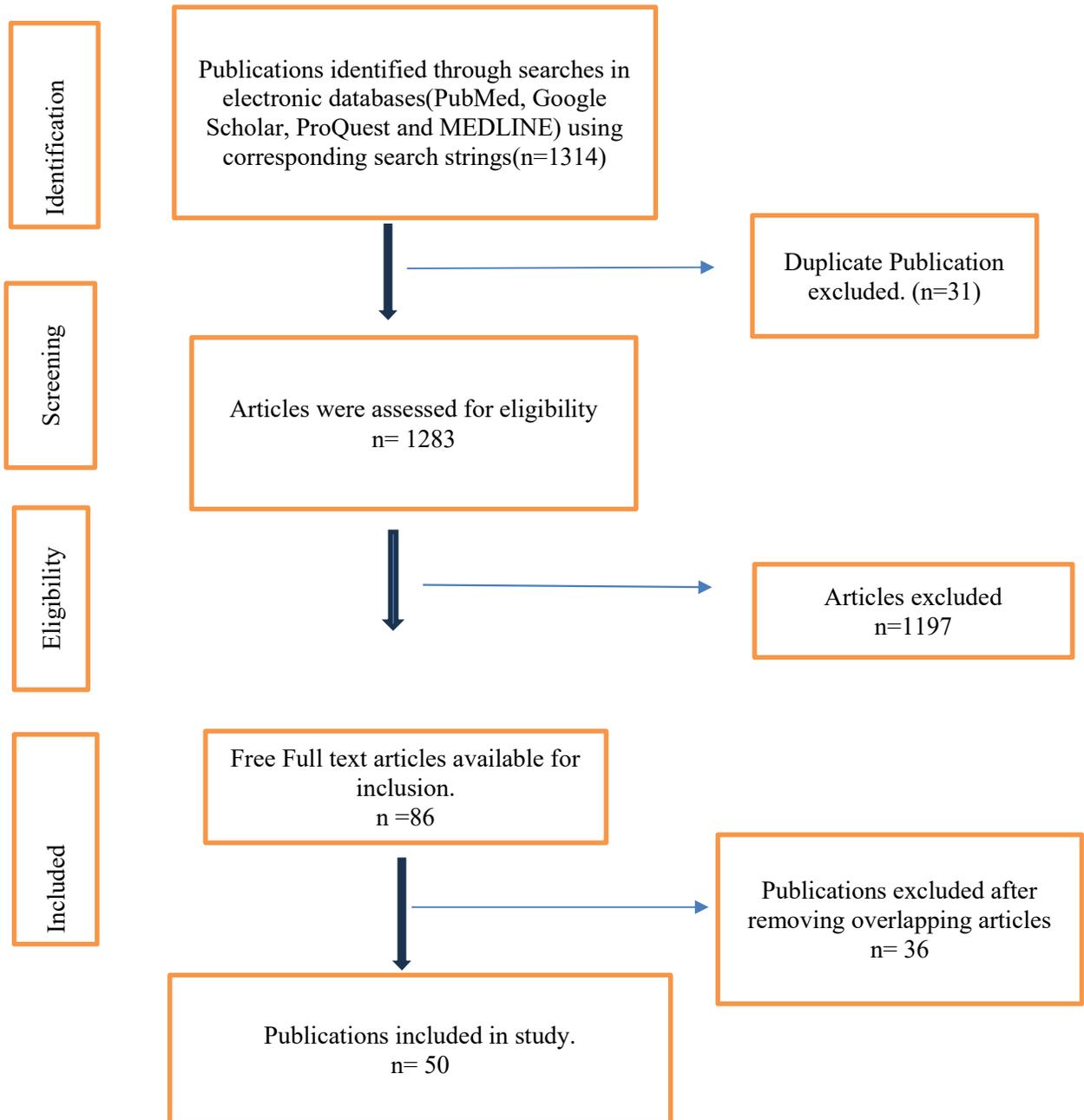
Selection of literature for study

A total of 1314 publications were found at the end of the initial search of the selected databases. Search strings and return values for each database are listed in Table 1, respectively. The list was filtered by removing duplicates, the remaining abstracts were assessed, and the publications that did not meet the inclusion and exclusion criteria were excluded. At the end of this process, 55 eligible publications for inclusion were identified. Figure 1 displays the search diagram and the number of articles assessed at each stage of the review.

Table 1

(“Elderly People” OR “Aged”) AND (“Home care” OR “Home based Healthcare”) AND (“Remote Monitoring” OR “Telemonitoring”)

Figure 1



Results

An examination of 50 complete papers indicates that several technologies have been developed for telemonitoring and remote monitoring. The studies were found to be either focused on the creation of new patient monitoring devices or on the adoption of existing technologies. The chosen papers were examined according to their goals, which can be summed up by the articles' main points, to ascertain the state and potential difficulties of remote monitoring technologies. As a result, the analysis can be categorized into the subsequent themes.

1. Medical Telemonitoring

Physicians can make decisions about patient care and occasionally assign tasks to another medical expert with the help of medical telemonitoring. In medical systems for postoperative care and management, as well as chronic illness in the elderly, medical telemonitoring has become an essential component [8]. Telemonitoring is viewed by healthcare service providers to improve care quality and reduce costs [9][10]. According to a Swedish study, telemonitoring with digital pen technology in conjunction with hospital-based home care greatly lowers the number of hospitalizations [11]. In a similar study it was found in patients with Chronic Obstructive Pulmonary disease, telemonitoring of patients reduces the number of hospitalizations by 60% thus reducing the healthcare costs [12]. An efficient technique for providing diabetic patients with telemonitoring and teleassistance over the recently announced 5G cellular network was demonstrated in an Italian study [13]. At Leiden University Medical Center (LUMC), a tertiary care facility, telemonitoring has been extensively utilized for the treatment of many illnesses. It has been found to be a safe and effective alternative to conventional therapy. Using this information, they developed the "COVID Box," which is currently the accepted method of treating patients who may have COVID-19 [14]. According to a study, hospitalizations, the average length of stay in the hospital, and mortality are all directly correlated with the proactive use of telemonitoring in conjunction with telemedicine in a structured care model for patients with COVID-19 who are quarantined at home after being detected at the time of diagnosis. Similar results were observed when managing elderly patients with chronic diseases [16][17].

2. Remote Monitoring solutions and smart home technologies

This theme comprises trailblazing systems that consist of home service robot; home and body sensors, mobile devices, cloud servers and remote caregivers. A smart home is an Internet of Things (IoT) technology-based system that connects and remotely or automatically controls smart devices (home appliances, lighting, sensors, and security) indoors. A gateway to connect communication technology such as a device to realize apps and services acting as a control hub, a cloud server is required for implementation of a smart home [18]. The Internet of Things (IoT) has advanced recently, bringing about changes across several industries, including the healthcare sector. With components that can communicate remotely with one another, new linked healthcare systems have arisen [19]. A smart healthcare monitoring system, or SW-SHMS, can help older and disabled people live independently by providing a safe and comfortable environment so they do not have to worry about medical emergencies or serious situations requiring care. Wearable sensors are used by SW-SHMS to collect physiological data from patients, which is then sent to the cloud for processing and analysis. As a result, the hospital platform will be used to notify the patient's doctors of any abnormalities found in their data [20]. Wearable IoT devices are used to detect activity and symptoms indicating medical condition [21]. Non-invasive Internet of Things (IoT) sensors enable improved support for caregivers and help collect the person's status with minimal involvement from them. They also lower the expense of routine check-ups [22]. Custom wearables and telemedicine equipment were preferred by many researchers who concentrated on remote monitoring, while those who studied smart homes preferred cutting-edge sensor systems and ultrasonic receivers and transmitters. Commercial gadgets and systems, such as those integrated into widely available smartphones, gather daily data from users (such as physical activity and food information) to paint a picture of their overall lifestyle. Typically, these goods are not subject to the same regulatory oversight as applications or medical devices designed particularly to gather health data (such as ECG reports and blood pressure measurements). These features are expanded upon by AI-powered health

monitoring systems, which do more than just gather and monitor different indications. Those devices are well equipped to mimic human intelligence, such as recognizing, learning, reasoning, adapting, predicting, and deciding thus, reducing the burden on family caregivers, and improving the quality of care [3]. Better blood pressure control was discovered with minimal incremental expenses in research evaluating the digital intervention for managing hypertension by integrating guided self-management with self-monitoring blood pressure [24].

3. Robotics Technologies

This theme explores the impact of robotic technologies on elder care. While some research investigated a variety of cutting-edge AI technologies, others evaluated robot-assisted activities by looking at simpler versions. The growing population of people in need of assistance and rehabilitation has prompted researchers to create new robotic systems that can be combined with senior care options. Mobile and sensor-based wearables can use a variety of deep learning algorithms to automatically extract information [25]. Machine learning is a subset of AI that uses statistical techniques to empower computer programs to make predictions and decisions on their own based on past data, allowing the programs to perform tasks progressively better through interactions and experiences. From longitudinal observations these optimization algorithms can identify and categorize patterns from data collected, and assess risk level and make care recommendations. For example, AI-enabled blood pressure or electrocardiogram monitors may help to pre various health concerns (e.g., hypertension, atrial fibrillation). Some more sophisticated AI home-health monitoring system such as computer vision analytics can classify activities such as standing or walking, and then learn the expected movements or activities for a particular older adult in a specific setting, such as the ease and the amount of time a person spends getting out of bed [26][27]. The AI technologies reduces the access barriers and caregiver burden by optimizing the limited human resources and equalize opportunities for older adults to age safely in their desired settings [28]. Some of the IoT based healthcare applications are mentioned in Table 2 [29]

Category	Task	Type
Robotics	Monitor and help the disabled person in need.	Robots Eg: Meet Mr. Robin grandma’s buddy
Smart Homes	Centralize and automate home tasks	Home based systems linked to local hospital
Wearables	Monitoring and helping individuals in daily life activities	Can be included in clothes and accessories Eg: Nuubo smart shirt, smart jacket, smart watches
Mobile devices	Monitor users’ activity and detect health issues	Carried in hands or pocket Eg: Mobile phone applications
Non-wearables	Collect behavioral information	Can be included in home objects

Table 2 Classification of Internet of Things (IoT) based healthcare application

*ADL aid to daily living, EADL electronic aids to daily living

4. Acceptance, patient compliance and feasibility of Remote monitoring solutions

Most of the research that we could find concentrated on the acceptability, feasibility, and compliance of patients with telemonitoring equipment [30][31][32]. Seniors living in the community must find telemonitoring to be as useful and acceptable as possible for both them and their caregivers [33]. There were notable discrepancies between the older population and the socioeconomic indicators that were utilized as control variables, especially when it came to greater levels of education. Higher self-rated economic position was correlated with a greater readiness to employ ICT for home-based healthcare. Moreover, older persons who felt poorly about their own health were less likely to use ICT for healthcare [34]. Home-telemonitoring was implemented in a randomized control study involving heart failure patients who were discharged, and it was discovered that patients who strictly adhered to the protocol had a better all-cause result than those who did not [35]. Amongst reasons for non-acceptance and non-use of home telemonitoring application, difficulty in handling the hardware and the program was most frequently reported [36]. In an Australian study, patient compliance with telemonitoring device self-management suggestions was evaluated. The patients had a higher rate of withdrawal than rigorous compliance, and they were diagnosed with chronic heart failure. While telemonitoring shows promise as a support strategy, more development is necessary [37]. However in a study conducted with patients with Parkinson's Disease using long-term home-monitoring sensor technology majority of the patients showed high adherence and acceptance rate [38] similarly high compliance and acceptability was found amongst older cancer patients who participated in a study amongst oncologic surgical patients [39]. Another study that examined the viability and efficacy of telerehabilitation programs for elderly patients with heart failure and chronic obstructive lung disease [40]. A reduction in the quantity of interactions, including face-to-face meetings, would result from remote monitoring. This is seen to be a possible drawback of using remote monitoring devices at home. Furthermore, face-to-face interactions contribute to socialization since they provide chances to preserve and expand personal support networks, with caregivers playing a crucial role in the adoption of cutting-edge assistive technology by individuals with cognitive impairments [41][42]. Contradicting to, use of remote monitoring devices for vulnerable elderly people living alone, Thordardottir et al, stated that having a close trustworthy relative or who is in a committed relationship with the care receiver is an important condition of remote monitoring home-based service use. As AI technologies collect, store, and process data to make predictions and/or give recommendations, there are questions of how older adults and their families may measure personal and data privacy considerations against the profits in independent living, physical safety, and convenience. As consent and the use of monitoring technologies is often carried out in a familial care setting, the ethical questions of balance in elderly person's autonomy, privacy, and well-being with the interests and preferences of family caregivers has also relevance [43]. In a survey, it was found that the primary defects of the remote monitoring devices is related to the volume and complexity of collected data, which interprets an onerous task for the caregivers [44]. Cyber security, privacy issues, costs, user friendliness and lots of other considerations are the main concerns involved with e-healthcare technologies [45]. In a comparative study of cost-effectiveness analysis between home telemonitoring, nurse telephone support and usual care in patients with chronic heart failure it was found that , home telemonitoring and nurse telephone support is more viable, cost -effective and also improves the survival chance of patients[46]. In order to prevent clinically unnecessary data from being collected and added to the workload of older persons and their family caregivers, we must take steps at the organizational and health system levels to ensure that the promises of AI health technology are kept. Technology for in-home monitoring was unfamiliar to the majority of nurses, family caregivers, and senior citizens [47]. However, they considered that such technologies can be pertinent in the future by improving the quality of care among elderly living independently at home. Moreover, the acceptance and the use of in-home technologies by elderly were often influenced by social network and work overload of nurses, cost, and lack of funding to be barriers to implement in-home monitoring technologies[48]. By educating and empowering patients, consumer-facing technology can be a low-cost, scalable intervention to improve the

medication safety of older persons. Correctable usability issues are found by using user-centered design and evaluation using demographically heterogeneous clinical samples. This approach also validates the effectiveness of interventions that aim to involve consumers as agents in shared decision making and behavior change[49]. Considering the benefits of telemonitoring, adequate studies are required to assess the usability of created technologies for the elderly population. Because older persons typically do not consider themselves viable users of the system, their chronic condition may also negatively impact the usability of telemedicine. Additionally, older adults may have less expertise with technology [50].

Discussion

The purpose of this literature review was to determine the best available evidence about the development and implementation of technological solutions for elderly care, and in this paper, we report that the evolving technology trends can transform the aging population and ways that AI and pattern recognition might impact older individuals' care. We examined publications about intelligent remote monitoring, smart home health care, and robotic technologies to respond to the following research questions: (1) what are the current trends in remote monitoring technology? and (2) what are the challenges and acceptance by elder individuals and family care givers and the nurses? To answer the first question, we determined the wide range of studies that focused on new technologies, novel patient monitoring and smart home technologies, intelligent algorithm development and software engineering, and robotics technologies. Studies focusing on benefits of telemonitoring over conventional methods and cost benefit analysis were very few(51) To answer the second question, most of the publications were qualitative. Our analysis demonstrated that many of the studies used unique technological solutions for different elderly groups. For example, studies that support independent lifestyle were designed for older people living alone in their home, whereas studies about new technologies for dementia and patients with Alzheimer disease were designed for older people living in nursing homes. Over the last decade, there has been a significant increase in the number of studies that focused on AI and machine learning and home-based healthcare devices specially after the COVID-19 pandemic [52][53]. Some studies investigated user perceptions, acceptability and adherence to the monitoring system developed using sensors and smart home devices, whereas others focused on the development of context-aware and adaptive technology development. This study identified several studies about novel innovative systems to monitor older people's health. Many of these studies were proof-of-concept systems to demonstrate the feasibility of the proposed equipment or app. Few studies also focused on the development of systems, programming languages to develop a tele-monitoring system[54]. In order to achieve maximum user's adherence, patients can be involved as co-designers, considering their needs(55). IoT advances have the potential to improve pervasive monitoring of the health and well-being of people, especially for elderly persons living in remote areas with limited access to care providers. However, there are many challenges in deploying viable systems beyond the proof-of-concept phase. Due to positioning requirements and infrastructure limitations, battery-operated devices provide flexibility in installation and use [56].

Limitations

This study has some limitations. First, most study findings were not comparable because of the various research settings and types of technology used. Majority of them were case studies and are applicable to a particular environment, place, or settings.

Conclusion

Remote monitoring systems that can provide a comprehensive snapshot of the elderly individuals' overall activity patterns and the environmental contexts within which various manifestations occur. Remote monitoring devices can be valuable tools for healthy aging. These technologies, if developed ethically, can be reasonable assistants for older adults, family caregivers, and healthcare professionals. They can reduce the burden on unpaid caregivers and at the same time acclaim current care provision, improving the quality of care. Big media and communication companies, who are already having high market penetration as well as robust infrastructures for high speed and secured data communication, and third-party healthcare service providers such as hospitals, clinics, and ambulance services may join forces to bring healthcare service facilities to the doorsteps of the people in need. Finally, manufacturers also need to work on the design aesthetics in addition to the performance and ease-of-use of the installed devices and systems. A home is the reflection of an individual's personal identity and a sphere of mental and physical comfort for the occupants. Therefore, a superior monitoring system with poor visual aesthetics may not be well accepted by the consumers.

Conflict of Interest

NIL

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