

A NEW ERA: UTILIZING TECHNOLOGY TOOLS TO ENHANCE ELDER
INDEPENDENCE

A Scholarly Project

Submitted to the

Faculty of Liberty University

In partial fulfillment of

The requirements for the degree

of Doctor of Nursing Practice

By

April Lisa Phelps

Liberty University

Lynchburg, VA

November, 2020

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Scholarly Project Chair Approval:

Tonia R. Kennedy, Ed.D, MSN, RN-BC, CCRN-K. Date

ABSTRACT

The goal of this integrative review was to examine the multitude of technology tools and the evidence which supports their use to enhance elders' independence when residing at home.

Multiple journal articles and books published between July 2015 and July 2020 were examined using the PRISMA model for evidence to support or oppose the use of technology to enhance the elders's independence. A total of 27 articles were included in the final review. An exploration of gaps in knowledge related to the issue of elders using technology tools such as wearable sensors, artificial intelligence, home monitoring, robots, mHealth, Internet of things, and smart phones to prolong independent living and the various benefits of technology tools was conducted. The findings of this review suggest technology tools can enhance an elder's independence. However, caregivers and professionals should proceed with caution, as there are concerns with implementing technology. Further studies are necessary to address concerns because of the revolutionary nature of technology tools and their relatively recent introduction to elders.

Keywords: elders, caregivers, technology, independence, mHealth, sensor, Internet of things, home monitoring, artificial intelligence

Dedication

I have committed this work to the Lord, and Christ has given me the strength and encouragement to see it come to fruition. May those caring for precious elders gain wisdom and blessing as a result of this integrative review. I must not forget all the support I have received from family and friends throughout this process. Hunter, I could not reach for the stars without your loving support. You are my rock! Nikolaus, you have sacrificed the most missing out on time with your mother. Nikolaus, one day may you be inspired to pursue your dreams with the enthusiasm you have witnessed. May you be rewarded as I have, knowing you have left the world a little better than you found it. My parents and in-laws deserve a shout out for all their love and support as well. Friends, you keep me going with your supportive and kind words.

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List of Abbreviations

Artificial intelligence (AI)

Assistive technology (AT)

Continuing Care Retirement Community (CCRC)

Internet of things (IoT)

Preferred Reporting Items for Systematic Reviews and Meta-Analysis (PRISMA)

SECTION ONE: FORMULATING THE REVIEW QUESTION

Introduction

The number of elders residing at home is continually growing. Experts predict that by the year 2030, there will be over one billion elders age 60 and older worldwide (Susnea et al., 2019). Family members are seeking strategies to keep their loved ones safe at home to avoid the outrageous costs of residential care facilities. Some family members fear their loved ones will have a diminished quality of life when they move into an institutional setting. In this integrative review, technology solutions are explored, with a focus on costs, involved stakeholder design, user acceptability, privacy, and security.

Elders common preference is to spend their remaining years at home, aging well in place. Approximately one third of the elders reside alone, highlighting the increasing need for technology tools that can aid elders independently living in their homes (Susnea et al., 2019). Revolutionary technology solutions for elders include sensors, artificial intelligence (AI), home monitoring, robots, mHealth, the Internet of things (IoT), and smartphones. As many of these technology solutions are cutting edge, there are gaps in knowledge, and multiple researchers have emphasized the need for further studies.

As of 2015, there were 1.3 million residents in long-term care facilities in the United States (Centers for Disease Control, 2020). Many families are concerned with excessive costs when an elder transitions into a retirement home setting. Cost comparison of nursing home options and additional average long-term care expenses as of 2016 are provided in Table 1 and Table 2 respectively (U.S. Department of Health and Human Services, 2020). Therefore, the goal of this review was to examine the various technology tools and the evidence which supports their use to enhance elders' independence while living at home.

Table 1*Cost Comparison of Nursing Home Options as of 2016*

Setting	Cost/day (\$)	Cost/month (\$)
Semi-private room in a nursing home	225	6,844
Private room in a nursing home	253	7,698
Assisted living (one-bedroom unit)	119	3,628

Table 2*Long-Term Care Expenses*

Service	Cost (\$)
Health aide	20.50/hour
Homemaker services	20.00/hour
Adult day health care center	68.00/day

Defining Concepts and Variables

The central concept as it relates to this integrative review is a relationship between the use of technology tools and elders' independence while residing at home. For this review, a technology tools include wearable sensors, AI, home monitoring, robots, mHealth, IoT, and smartphones. To understand the concept of the relationship between an elder's independence and a technology tool, a variety of variables for the technology tool are examined, to include costs, stakeholder-involved design, user acceptability, privacy, and security.

The Rationale for Conducting the Review

During a clinical assignment, the writer identified a knowledge gap at a continuing care retirement community (CCRC) where several elders expressed their desire to stay in independent living for as long as they could due to fear of losing their independence. The writer noticed elders using technology to enhance their independence. They utilized the virtual AI assistant technology known as Amazon Alexa (n.d.) to help keep a schedule when they were in the early

stages of dementia. Amazon Alexa (n.d.) would remind the elder via voice activation of their scheduled appointment or planned activity. Elders reported it kept them company and helped them stay on schedule.

Medication adherence is an additional challenge in a CCRC. Elders who resided in independent living would take the morning medications while supervised. However, every evening, when the staff was not available in the independent living area, some elders failed to take their evening medication despite notes reminding them. Some of the elders who would forget their evening medications were very independent and mobile in every other aspect of their activities of daily living. A solution was needed to avoid moving the elders to higher levels of care, causing them to lose their independence or need to use other medications such as long-acting formulas that may not be available for the elder. As a result, this gap in knowledge led to a search for technology solutions to address the elders needs to enhance their independent living.

A technology tool was already available to aid elders with medication adherence. Smart digital bottles and pillboxes such as Vitality's GlowCaps and AdhereTech can monitor wirelessly when opened (Topol, 2015b). When a scheduled medication is due, the GlowCaps begin glowing and beep until the medication is taken (Topol, 2015b). The writer discovered a small, randomized trial on GlowCaps indicating an increased adherence from 71% to 97% when using Glow Cap (Dolan, 2010; Topol, 2015b). Another up-and-coming option, AdhereTech, can measure the contents of the bottle, using sensors to identify precisely how much medication remains. Users can decide if they would like texts, e-mails, or blinking lights to remind them when it is time to take the drug (Topol, 2015b).

Further research highlighted multiple technology tools available on smartphones. For example, an elder with a rash can use a smartphone to take a picture of the rash and send it to a

dermatologist for diagnosis and treatment (Topol, 2015a). Also, wireless sensors can track an elder's blood pressure and glucose and even conduct an electrocardiogram (Topol, 2015a). Soon shoes will be developed that can monitor an elder's gait to ensure their Parkinson's medications are working and recognize if they are at risk of falling (Topol, 2015a). Many elders lose independence rapidly once they are no longer able to drive due to visual or motor delays. Now Uber Health provides flexible and HIPAA-compliant ride scheduling for caregivers and medical staff (Weber, 2018).

Review Questions

There are several technology tools available to elders. The questions to be explored are: Can technology tools enhance elders' independence when residing at home? Is there evidence that supports their use in practice?

Formulate Inclusion and Exclusion Criteria

This review includes studies of elderly populations; the age range of an elder was not strictly defined (Toronto & Remington, 2020). Studies that investigated both technology tools and elder independence were included. The search focused on the highest level of applicable evidence possible. Many technology tools were included in this integrative review, to include mHealth, the IoT, implants, sensors, home monitoring, and AI. Articles were limited to those published between July 2015 and July 2020. Date limits narrowed to most recent years when the search resulted in vast number of articles. White literature was excluded from the review. Excluded studies included those focusing on specific diseases (e.g., mental health or sarcopenia), data collection, virtual reality tools, specific disabilities or accommodations (e.g., wheelchair technology), gaming, population health, healthy eating, social injustice, and immunizations. Study designs were not restricted, yet higher levels of evidence was prioritized over lower levels.

Conceptual Framework

Lawton's theory of person-environment fit served as the conceptual and theoretical framework for this review. When an elder's environment is mismatched to their needs, it affects the elder's ability to cope (Crist et al., 2019). If the elder's health and cognizance or the caregiver's availability become stressed, it can impact the environment and lead to a tipping point (Crist et al., 2019). A tipping point is a catastrophic event such as a fall while sustaining a fractured hip (Crist et al., 2019). Elderly person-environment-fit housing challenges relate to activities of daily living and independence (Iwarsson, 2005). If an elder is no longer able to maintain their activities of daily living their independence can suffer. As elders function declines the person-environmental-fit setbacks increase. Also, environmental changes can affect elder's independence as well (Iwarsson, 2005).

SECTION TWO: COMPREHENSIVE AND SYSTEMATIC SEARCH

Search Organization and Reporting Strategies

The writer conducted a systematic search of the literature utilizing a variety of databases including CINAHL, EBSCO, Proquest, and Cochrane (Toronto & Remington, 2020). This review covered articles published between July 2015 and July 2020. If a database returned a substantial amount of data (an amount that the writer could not feasibly screen), the results were narrowed to more recent publication dates. See Appendix A for an electronic search methodology chart. Papers were screened by their titles and abstracts (Mardini et al., 2019). The full text was examined when it was unclear if the paper would apply to the integrative review. By narrowing the focus of the review, prospective identified research decreased from 1,006 to 27 studies (Whittemore & Knafl, 2005).

PRISMA/ Toronto and Remington

The framework utilized by the writer was the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA). See Appendix B for a copy of the PRISMA flow diagram for this integrative review (Moher et al., 2009). Toronto and Remington (2020) served as an additional guide and framework for various elements of the review. The following Boolean phrases were used during the search of literature: mHealth and elder independence, systematic review and mHealth and elderly independence, meta-analysis and mHealth and elderly independence, Internet of things and elderly independence, sensor and elder independence, home monitoring, and elder independence, and artificial intelligence and elder independence.

Terminology

Technology terminology can be unclear. To establish an understanding of the technology tools examined in this integrative review, the following terms will be defined: “mHealth”, “sensor”, “Internet of things”, “home monitoring”, and “artificial intelligence.”. mHealth is the use of mobile devices to provide health information (for health care or public health), which can include educational materials, a text which targets specific conditions, and alerts on disease outbreaks (Office of the National Coordinator for Health Information Technology, 2017). Sensors monitor the user’s health continually (Li et al., 2020). There are three different types of sensors: mechanical, humidity, and temperature. For this review, sensors were examined to assess their ability to enhance the elder’s independence. IoT is the linking of devices to the Internet, excluding computers and smartphones. If a stand-alone device can be monitored and controlled from a separate location, it is regarded as an IoT device (Meola, 2018). Home monitoring is also known as a “smart home” and entails four elements: first, services such as remote home monitoring and emergency response services; second, a computing platform to

make decisions; third, a network for communication; and fourth, a sensor, including those for health monitoring (Majumder et al., 2017). AI is quickly progressing in the field of computer science. AI is a machine that can react to its environment independently. AI can perceive and respond to its environment independently and complete tasks that typically need human intelligence to make decisions but are absent from direct human interventions (U.S. Department of Justice, n.d.).

SECTION THREE: MANAGING THE COLLECTED DATA

Data Collection

A debate exists on whether all studies on a given subject should be included in an integrative review. By including lower-rated studies, a diverse sample is ensured (Toronto & Remington, 2020). The writer assessed the level of evidence when selecting articles for review. A variety of studies with varying levels of evidence were included in the review. The review question guided the included literature (Toronto & Remington, 2020). Studies were closely examined for bias, and these findings are highlighted in the study limitations category in Appendix C and the limitations section of the review. Validity refers to how closely the study aligns with the truth (Toronto & Remington, 2020). The writer took careful consideration when selecting studies to ensure they focused on elderly populations. Global studies were chosen to support a broad, general view. The critical appraisal tool selected for this review is located in Appendix C.

Information Sources

The writer integrated research from a variety of professional resources. Qualitative studies were utilized, as suggested by Whitemore and Knafl (2005), to improve the rigor of the review by joining a variety of methodologies to include both empirical and theoretical resources.

Primary sources selected prevented incompleteness or incorrect interpretations (Whittemore & Knaf, 2005). The Liberty University librarian was used for assistance in obtaining studies from the interlibrary loan program and as a guide when research questions surfaced.

Eligibility Criteria

During the screening for eligibility, studies that did not apply to elderly populations were eliminated (Toronto & Remington, 2020). Grey literature was excluded, as were resources that were not peer reviewed. Duplicate studies were eliminated before screening to avoid duplicate counting (Toronto & Remington, 2020). Screening of research titles determined the article's eligibility for inclusion. If the title was unclear, then the abstract was reviewed. Two articles were eliminated after the critique and leveling of evidence because one was randomized control trial study protocol proposal and the second focused on using information technology to eliminate stigma related to Alzheimer disease, which did not apply to the review question (Pillozzi & Huang, 2020; Recio-Rodríguez et al., 2019).

SECTION FOUR: QUALITY APPRAISAL

A critical component of an integrative review is the analysis of the quality of the selected research (Toronto & Remington, 2020). The quality of studies is a direct indicator of the strength of the review (Toronto & Remington, 2020). The writer utilized the Melnyk Levels of Evidence as a quality appraisal tool for the integrative review (Melnyk & Fineout-Overholt, 2015).

Sources of Bias

The most prominent bias of the selected studies seemed to be found in their external validity. The majority of studies were not randomized, used small sample sizes lacking controls, and took place outside the United States, making it challenging to generalize findings. Selection bias and not representing a specifically selected sample contributed to the inability to generalize

the findings. The type of journals examined introduced some publication bias (Kruse et al., 2017). In one study, focus groups of physical therapists were conducted in their work environment, which could have limited their openness of responses (Louie et al., 2020). In another, Silvius et al. (2020) reported accidentally excluding one key stakeholder (insurance companies), as well as various cultures and social issues or illnesses, which could introduce bias. Susnea et al. (2019) focused on elders residing at home alone, which makes it difficult to generalize their findings to other elderly populations, such as those living with a spouse. The study was limited to a small percent of experts from three separate nations with various health care methods, which also makes it difficult to generalize findings. One study reported that specific ethical topics may have been avoided because of the interviewer's presence, eliminating specific ethical topics as a result (Louie et al., 2020). Not all stakeholders, such as end-users and family members, were included in the study, decreasing its comprehensiveness.

Internal Validity

The internal validity of a study is measured by assessing the risk of bias (Toronto & Remington, 2020). Integrative reviews' selected studies should be judiciously appraised (Toronto & Remington, 2020). One researcher conducted this integrative review. The researcher selected studies that closely aligned with the review question. Therefore, the risk of introducing bias was present in this review. The leveling and critique framework based on Melynck's table of evidence was used to mitigate this risk (Melynck & Fineout-Overholt, 2015). The leveling and critique framework and to examine the appraisal tool, which can be used to examine the applicability of results, is found in Appendix C.

Reporting Guidelines

The writer utilized the PRISMA guideline to improve the transparency and quality of the review (Toronto & Remington, 2020). PRISMA was used to report the findings of the final review (Moher et al., 2009; Toronto & Remington, 2020). Details of the PRISMA flow diagram for the integrative review are located in Appendix B. A variety of evidence levels were retrieved during the search: two level-one articles, two level two, one level three, six level four, eight level five, six level six, and two level seven (Melnyk & Fineout-Overholt, 2015).

SECTION FIVE: DATA ANALYSIS AND SYNTHESIS

Analysis

Ten studies recommended including stakeholders when designing technology tools so they are accepted and user friendly (Carroll & Hopper, 2019; D’Onofrio et al., 2019; Klimova & Valis, 2018; Louie et al., 2020; Majumder & Deen, 2019; Mora et al., 2019; Myles et al., 2020; Silvius et al., 2020; Susnea et al., 2019; & Wangmo et al., 2019). Ten studies confirmed stakeholders’ needs and capabilities need to be taken into consideration when developing technological tools to aid an elder’s independence. Other critical components are supporting the training of consumers, user-friendly design, and user security, as well as examining various barriers to acceptance and use. (Carroll & Hopper, 2019; D’Onofrio et al., 2019; Klimova & Valis, 2018; Louie et al., 2020; Majumder, & Deen, 2019; Mora et al., 2019; Myles et al., 2020; Silvius et al., 2020; Susnea et al., 2019; & Wangmo et al., 2019).

According to three studies, privacy should be taken into consideration when implementing home monitoring along with the digital literacy of the user and accessibility of technology infrastructures. (Al-shaqi et al., 2016; Choi et al., 2019; & Pillozzi & Huang, 2020). Three studies emphasized technology is a low-cost option, for example, living at home and using

home monitoring systems instead of in an assisted living setting can result in a substantial reduction in costs. Also, technology can provide low-cost healthcare as a result of continuous monitoring (Majumder, & Deen, 2019; Mora et al., 2019; Obayashi & Masuyama, 2020; & Susnea et al., 2019). There is great potential for economic improvements using technology (sensors, for example; Eskofier et al., 2017; Susnea et al., 2019).

Embedded sensors in smartphones have the potential to aid elders in leading an independent and active life. Noninvasive monitoring of an individual's health at a low cost is now possible. Smartphone monitoring can provide information about a user's overall health and wellness over an extended time. Smartphones and sensors can screen for diseases such as cancer and diabetic retinopathy and can remotely monitoring the progression of some diseases via remote monitoring (Majumder & Deen, 2019). The utilization of smartphone technology and sensors has the potential to provide cost-effective health care to remote populations previously lacking access to care (Majumder & Deen, 2019). Two studies demonstrated that data gleaned from the use of technology supplies care providers and health professionals with precise and useful information, which can be utilized to aid in the patient's care and decrease care provider burden (Obayashi & Masuyama, 2020; Sriram et al., 2020). Low-power design techniques were encouraged by two studies (Mardini et al., 2019; Mora et al., 2019).

Descriptive Results

Technology can aid both mental and physical health for elders (Belkacem et al., 2020; Giannouli et al., 2019). A variety of technology tools, especially IoT, can enhance an elder's independence and safety and ease caregiver burden (Carrol & Hopper, 2019; Eskofier et al., 2017; Mora et al., 2019, Myles et al., 2020; Obayashi & Masuyama, 2020). Four studies highlighted ethical concerns related to technology, for example, coercion, stalking, and privacy

issues, which should be taken into consideration when implementing home monitoring equipment (Eskofier et al., 2017; Morley & Luciano, 2020; Sriram et al., 2020; Wangmo et al., 2019).

Smart devices can be useful by enhancing elders' independence, relieving caregiver burden, and identifying unsafe behaviors such as leaving a stove on or wandering outside the home environment (Keum et al., 2020; Willner et al., 2015). Three studies supported the use of technology tools to offer users the potential for greater independence, medical literacy, and quality of life. mHealth can enhance health outcomes and alter the course of health care provided in the future (Borelli et al., 2019; Eskofier et al., 2017; Kruse et al., 2017). A variety of topics related to healthcare monitoring, such as sensor minimization, efficient power, security, data science, cloud computing, and sensor standardization, remain immature, which can guide future studies (Mardini et al., 2019). Introducing new technology to elders can be a challenge, despite its benefits. As individuals age, they tend to learn fewer new things so trying to pinpoint the right technology proves challenging (Silvius et al., 2020).

Synthesis

Technology tools for enhancing elders' independence is a pioneering field of research. Future studies should focus particular attention on challenges and stakeholder concerns (Majumder & Deen, 2019; Mardini et al., 2019). Some of these concerns include power consumption, biological effects, reliability, mobility, portability, availability, acceptability, unobtrusiveness, interoperability, scalability, size, standardization, costs, testing, cloud and fog computing, battery life challenges, and radiofrequency exposure (Al-shaqi et al., 2016; Mardini et al., 2019; Mora et al., 2019). Regulation of data, privacy, and ethics also requires further

examination (Al-shaqi et al., 2016; Choi et al., 2019; Eskofier et al., 2017; Mardini et al., 2019; Morley & Luciano, 2020; Pilozzi & Huang, 2020; Sriram et al., 2020; Wangmo et al., 2019).

Health care monitoring systems have the potential to become intelligent, widespread, and available to both elderly and chronically ill populations in the future (Mardini et al., 2019). Robust security mechanisms when it comes to data transfer, data storage, and analysis are critical but mostly lacking from current monitoring systems (Mardini et al., 2019). Some caregivers report feeling overwhelmed by the vast amount of technology tools and being unsure how they work or how they are useful for them and the one they care for (Myles et al., 2020). Assistive technology (AT) is useful initially for dementia patients, but as their disease progresses, its usefulness deteriorates (Sriram et al., 2020). This finding emphasizes the need to tailor the technology to an elder's needs, involve stakeholders, and closely examine ethical requirements. Silvius et al. (2020) recommended including insurance providers as critical stakeholders during technology tool development. As insurance providers would likely provide funding for the technology tools, they should be involved.

Researchers disagreed as to whether the costs of technology tools were low. A few researchers suggested the prices of technology tools were low (Majumder & Deen, 2019; Mora et al., 2019; & Susnea et al., 2019). Others reported costs of technology tools are challenging (Mardini et al., 2019). Further studies should examine technology affordability (Al-shaqi et al., 2016; Silvius et al., 2020). The writer suggests basing the affordability on lower socioeconomic classes, which have limited funds and the most significant potential gain if long-term care expenses are decreased.

Table 3*Technology Tools and Cost Comparison*

Technology tool	Cost (\$)	Function	Resource
Robotic pet	119	Provide comfort and companionship	Crouch (2018)
Paro	6,000	Interactive baby seal that provides emotional support	Petrecu (2018)
Amazon Alexa	100+	Artificial intelligence smart home device and companion	Amazon (n.d.)
GlowCaps	10/cap plus 15 per month subscription	Smart medicine bottle which provides an alarm when medication is due and tracks wirelessly when taken	Topol (2015b)

One study cautioned readers against defining technology tools as empowering devices. Instead, the authors urged professionals instead to call them digital companions as their popularity increases (Morley & Luciano, 2020). This paradigm shift from empowerment to companionship is supported by examining the conceptual, methodological, and ethical issues technology tools present (Morley & Luciano, 2020). Morley and Luciano (2020) were the only researchers that presented this warning, which warrants further examination. Future studies should examine the elderly user's attitudes as they relate to technology tools. The concern is that technology tools could provide too much autonomy for the end-users, creating a lack of proper healthcare provider oversight and a false sense of security for end-users (Morley & Luciano, 2020).

Silvius et al.'s (2020) study emphasized introducing new technology to elders; despite their benefits being challenging initially because as individuals age, learning new things becomes difficult. An additional interesting theme in the literature was the process of pinpointing the right technology for the right individual at the right time. Tailoring the technology equipment to the elder's specific needs requires further study. The writer suggests the development of a toolkit to assess the quality of technology tools matched with a particular end-user. Another critical aspect

of the toolkit would be ensuring a medical professional is not being replaced by the technology to the unsafe detriment of the elder's safety. Medical professionals and elders alike should take caution before implementing technology. Trying to get elders technology training, may have an adverse effect their health, which is an interesting perspective (Silvius et al., 2020). Future studies should examine this topic.

Users reported mixed opinions on whether technology tools aided their independent living. Some liked using the tools; others did not (Silvius et al., 2020). The higher the technology match the elder it resulted in improved perceived physical health (Silvius et al., 2020). Physical health was only perceived as enhanced if the technology was an in-house adaptation. Tailoring technology interventions to elders' needs can increase acceptance and adoption (Silvius et al., 2020).

Limitations

One researcher conducted this integrative review, which could introduce some bias. The PRISMA flowchart and a leveling and critique framework were utilized for the selected studies to mitigate single-researcher bias. Due to the revolutionary nature of the topic of technology tools, another limitation was the flaws of the selected studies. External validity was a limitation due to the limited number of studies with a high level of evidence. The majority of studies were conducted with small sample sizes. The writer encountered multiple study proposals. While helpful for future studies, they could not be used for this review.

Dissemination

Technology tools are an emerging area in the practice of nursing. The writer values disseminating the findings of the integrative review to advance the practice of nursing further and enhance outcomes. Due to a large gap in the literature on the topic of technology tools in the

practice of nursing, the writer plans to submit the integrative review for publication. The writer intends to submit an abstract for a podium or poster presentation to an aging conference to inform fellow nurses of the strengths, challenges, and gaps when introducing technology tools to enhance elders' independence. The writer also plans to disseminate the findings to her original CCRC practicum site, where placement ended due to the pandemic.

Theoretical Framework

This integrative review utilized Lawton's theory of person-environment fit as a framework (Crist et al., 2019). When elders who are mismatched with their environment, their ability to cope is compromised (Crist et al., 2019). If a technology tool can improve an elder's match with their present environment to avoid a tipping point, such as fracturing a hip, it can enhance their independence (Crist et al., 2019). Detecting a tipping point before it occurs can aid families in selecting the appropriate setting at the correct time (Crist et al., 2019).

Discussion

This study furthers the knowledge of how technology tools can enhance the elders' independence by synthesizing findings from a variety of study types. Professionals' knowledge of various technology tools that can enhance elder independence was an identified gap in the literature that the findings of this review have helped to fill. Technology solutions are quickly needed due to the outrageous costs tied with assisted living settings, as technology can decrease expenses and ease caregiver burden while keeping elders safe when residing at home. Several technology solutions are highlighted as affordable. However, further studies are needed to examine costs as they relate to the accessibility of some technology solutions to all elderly populations.

When developing technology tools, end-users and all the various stakeholders must be included in the design, so the resulting equipment is user friendly and accepted by users. The elder's digital literacy skills should be assessed before technology is implemented. Wearable sensors can decrease costs while increasing independence due to continuous monitoring. Technology tools can provide a bonus to elders by screening for disease and monitoring illness remotely, enhancing independence. Also, elderly populations residing in remote areas have improved access to care as a result of monitoring technology tools. Power is a challenge for technology tools—especially for elders who, because of their conditions (e.g., Alzheimer's or dementia), may forget to charge their devices.

Further studies are needed to explore low-power designs and the effects of technology tools such as radiofrequency exposure. IoT is a remarkable technological tool serving multiple purposes. An IoT tool can help an elder with memory problems with a schedule and serve as a reminder for essential tasks such as scheduled medication times. Additionally, IoT technology can keep an elder company through voice recognition software. IoT aids in creating a smart home, enhancing the elder's safety and health and decreasing the caregiver's burden. One fascinating benefit that technology tools provide to elders is increased health literacy. Technology tools allow an elder to obtain knowledge on their conditions in real time to enhance their health literacy. Greater independence and an enhanced quality of life are possible as a result of the use of technology tools. Further studies are needed to examine decreasing the size of sensors along with the standardization of sensor tools. With the vast array of technology tools available to elders, the correct tool must be identified for the elder's needs.

Technology tools have great potential to enhance independence. Yet, professionals should advance cautiously, especially as it relates to ethical implications of implementing

technology and/or replacing a care provider to the detriment of users. The potential drawback is creating a false sense of security and enhancing the potential for harm. Additionally, effective security systems are necessary for the transfer and storage of data obtained from technology tools, requiring further examination.

Implications for Nurses

Technology tools have a great potential to alleviate caregiver burden while simultaneously keeping elders safer. Care provider of elders with dementia or Alzheimer's disease often undergo stress due to the elders' potential for wandering. Noninvasive technology can warn care providers (medical and family members) of unsafe behavior (stove left on or roaming) while easing the caregiver burden and ensuring the elder's welfare.

Robots temporarily responded in one study to nurse calls and have the potential to decrease the burden on nursing care staff. Robots can encourage elderly individuals to enhance communication with others ($p < 0.05$; Obayashi & Masuyama, 2020). When robots vocalize with elders, it can prevent the deterioration of quality of life for elders. The potential benefits of the use of technology tools are endless for healthcare professionals.

Another advantage technology tools such as GlowCap present is the ability of a provider to assess if medications are taken and if they are achieving the intended purpose. Imagine prescribing a medication for an elder diagnosed with Parkinson's, and at a follow-up visit being able to examine data from the elder's shoes to assess if the medication is effective (Eskofier et al., 2017). Wearable sensors can now do that. Wearable sensors can allow providers access to data to make informed clinical decisions.

At the same time, further studies are needed to ensure the user's privacy and security. There is a concern that home monitoring equipment could be misused on elders, potentially

decreasing their privacy or allowing them to be coerced. Healthcare providers must consider these ethical concerns when debating whether technology tools should be utilized. Further studies are needed to assess and address the inappropriate use of technology tools (home monitoring, for example). Another topic in need of further research is a method for pinpointing the correct technology tool for the specific elder's need (Silvius et al.,2020).

Further studies are needed to examine pinpointing the correct technology tool for the elder, which is becoming a growing need, especially as more and more elders age. Also, this review revealed that the better the technology matches the elder, the greater the perceived physical health (Silvius et al., 2020). In-house technology adaptations were critical to increasing the perception of physical health. Thus, further studies are needed on the topic of adapting technology to the physical environment of the elder.

For elders who are unable to drive due to deteriorating health concerns, an incredible technological tool to enhance independence is Uber Health (Uber Health, 2020). Not only does this technological tool alleviate the caregiver's burden, but it also allows healthcare providers to schedule transportation for medical appointments, thus enhancing outcomes and access to care.

Caregivers have reported feeling overwhelmed by the vast array of technology tools and feeling unsure how they can be helpful for the ones they care for. Caregivers often turn to nurses to provide education and guidance as they select the appropriate technology tools for their loved ones. Further training will be necessary for nurses, and the writer suggests introducing technology solution training to nursing school institutions so they can be champions of this knowledge in their workplaces after graduation.

A significant finding of this review is the possibility of adverse effects when elders receive technology training and initially implement it in their daily activities. The likelihood is it

may initially negatively affect their health (Silvius et al., 2020). While concerning, researchers must start somewhere to advance. There is an inherent risk when implementing something new. An example can be found in the transition from trains to airplanes. Initially, trains were faster than airplanes. The first airplanes were cumbersome and unsafe. While now ubiquitous, 120 years ago, air travel was unfathomable. Today people think nothing of getting on a plane and flying around the globe. The future of technology is endless. While society is standing on the edge of a technology chasm, the future looks bright, primarily because of the likelihood of enhancing the elder's independence, with a bonus of alleviating the caregiver's burden.

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Appendix A

Electronic Database Search Methodology

Database	Search Date Range:	Boolean Phrase	Total References Identified	Number of applicable references	Number of Duplicate articles	Number of articles selected for review	Number of articles excluded	The final total of relevant references
CINAHL	Jul 2015- July 2020	mHealth and elder independence	0	0	0	0	0	0
EBSCO	Jul 2015- Jul 2020	mHealth and elderly and independence	4	0	0	4	1	3
Proquest	July 2015- July 2020	mHealth and elder independence	114	12	0	12	102	8
Cochrane	July 2015- July 2020	mHealth and elder independence	8	0	0	0	0	0
CINAHL	Jul 2015- Jul 2020	Systematic review and mHealth and elderly independence	0	0	0	0	0	0
EBSCO	Jul 2015-	Systematic review and	0	0	0	0	0	0

Database	Search Date Range:	Boolean Phrase	Total References Identified	Number of applicable references	Number of Duplicate articles	Number of articles selected for review	Number of articles excluded	The final total of relevant references
	July 2020	mHealth and elderly independence						
Proquest	Jul 2015-Jul 2020	Systematic review and mHealth and elderly independence	59	1	7	1	0	0
Cochrane	Jul 2015-Jul 2020	Systematic review and mHealth and elderly independence	0	0	0	0	0	0
CINAHL	Jul 2015-Jul 2020	Meta-analysis and mHealth and Elderly Independence	0	0	0	0	0	0
EBSCO	Jul 2015-Jul 2020	Meta-analysis and mHealth and Elderly Independence	0	0	0	0	0	0
Proquest	Jul 2018-Jul 2020	Meta-analysis and mHealth and	17	2	1	1	14	2

Database	Search Date Range:	Boolean Phrase	Total References Identified	Number of applicable references	Number of Duplicate articles	Number of articles selected for review	Number of articles excluded	The final total of relevant references
		Elderly independence						
Cochrane	Jul 2015-Jul 2020	Meta-analysis and mHealth and Elderly Independence	0	0	0	0	0	0
CINAHL	Jul 2015-Jul 2020	Internet of things and elderly independence	0	0	0	0	0	0
EBSCO	Jul 2015-Jul 2020	Internet of things and elderly independence	2	2	0	2	0	0
Proquest	Jul 2018-Jul 2020	Internet of things and elderly independence	98	13	3	10	88	5
Cochrane	Jul 2015-Jul 2020	Internet of things and elderly independence	0	0	0	0	0	0
CINAHL	Jul 2015-July 2020	Implants and Elder independence	0	0	0	0	0	0

Database	Search Date Range:	Boolean Phrase	Total References Identified	Number of applicable references	Number of Duplicate articles	Number of articles selected for review	Number of articles excluded	The final total of relevant references
EBSCO	Jul 2015-Jul 2020	Implants and Elder independence	0	0	0	0	0	0
Proquest	Jul 19-Jul 2020	Implants and Elder independence	128	3	0	3	125	1
Cochrane	Jul 2015-Jul 2020	Implants and Elder independence	2	0	0	0	0	0
CINAHL	Jul 2015-Jul 2020	Sensor and elder independence	0	0	0	0	0	0
EBSCO	Jul 2015-Jul 2020	Sensor and elder independence	0	0	0	0	0	0
Proquest	Jul 2019-Jul 2020	Sensor and elder independence	67	1	0	0	0	0
Cochrane	Jul 2015-Jul 2020	Sensor and elder independence	1	0	0	0	0	0
CINAHL	Jul 2015-Jul 2020	Home monitoring and elder independence	0	0	0	0	0	0

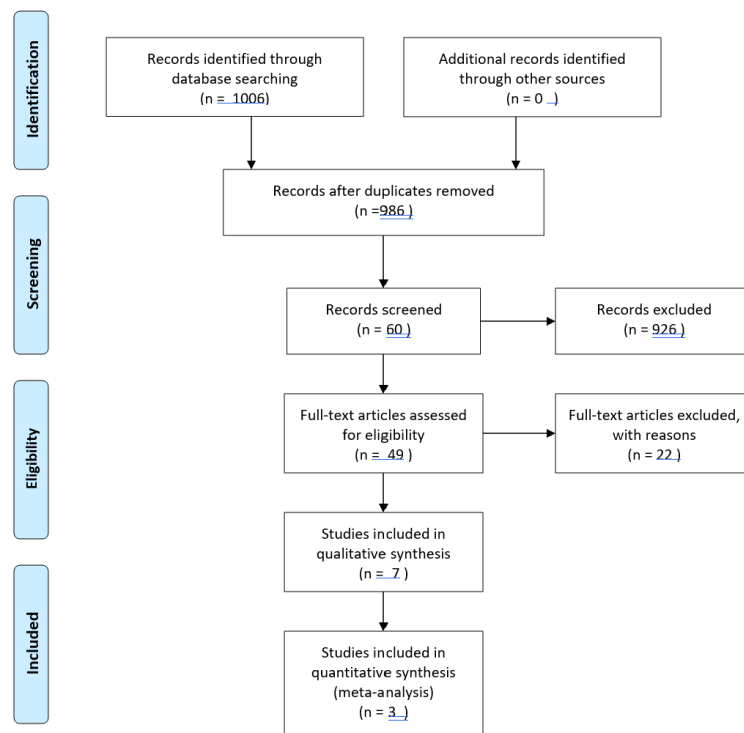
Database	Search Date Range:	Boolean Phrase	Total References Identified	Number of applicable references	Number of Duplicate articles	Number of articles selected for review	Number of articles excluded	The final total of relevant references
EBSCO	Jul 2015-Jul 2020	Home monitoring and elder independence	0	0	0	0	0	0
Proquest	Jan 2020-Jul 2020	Home monitoring and elder independence	232	5	4	1	231	1
Cochrane	Jul 2015-Jul 2020	Home monitoring and elder independence	1	0	0	0	0	0
CINAHL	Jul 2015-Jul 2020	Artificial intelligence and elder independence	0	0	0	0	0	0
EBSCO	Jul 2015-Jul 2020	Artificial intelligence and elder independence	0	0	0	0	0	0
Proquest	Jul 2018-Jul 2020	Artificial intelligence and elder independence	272	21	5	15	265	7
1	Jul 2018-Jul 2020	Artificial intelligence	1	0	0	0	0	0

Database	Search Date Range:	Boolean Phrase	Total References Identified	Number of applicable references	Number of Duplicate articles	Number of articles selected for review	Number of articles excluded	The final total of relevant references
		and elder independence						
Total			1006	60	20	49	826	27

Appendix B



PRISMA 2009 Flow Diagram



From: Moher D, Liberati A, Tetzlaff J, Altman DG, The PRISMA Group (2009). Preferred Reporting Items for Systematic Reviews and Meta-Analyses: The PRISMA Statement. *PLoS Med* 6(7): e1000097. doi:10.1371/journal.pmed1000097

For more information, visit www.prisma-statement.org.

Appendix C

Leveling and Critiquing the Research

Article Title, Author, etc. (Current APA Format)	Study Purpose	Sample (Characteristics of the Sample: Demographics, etc.)	Methods	Study Results	Level of Evidence (Use Melnyk Framework)	Study Limitations	Would Use as Evidence to Support a Change? (Yes or No) Provide Rationale.
Al-shaqi, R., Mourshed, M., & Rezgui, Y. (2016)	Reviews the methods of creating ambient assisted living systems (AALS) in research to recognize customary practices, limitations and guidance for future research. This study examined and critiqued the structures and sensor systems used in multiple AALS and how	133 papers from 2001-2016 on various topics related to AALS were examined.	Thorough review of the technology and categorizing current developments so gaps can be highlighted.	Many frameworks concentrated on activity monitoring for analyzing urgent risks (falls for example). Frequently overlooked were combining environmental features with analytics and decision-making,	5	Findings from the studies examined regarding limitations included: The absence of clinical evidence to confirm elders enhanced quality of life obtained by integrating AALS. Another limitation was elders approval of the	Yes, the findings of this study highlight many gaps and recommendations for future studies. There is much room for further investigation into this topic as recommended by this review.

Article Title, Author, etc. (Current APA Format)	Study Purpose	Sample (Characteristics of the Sample: Demographics, etc.)	Methods	Study Results	Level of Evidence (Use Melnyk Framework)	Study Limitations	Would Use as Evidence to Support a Change? (Yes or No) Provide Rationale.
	<p>they are tied to both care and clinical systems.</p>			<p>especially in long term care. There is room for much future studies on this topic. Including the capacity for wearable devices and sensors, storage and access (cloud). Developing economical embedded computing and reducing the size of electronics.</p>		<p>technology in regards to its usability, implementation, ethical and privacy concerns. Specific requirement of end-users such as elderly and care takers were not addressed. Instead, many projects were developed based on researchers assumptions. Medical staff and care takers have</p>	

Article Title, Author, etc. (Current APA Format)	Study Purpose	Sample (Characteristics of the Sample: Demographics, etc.)	Methods	Study Results	Level of Evidence (Use Melnyk Framework)	Study Limitations	Would Use as Evidence to Support a Change? (Yes or No) Provide Rationale.
						not always been trained and briefed about the AALS for the populations they care for, especially features affecting their work practices.	
Belkacem, Jamil, Palmer, Ouhbi & Chen (2020)	The purpose of the review is to analyze examples where brain computer interface (BCIs) are feasible and helpful medical and nonmedical apps for healthy elders utilizing non-invasive measurements	Literature review of 11 articles with topics related to elders with BCI, EEG, cognitive function, and motor control delays.	Systematic Review	Various external aids and neurofeedback evaluations are accessible, and have been identified as useful for elders, healthcare	5	Some non-elderly participants were included if the outcomes seemed useful to the researchers due to the shortage of brain computer interface (BCI) articles in	Yes, the findings of this study support elders utilizing technology to enhance their independence and ability to reside at home safely. BCI has indicated positive results to aid both

Article Title, Author, etc. (Current APA Format)	Study Purpose	Sample (Characteristics of the Sample: Demographics, etc.)	Methods	Study Results	Level of Evidence (Use Melnyk Framework)	Study Limitations	Would Use as Evidence to Support a Change? (Yes or No) Provide Rationale.
	such as electroencephalogram (EEG) to enhance life quality.			personnel, caretakers and family members. Interactional gaming tests can examine and enhance cognitive abilities in elders. Wheelchair exoskeleton technologies have been created to aid elders and let them continue their daily routines and offer rehabilitation		which generalization of findings should be avoided for all elderly populations.	cognitive and physical support, and rehabilitation for elders residing at home.

Article Title, Author, etc. (Current APA Format)	Study Purpose	Sample (Characteris- tics of the Sample: Demographi- cs, etc.)	Methods	Study Results	Level of Evidence (Use Melnik Framewo- rk)	Study Limitations	Would Use as Evidence to Support a Change? (Yes or No) Provide Rationale.
				of decreased muscle and motor functionality. Home monitoring environments can aid elders independent living and to feel safe in their own homes. Devices based on BCI for senior citizens. BCI technology has already shown promising			

Article Title, Author, etc. (Current APA Format)	Study Purpose	Sample (Characteristics of the Sample: Demographics, etc.)	Methods	Study Results	Level of Evidence (Use Melnyk Framework)	Study Limitations	Would Use as Evidence to Support a Change? (Yes or No) Provide Rationale.
				results in aiding both cognitive and physical support and rehabilitation , and we look forward to future innovation in this important area of research that affects all of us eventually.			
Borelli et al. (2019)	This study describes the flexibility of system-level platforms describing the	The HABITAT final system was tested on final users (independent	User centered design method/ Cohort study	Four items were highlighted at the conclusion of the study:	4	Not randomized potential for bias.	Yes, various technology tools and how they can support elderly populations

Article Title, Author, etc. (Current APA Format)	Study Purpose	Sample (Characteristics of the Sample: Demographics, etc.)	Methods	Study Results	Level of Evidence (Use Melnyk Framework)	Study Limitations	Would Use as Evidence to Support a Change? (Yes or No) Provide Rationale.
	various smart devices and how they interact. The goal of this study is to examine the internet of things which can support elderly populations residing at home and in retirement communities. By including these devices in everyday life, the potential exists to decrease the expenses for healthcare and enhance the quality of life for	and non-independent users) and their caregivers. Specific number of participants was not provided		indoor localization systems, smart armchairs, belt for movement information, and SPARQL Event Processing Architecture (SEPA). Two or greater Radio Frequency Identification (RFID) readers can be implemented			who reside at home to enhance their independence were discussed to include smart arm chairs, bi-dimensional beam technology to detect falls, and belts to detect movements.

Article Title, Author, etc. (Current APA Format)	Study Purpose	Sample (Characteristics of the Sample: Demographics, etc.)	Methods	Study Results	Level of Evidence (Use Melnyk Framework)	Study Limitations	Would Use as Evidence to Support a Change? (Yes or No) Provide Rationale.
	elderly users. Development of “HABITAT” (Home Assistance Based on the Internet of Things for the Autonomy of Everybody) with a focus on elder independence.			in the same environment to enhance their accuracy. Further research is needed on a bi-dimensional electronic beam steering to detect elder falls in a restricted area. Further studies are needed on the dimensions of a recognition			

Article Title, Author, etc. (Current APA Format)	Study Purpose	Sample (Characteristics of the Sample: Demographics, etc.)	Methods	Study Results	Level of Evidence (Use Melnyk Framework)	Study Limitations	Would Use as Evidence to Support a Change? (Yes or No) Provide Rationale.
				tag. Further researchers should consider integrating an antenna into the clothing materials of users with a goal of shrinking the size and bulkiness and weight of the current tag size. A smart armchair design could be improved with automatic			

Article Title, Author, etc. (Current APA Format)	Study Purpose	Sample (Characteristics of the Sample: Demographics, etc.)	Methods	Study Results	Level of Evidence (Use Melnyk Framework)	Study Limitations	Would Use as Evidence to Support a Change? (Yes or No) Provide Rationale.
				movement of the seat. Much like some vehicles can adjust to the needs of their driver the chair could adjust to the customized profile of the user. The belt for movement information served the following functions: number of steps, time of activity and			

Article Title, Author, etc. (Current APA Format)	Study Purpose	Sample (Characteristics of the Sample: Demographics, etc.)	Methods	Study Results	Level of Evidence (Use Melnyk Framework)	Study Limitations	Would Use as Evidence to Support a Change? (Yes or No) Provide Rationale.
				time of rest. Future studies should examine how to decrease the bulkiness of the belt to increase its acceptance and use. Regarding SEPA future studies should define the precise benchmarking of semantic publish-subscribe architectures, and creating			

Article Title, Author, etc. (Current APA Format)	Study Purpose	Sample (Characteristics of the Sample: Demographics, etc.)	Methods	Study Results	Level of Evidence (Use Melnyk Framework)	Study Limitations	Would Use as Evidence to Support a Change? (Yes or No) Provide Rationale.
				elevated performant algorithm for the semantic subscription engine. Allowing researchers new approaches to the IoT, like (semantic) Web of Things.			
Carroll & Hopper (2019)	Involving older adults to assist in developing a virtual coach assistant (CAPTAIN) to aid independent living at home.	Ten elderly, three caregivers, and two healthcare care providers.	Cohort Study	Personas helped stakeholder conversations during design sessions. Participants	4	A total of 15 participants and no randomization of participants could result in bias and caution when	Yes, including elderly end-users and caregivers/providers in the design of technology to enhance

Article Title, Author, etc. (Current APA Format)	Study Purpose	Sample (Characteristics of the Sample: Demographics, etc.)	Methods	Study Results	Level of Evidence (Use Melnyk Framework)	Study Limitations	Would Use as Evidence to Support a Change? (Yes or No) Provide Rationale.
				were able to verbalize elders needs and make suggestions on where technology could be useful and supportive, and recommended features CAPTAIN should offer.		generalizing findings to all elderly populations.	independent elderly living is a valuable approach. Further studies into the seven areas identified by end users are recommended when developing future editions of CAPTAIN (nutrition, health, cognitive and physical activity, accessibility, education, social interaction, and safety).

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Choi, Lazar, Demiris, & Thompson (2019).	This research reviews existing and developing smart home technology (SmHT) and discusses opportunities to influence this technology to increase the ability of elders to be engaged as they age.	A study on the use of smart home technology on elders	Expert Opinion	Smart home technologies (SmHT) are valuable tools to increase the physical and cognitive ability of elders. SmHT that increases engagement with elders should use friendly design and execution. Driving	7	Low level of Melnyk’s evidence.	Yes, various applicable ethical concerns were examined such as coercion, stalking, and privacy which should be taken into consideration when implementing SmHT. Additional elements of SmHT should be weighed carefully before

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				forces and barriers, including digital literacy, privacy, and technology accessibility, should be examined to ensure adoption of smart home tools.			implementation to include digital literacy of the user, accessibility of technology infrastructures, and privacy.
D’Onofrio et al. (2019)	The goal of the study is to develop an initial qualitative analysis of elderly people needs and their caregivers when involved with	The interviews were conducted in Japan and Italy. Seventeen elderly and 36 care	Qualitative Research	Three categories of needs were identified: Communication, Emotion Detection, and Safety. Elders robot	6	This study took place in Italy and Japan one should use caution when generalizing to other populations.	Yes, this study once again confirmed stakeholders needs and capabilities need to be taken into consideration

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	conversational robots and priority development needs based on end-user input.	providers were included in the study.		acceptance was ranked as good. Positive opinions of robot use prevailed at the pilot sites. A positive opinion of elderly participants using a robotic solution was identified and a variety of needs can be addressed by a carefully developed			when developing technological tools to aid in elder's independence.

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				robot. Stakeholders needs and capabilities is recommended for future studies.			
Eskofier et al. (2017)	This study examines smart shoes (a type of smart technology for the future internet of health things).	A randomized clinical trial with 19 individuals, including both glaucoma patients and age-matched health controls.	Randomized Clinical Trial	We are rapidly approaching technologicaly advanced digital medicine monitoring systems. The potential to enhance quality of life and care, decrease comorbidity,	2	Small sample size. Findings should not be generalized as a result.	Yes, a potential IOT tool to enhance elder’s independence and family members and caretakers (safety) reassurance.

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				and enhance healthcare is near. Wearable sensors will alter the way that healthcare takes place. There is great potential for economic improvements and the need for regulation of data/privacy and ethics (which needs further examination). Smart			

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				shoes have the potential to play an instrumental role in this change process. Gait is an excellent target parameter, as it is linked to both mobility and autonomy.			
Giannouli et al. (2019)	The aim of this study was to analyze the connection of prospective predictors from various domains of mobility in	Community-dwelling elders were recruited via brochures and presentations about the	Case Control Study	For elders without mobility limitations, real-life mobility was linked mostly with	4	No randomization which could present some study bias.	Yes, this study highlights that both physical and mental elements are key elements to elders mobility (as opposed to

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	elders who did not have severe physical and/or cognitive delays.	study at local senior center gatherings. The final study included Eighty-five individuals for Wave one and sixty-nine individuals for Wave two.		measures of physical functioning. Psychological functioning was also an important aspect of real-life mobility. Yet they were more pronounced for physical activity-based mobility than life-space mobility. Future interventions could examine			cognitive and social).

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				both physical exercise and increased self-efficacy via social networks or social cognitive therapies.			
Keum, Yu, & Kang (2020)	The study implemented a self-organized device network structure that operates based on user insight, positioning, and behavioral perception at the same time. This allows researchers to compile user	The proposed user is an elder residing at home.	Descriptive Study	Researchers proposed a computing device network and created three kinds of smart devices (wearable, tag, and stationary). The smart devices	6	The proposed study is not randomized so could be prone to selection bias.	Yes, after the proposed study is implemented the gathered information could be useful to enhance elder's independence and identify unsafe behaviors such as leaving a stove on or

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	activity data, analyze ADL in real-time and decide if the user's behavior was successful or atypical, and keep track of the physical capability of the user to transition among fixed spaces. The system allows researchers to identify patients from other household members and deliver real-time notifications if the user participated in			gather the user's activities of daily living in their homes. The expected outcomes are to keep a record of actions, forgetfulness, and moving capabilities of the patients. A machine-learning algorithm will analyze the mental and physical			wandering outside the home environment.

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	forgetful or incorrect behavior.			health of the users.			
Klimova & Valis (2018)	The aim of this article is to examine the capability of smartphone applications to improve the cognitive functions of elderly.	European elderly smartphone users	Expert opinion	Smartphone apps have the potential to be used as intervention devices for cognitive training of elders. Some things must be kept into consideration such as training the elderly user, smartphone design, level of complexity for cognitive	7	No randomization of participants' potential bias. Future studies recommend randomized control trials by authors.	Yes, supports training of users, user friendly design, and user security with smartphone apps.

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				training, and security should be considered.			
Kruse, Mileski, & Moreno (2017)	The goal of the review is to identify and examine catalysts and obstacles to adopting of mHealth tools via sensemaking.	Thirty-six articles which contained the same Boolean Phrases and key words.	Systematic Review	The three highlighted facilitators to mHealth most frequently mentioned in the reviewed studies were independence (18%), visibility (13%), and understanding. Three obstacles most frequently	5	Selection bias and not representing a specific selected sample. Possible publication bias based on the type of journals examined.	Yes, the study supports that mHealth offers the users the potential for greater independence, medical literacy and enhanced quality of life. mHealth has the possibility to enhance health outcomes and alter the course of health care provided in the future.

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				mentioned were complexity (21%), ineffective (12%), and limited by users (12%).			
Li et al. (2020)	Examining skin inspired electronics using physical sensors	Articles on the most current advancements of skin, temperature, and humidity sensors. A review of the mechanisms, materials, structures, and how they performed. Also	Systematic Review of descriptive studies	Physical sensors have valuable properties, versatility, they are implantable, and able to self-heal. Sensors allow for new chances for health monitoring, disease	5	For the purposes of this review it did not focus on elderly populations so it will be difficult to generalize findings to elderly populations.	Yes, this study supports that sensors monitor the user's health continually.

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		reviewed is how to apply sensors to health monitoring, diagnosis, and treatment. Also, intelligent robots are examined.		diagnosis, treatment options, and robots that are intelligent.			
Louie, Bird, Menon, & Eng, (2020)	The purpose of this article was to characterize critical considerations when developing lower extremity (stroke-specific) wearable monitoring technological	Seventeen physical therapists (PT) and three patients who had a stroke were involved with five separate focus groups.	Qualitative research design with focus groups	The creation of stroke-specific lower extremity wearable monitoring technology had positive feedback from	6	Limited sample of only 3 stroke patients. Physical therapist focus groups were in their work environment which could have limited	Yes, future wearable device studies should consider user design characteristics and various barriers to acceptance and use.

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	<p>tools used for rehabilitation via the key stakeholders (end users and physical therapists).</p>	<p>Participants (PT and patients) were recruited from a rehab hospital and two private neurorehab clinics. PT were recruited by letter. Patients were recruited from a list of previously recruited and discharged from the rehab hospital. They were at</p>		<p>physical therapists and those who had suffered from a stroke. The potential for a single, specific device to accommodate all the various needs of therapists and their patients. Participants did agree wearable monitoring technology</p>		<p>their openness of responses.</p>	

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		least 6 months post stroke and >19 years old.		can improve how PT's evaluate and treat their patients. Future wearable device studies should be created by considering design characteristics and various barriers to acceptance and use.			
Majumder et al. (2017).	Comprehensive review on the most current research and developments in	Review of research studies on the topic of	Systematic Review	This study supports smart homes allowing elders to	5	This study was funded via grants in Canada. Caution should	Yes, this article does a wonderful job explaining Home monitoring which is also known as a

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	remote smart home healthcare technology.	smart home technology.		decrease their frequency of visits or stay in expensive long term or hospital settings by supporting independent and active lives. In addition, smart homes can monitor and oversee the home environment by analyzing the daily behavior and patterns of the user. The		be taken when trying to generalize findings outside of Canada.	“smart home” and entails four elements: first, services such as remote home monitoring and emergency response services. Second, a computing platform to make decisions. Third, a network for communication. Fourth, a sensor, including those for health monitoring

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				technology also allows for low-power, miniature size, and low-cost sensors, enabling continuous monitoring which can occur at a distance.			
Majumder, & Deen (2019)	The writers research modern technology developments in smartphone and sensor-based health care. Regulations and policies for	Comprehensive review of smart sensors for health monitoring.	Systematic Review including qualitative studies	Various imbedded sensors in smartphones have the potential to aid elders in leading an independent	5	Because of the limited number of nonrandomized, non-blinded studies on a small number of participants the potential for	Yes, multiple valuable health potentials exist from utilizing smartphone sensors. Future study directions as well as challenges/cauti

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	medical devices and their association to smartphone-healthcare systems are examined. Future research suggestions for smartphone-based healthcare systems are reviewed.			and active life. The non-invasive monitoring of an individual's health for a low cost is now possible. Smart phone monitoring can provide information about a user's overall health and wellness over an extended period of time.		bias exists. Rigorous clinical trials are recommended for future studies. Harmful results for users exist because of the blurred lines between fitness and wellness apps and patient care treatment plans. These blurred lines need to be resolved to eliminate harmful effects for users.	ons for stakeholders are highlighted.

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				Smartphones have the potential to provide cost effective health care by utilizing sensors and communication technology to remote populations. Health clinicians can review the collected data from smart phone sensors to provide low cost healthcare			

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				because of continuous monitoring. Smartphones can also be utilized to screen for diseases such as cancer, and diabetic retinopathy, and monitoring the progression of some diseases via remote monitoring.			
Mardini, Iraqi, & Agoulmine (2019)	The goal of this study was to analyze current applications in	Reviewed 41 articles from 2004-2018 using	Systematic review of descriptive studies	Current challenges related to elders and	5	Search strategy initially began with the work from one	Yes, very thorough overview of healthcare

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	<p>healthcare monitoring. Applications are then broken into various categories and their common architecture are discussed. Healthcare monitoring standards and obstacles faced in this field are reviewed. Comparing applications and future research directions are examined.</p>	<p>specific Boolean Phrases such as Elderly and Healthcare Monitoring.</p>		<p>healthcare monitoring, not listed in order of importance, include: privacy and security, power consumption , biological effects, reliability, mobility, portability, availability, acceptability, unobtrusiveness, interoperability, scalability, costs testing,</p>		<p>conference which could introduce bias from the one source making it difficult to generalize the findings elsewhere.</p>	<p>monitoring systems, sensors, and potentials for enhancing elder independence. A variety of topics related to healthcare monitoring remain immature such as sensor minimization, efficient power, security, data science, cloud computing, and sensor standardization. Healthcare monitoring systems have</p>

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				and cloud and fog computing. Dementia patients may often forget to charge their sensors. Therefore, researchers have developed a sensor that does not use a battery and instead it is powered wirelessly using a chest band. The charging band can locate the			the potential to become intelligent, widespread, and available to both elderly and chronically ill populations in the future.

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				sensors by using signals and provide the needed power wirelessly. Researchers are trying to develop low power sensors and to decrease processing requirements because of battery life challenges. Continuous radiofrequency exposure to users is an additional concern and			

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				requires further study. Developing secure platforms for privacy concerns was recommended. Strong security mechanisms when it comes to data transfer, data storage, and analysis are critical but mostly lacking from current monitoring systems.			

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				Portability of monitoring is also necessary so users are not restricted to one location and will require future studies. To decrease the obtrusiveness of sensors researchers have developed watches and sensors that embed in a user's garment. Interoperabil			

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				ity is an additional feature sensor studies should take into consideration because it increases acceptance of the device as well as tying in new devices. Testing of health monitoring systems is crucial but can be burdensome for users.			

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				Costs of building and maintaining monitoring systems remains a challenge. Cloud and fog computing increases data storage capabilities and is necessary.			
Mora et al. (2019)	Technical solutions are introduced to support an internet of things (IOT) project to enhance continuity of care	200 individuals age 65 and grater who experienced a stroke and had various	Cohort Study	Interestingly this study introduced a comprehensive IoT architecture, implemented it, using	1	European Union funded a grant for this study. Generalizing the findings outside EU	Yes, this is the second study in the integrative review that took into consideration low power design (in this

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	for elders (65+ years old) who had a stroke event. A wireless Wi-Fi sensor kit was developed to monitor behavioral characteristics related to health and wellbeing, which included room presence, bed/rests patterns, toilet usage, and various others.	levels of frailty.		home sensors based on Wi-Fi cloud-enabled analytics. Developing and engineering the IoT wireless kit was depicted, with a stress on low-power design techniques (which previous other studies have highlighted as important		should be done so with caution.	study for IOT technology) which is an important aspect of future acceptance and usability of IOT technology.

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				for future study directions). The results of this study allowed researchers to recognize abnormalities and meaningful events from the analysis of sensor collected data. The data delivers care providers and health professionals with precise and useful			

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				information, which can be utilized to aid in the patient's care.			
Morley & Luciano (2020)	This study highlights the confines of the health- and wellbeing-digital tools (mHealth technology) and warns against defining them as <i>empowering devices</i> . Instead, urging professionals that mHealth technologies should instead be called <i>digital</i>	Articles which supported the Boolean Phrases such as mHealth and digital companions.	Systematic Review of Qualitative and Descriptive Studies	The empowerment narrative currently encompassing the digital health tools where developed to shift the provider-patient relationship away from paternalism and instead to autonomy,	5	Bias could be introduced to this study as randomization was not prioritized/included in the findings.	Yes, the authors of this study highlight concern with mHealth technology tools providing too much autonomy for the end users and a lack of proper healthcare provider oversight. Creating a false sense of

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	<p><i>companions</i> as their popularity increases. This paradigm shift from empowerment to companionship is supported by examining the conceptual, methodological, and ethical issues defining mHealth as empowering presents. Also examined are concerns of medical paternalism, which can be weakened by highlighting the possibility for</p>			<p>while decreasing the price of delivering healthcare by using prevention strategies to allow those with chronic health problems to do so independently. Authors recognizing it is a worthy cause but went too far.</p>			<p>security for end users. They recommend a paradigm shift away from mHealth being referred to as empowering devices and instead being referred to as digital companions.</p>

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	mHealth tools to facilitate a relationship from users of clinical advice and givers of clinical advice.						
Myles et al. (2020)	The purpose of this study focused on recognizing the goals of family care providers of elders and how the goals do or do not link family care givers views on technology as potential support platforms. Exploring how technology assist	599 family care providers residing in Canada varying in ages from less than 35 years old to greater than 75 years old. 45.1% were retired, 32.5% were employed, and less than	Sequential mixed-method qualitative approach using family care provider focus groups.	As suggested by a caregiver (stakeholder on how technology could be useful to them) , “There is too much information and not enough time to make that	6	The study was conducted in Canada one should caution generalizing these findings outside of the Canadian setting. Further studies should focus on various institutional and cultural settings.	Yes, one can identify the challenges family care providers encounter when caring for elderly populations and based on suggestions which technological tools would be useful for them as stakeholders

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	<p>family care providers in achieving goals achieving those goals was a main goal of this study. Very little is known about family care providers perspectives on how technology can aid in making their work more sustainable. The research aimed to examine this gap in knowledge.</p>	<p>9% reported productive secondary work while functioning as a family care provider.</p>		<p>information utilizable. There are so many websites, apps, checklists etc etc etc (I can't add too many etc.'s). It is like a library with the books in a pile on the floor and no card catalogue to even let me know where to start. SR50” (Myles et al., 2020, pg 6).</p>			<p>when developing mHealth, IOT, sensor solutions.</p>

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				The study highlights the need for a paradigm shift where care providing is reframed from a ‘burden of care’ and instead to sustainability and resiliency. By doing so the researchers hope providers work becomes more			

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				sustainable. Fragmented care and lack of social support are also highlighted as challenges for family care providers.			
Obayashi & Masuyama, (2020)	A pilot pre-post study examined communicative robots effect, using a sensing system backed by cloud robotics, when caring for elderly.	The pilot study took place in Japan. Two elderly females residing in nursing homes and four care providers participated.	Pilot Study	Care providers dedicated 3 hours to record keeping during their most stressful work times. Automatic recording of	4	Further research is needed to draw conclusions to the general elderly population as this study was a small pilot study.	Yes, robot have the potential to decrease the burden on provider staff and enhance elder’s communication with others.

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				important data utilizing robot sensors can enhance the quality of nursing care. Care providers' stress levels increased when acting on nurse calls. Robots temporary responded to nurse calls and have the potential to decrease the burden on nursing care staff. Robots can promote			

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				elderly individuals to enhance communication with others (P < 0.05). When robots vocalize with elders it can prevent the deterioration of quality of life for elders.			
Pillozzi & Huang (2020)	Recent advancements in information technology can be used to decrease stigmas surrounding Alzheimer	Articles were selected based on a set of applicable topics	Systematic Review	Utilizing blockchain when implementing Electronic Health Records (EHR)	1	Further studies are needed to generalize to all elderly populations.	No, not for this integrative review as it discusses utilizing information technology to decrease

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	disease (AD). Artificial intelligence (AI) technologies, such as natural language processing (NLP), to categorize the response and tone of texts, including online posts on various social media sites, has proven to be an valuable tool for measuring the opinions of the general population on specific topics such as AD.			system has the potential to be more secure and patient-privacy-oriented network, that provides patients with confidence in the privacy and confidentiality of their diagnosis and information. Using Natural Language Processing (NLP) to			Alzheimer stigmas.

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				analyze and monitor the opinions of the public may prove valuable in quantifying the predominance of stigma (regarding AD) and evaluating the success of anti-stigma campaigns. Individuals avoid diagnosis of AD because of the social and			

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				institutional problems it causes. Therefore, block chain EHR and NLP may prove to decrease stigma and aid in future knowledge of AD from earlier diagnosis.			
Recio-Rodríguez et al. (2019)	The purpose of the study is to assess the effectiveness of joining the use of smartphone and smart band technology for	Participants are recruited from urban medical centers located in Spain.	Study protocol for a randomized clinical trial	As this is a study protocol researchers are hypothesizing the outcomes of	2	As the study is taking place in Spain generalization to all elderly populations is discouraged. Researchers	No, this is a clinical randomized study protocol which has not taken place. Once the study has been

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	three months including concise counseling on behaviors, in contrast to counseling only, in boosting physical activity and enhancing adherence to the Mediterranean diet.	160 individuals between the ages of 65 and 80 with no history of cardiovascular disease or cognitive impairment will be recruited.		the trial. Researchers hope to increase the number of measured accelerometer steps. In addition participants observance of the Mediterranean diet, time sitting, body composition, quality of life, independence in daily activity and cognitive functioning		will randomize participants which will aid in decreasing bias.	completed the findings may support a change but not in the current protocol state.

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				will be measured.			
Silvius et al. (2020)	The purpose of this study is to analyze if need-driven establishment of technology for adults can lead to enhanced self-reliance and an improved perception of quality of life.	Two separate communities in the Hague were compared. An intervention site community of individuals age 55+ with 279 households. A control site containing 4 apartment buildings, with approximatel	Controlled observational study	Introducing technology to elders is challenging, as the capability to learn new things typically decreases as individuals age and have the potential to be worse despite them having the most to gain from doing so. Developing technological	3	Despite the long-term benefits that technological advances can provide for elders, insurance stakeholders were not involved in this study. Further studies should include this necessary stakeholder. This study did not include elders from various cultures and individuals	Yes, an interesting article as it is the first study that pointed out introducing new technology to elders despite them being beneficial to them is challenging. As individuals age learning new things decreases. An additional interesting finding is trying to pinpoint the right

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		y 322 individuals.		interventions that are tailored to their needs may enhance adoption, acceptance, and use. This study shows that by doing so they are more accepted by elderly populations. Acceptance of technology has been shown to enhance quality of		suffering from social issues or illnesses which left entire populations unaccounted for from this study. Further research is necessary to establish the existence of care needs that are unmet for elders to assess if the seen effect can be enhanced, by making it more cost-effective.	technology, for the right individual, at the right time. Further studies are needed and are currently in the works to aid in this. This study highlights that caution should be taken before implementing technology as there may be a negative affect trying to get elders up and trained to the technology could initially negatively

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				life for elders. The effect of technology of elder's physical health were enhanced by in-house technology adaptations as opposed to high or low technology solutions. Users rated acceptability as one of the highest critical domains. Another			affect their health.

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				interesting finding of this study is implementing the correct technology at the precise moment for the appropriate reason and the proper person is challenging. Tools are being created to aid in this process. The appropriate tool for the specific problem is problematic.			

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				Researchers have been working to create a taxonomy to describe the critical characteristics of interventions . One should identify who would benefit from technological interventions , assess the elders needs, and intervene as appropriate. Communicating with			

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				elders about needs is a vital element when introducing technology. Tor technology advances to help people perform in an enhanced manner, it may backfire initially by making them feel worse (for example, lost time solving functionality problems and testing			

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				might have negatively affected the physical health perceive).			
Sriram, Jenkinson, & Peters (2020)	The study investigates care providers experiences using assistive technology (AT) in aiding and caring for individuals diagnosed with dementia and who reside at home.	23 individuals (14 women, 9 men) adult care providers of individuals diagnosed with dementia who have used at least one Assistive Technology device.	Qualitative phenomenological Study	Individuals stated various benefits from utilizing AT. There were 5 themes and 18 subthemes that were noted as reasons for utilizing AT and using AT over time. Some of the	6	The study took place in the United Kingdom, generalizing findings to all elder should be done so with caution. Participants were not randomized which could introduce some bias to the findings.	Yes, this study highlights that AT is useful initially for individuals with dementia. As their illness progresses continuing to use AT decreases.

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				categories included delivering care for an individual with dementia, the motivation for using AT, changes to routines and roles, care provider knowledge and proficiencies for using AT and environmental, social, and ethical considerations. AT can			

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				deliver reassurance and support for care providers of individuals with dementia but there are challenges with obtaining and prolonged use of AT as dementia advances.			
Susnea et al. (2019)	The purpose of this study was to suggest a method to track the activity of elders residing alone	Monitoring elderly residence who reside alone using low budget	Proposed case control study	The suggested monitoring solution addresses the disadvantage	4	Study limitations of this method are they apply only to elders residing alone.	Yes, low cost unobtrusive monitoring solution for elders residing at home. The

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	<p>and identify deviations from the prior activity patterns. Using virtual pheromones—one can develop images of the pheromone dispersal maps, which explain the spatiotemporal change of the interactions from the user and the environment. Utilizing a simple statistical analysis of the images one should be able to detect changes</p>	<p>binary sensors that were unobtrusive.</p>		<p>s of long-term monitoring systems of activity: The design includes economical passive inferred motion detectors and doors with magnetic contacts, which are unobtrusive and require minimal set up; The proposed monitoring system is</p>		<p>Caution should be used when generalizing to the greater elderly population.</p>	<p>proposed system includes a fall detection element, and a panic button at a low cost.</p>

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	from the normal activity routines.			economical and requires no complex personalization and training; it is independent from the monitored living space.			
Wangmo, Lipps, Kressig, & Ienca (2019)	The purpose of this study is to examine and evaluate the ethical issues professional key stakeholders identify in creation and use of intelligent assistive technology (IAT) in elder	Twenty healthcare staff were recruited from Germany, Italy, and Switzerland utilizing purposive sampling methods.	Qualitative interviews were conducted at multiple sites with researchers and health care staff.	Healthcare stakeholders identify ethical priorities to include patient autonomy, informed consent, justice, quality of data management,	6	The study was limited to a small percent of experts from three separate nations with various health care methods which makes it difficult to generalize. Purposive sampling was	Yes, the results of this study can direct policy makers and stakeholders with qualitative data regarding solutions IAT governance that is ethically-aligned.

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	and individuals dementia care.			and human contact. Differences of opinion surfaced in relation to interpretation of ethical issues, including how to solve differences of ethical principles and which solutions should be applied to overcome these challenges. A general agreement		utilized for this study. Certain ethical topics may have been avoided because of the interviewer’s presence. Implying certain ethical topics may have been avoided. Not all stakeholders such as end-users and family members were included in the study decreasing the comprehensive-ness.	

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				from professional stakeholders on ethical issues and challenges surface by using IATs among elder and disabled consumers. Strategies are necessary for the safe and successful implementation of IATs. Unmet ethical needs should be closely examined by			

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				IAT developers.			
Willner, Schneider, & Feichtenschlager (2015)	This paper presents the findings of a confidence assistance service (assistance call, emergency SOS, environmental info- weather, calendar, and navigation) and its impact on elder’s lives. The goal is for elders to age well in place by safeguarding mobility and decreasing caregiver burden.	41 participants age 49-89 median age 71 from Austria. The field trial took place in both urban and rural areas. Nineteen primary and nineteen secondary end-users (seven relatives, six care professionals , and six	Case controlled	Half of users ranked their quality of life better after utilizing the confidence assistance service. The other half reported it did not help. The writer concluded that assistive technologies can potentially positively affect elders’ lives.	4	This study did not randomize participants so the potential for bias exists.	Yes, this study showed a link from positive attitudes towards technology prior use and a positive impact after using confidence assistance service was found.

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		volunteers) participated.		Confidence relates to various quality of life characteristics such as independence, health, mental wellbeing, and social connections.			