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Deployment of technologies in North American long-term care homes during the COVID-19 pandemic: A scoping review

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Abstract

Background: During the COVID-19 pandemic, new processes and policies were implemented to limit the spread of COVID-19 in long-term care homes (LTCH). Technology use within LTCH changed significantly.
Research Aim: The purpose of this literature review was to examine the breath of evidence in the use of technology in LTCHs in North America during the COVID-19 pandemic.
Methods: Guided by Arksey and O'Malley's scoping review framework, five databases were searched to identify peer-reviewed articles using key words and subject headings related to Long Term Care, COVID-19, and Technology.
Results: Research articles that described the investigation of, or the analysis of reported data on, the use of any kind of technology in LTCHs in North America during the COVID-19 pandemic were included for analysis. There were 121 articles retrieved, of which 32 articles met the inclusion and exclusion criteria and were included for analysis. Technology was deployed in support of the quality of life of LTCH residents in the context of social isolation, telehealth, virtual services, multidisciplinary collaborations, continuing education and training, infection prevention and control services, and activities, computer-based modelling for the LTCH setting. Technologies described included robots, web-based websites and games, and computer-based models that predict COVID-19 transmission in LTCHs, though most described the use of information and communication technologies to connect people within the LTCH to those outside the LTCH. Researchers also noted technology challenges in LTCH such as poor technological infrastructure, unstable Wi-Fi connectivity and inadequate number of devices to support virtual visits, other online recreation activities in LTCH, as well as the provision of telehealth services.
Conclusion: Findings emphasize the need to examine the impacts of technology use in LTCH in rural and remote areas, to inform actionable insights to the promote accessible, inclusive, and sustainable adoption of new technologies across all LTCH settings.

Keywords: COVID-19 pandemic

Introduction

As populations continue to age, more older adults will require supportive care services in the community or in specialized facilities. Several reports have sounded the alarm regarding the long stressed and under-resourced state of the long-term care home (LTCH) sector, recognizing that serious problems within the LTCH sector existed well before the onset of the COVID-19 pandemic. The increasing complexity of the needs of LTCH residents, aging LTCH infrastructure with many buildings not built to meet current LTCH residents' needs, as well as the ongoing LTCH staffing challenges and service gaps, worsened greatly during the COVID-19 pandemic. It is common for LTCHs to have outdated building designs with antiquated technological infrastructure – many LTCHs lack even basic internet access. Core LTCH services, such as routine activities, programs, and services for residents, as well as communication between residents and formal caregivers, family, and friends, are often not supported consistently with technology. Further, technology adoption in LTCH was slower than in other health sectors, such as acute care. These issues are exacerbated in rural and remote regions where there is a lack of affordable high-speed internet access. A report on the urban-rural divide in terms of internet connectivity by the Canadian Radio-television and Telecommunications Commission found that while 87.4% of households have access to internet connections at broadband speeds (at least 50 Mbps download and 10Mbps upload and access to unlimited data), only 45.6% Canadians living in rural and remote areas do. In an April 2021 press release, the Ca-

nadian Internet Registration Authority reported a significant difference in the median download speeds in rural areas compared with cities at the start of COVID-19, and this divide has continued to widen further during the pandemic.

Long-term care residents were disproportionally negatively affected by COVID-19– not only do many LTCH residents have underlying medical conditions that put them at higher risk of developing more severe forms of the disease, but they also live in congregate living environments that put them in unavoidable close contact with other LTCH residents as well as LTCH staff. In response to COVID-19 in Canada, the health ministries of the different provinces created and implemented new policies regarding infection prevention and control, use of personal protective equipment, staffing and other on-site work policies, visitation, and outbreak management. For many months, LTCHs had strict visitor restrictions policies such that visitors were all denied entry except for end-of-life or if visitors were deemed essential – these visitors were allowed entry under exceptional situations. Technology became critical in the facilitation of social connections in LTCHs, though many homes experienced challenges related to the rapid deployment. As recognized by our health systems collaborators, there was a strong desire to better understand how technology was used in LTCHs during the COVID-19 pandemic and to more clearly describe the perspectives of those who used technology within the LTCH setting. Therefore, the purpose of this review was to examine the breadth of evidence in the use of technology in the LTCH setting during the COVID-19 pandemic. The research question this scoping review answered was: "What is known about the kinds of technology used, the purposes that this technology served, as well as the users using the technologies in LTCHs during the COVID-19 pandemic?

Search methodology

Guided by Arksey and O'Malley's scoping review framework, a systematic literature search was conducted to identify peer-reviewed articles using keywords and subject headings related to Long Term Care, COVID-19, and Technology.

Arksey and O'Malley identified four reasons to undertake a scoping study, of which the latter two - "summarize and disseminate research findings" and "identify research gaps in the existing literature" (p21) - explained the choice to use Arksey and O'Malley's approach, which was to examine key concepts about the use of technology in the LTCH setting during COVID-19 as well to identify research gaps in the existing literature. Therefore, this was the ideal search methodology for the literature review for this research study. Arksey and O'Malley's framework consists of five stages:

Stage 1 Identifying the research question
Stage 2 Identifying relevant studies
Stage 3 Study selection
Stage 4 Charting the data
Stage 5 Collating, summarizing, and reporting the results

Stage 1: Identifying the research question

A Population, Intervention, and Effect table (*Table 1*) was created to help generate the research question. The terms in the PIE table were conceptualized to generate similar words that were identified. *Table 2* displays a list of search terms.

Stages 2 and 3: Identifying relevant studies and study selection

For this literature review, five databases were searched separately – Pubmed, PyschInfo, CINAHL, SocIndex, and Web of Science (see Supporting Information for the search strategies used in the databases). Research articles that described the investigations and/or intervention studies (qualitative and/or quantitative) of, or the analyses of reported data from cross-sectional or longitudinal studies and surveys on, the use of any kind of technology in LTCHs during COVID-19 were included for analysis. Articles that did not describe investigations, interventions or reported data analyses (for example articles that described a problem with a narrative review and a call-to-action) or described research studies that looked at the technology in settings outside LTCHs or before COVID-19, were excluded from analysis. Due to the large number of articles found, two additional exclusion criteria were added - investigations that were done outside North America and articles that were not peer-reviewed journal articles (for example, short reports, proceedings of conferences and posters abstracts, dissertations).

Stage 4: Charting the data

A literature matrix was created with Microsoft Excel for Mac Version 16.71. The data from the articles were entered into a Microsoft Excel spreadsheet (see Supporting Information for list of citations, characteristics of the articles, as well as descriptions of technology and user perspectives).

Stage 5: Collecting, summarizing, and reporting the results

There were 121 articles retrieved, of which 32 articles met the inclusion and exclusion criteria and were included for analysis. *Fig 1* shows the PRISMA diagram of the literature review.

Table 1. Population, intervention and effect keywords

Population/problem/patient	Long term care during the COVID-19 pandemic
Intervention/issue	Technology use
Effect/evaluation	Activities + electronic

Results

The articles retrieved were published between 2020 and October 2022. Of these 32 articles, nine were published in 2021 and 23 were published in 2022. There were 22 studies from the United States of America (USA), of which seven were involved in the participation in surveys or virtual participation (for example virtual education sessions) where subjects in the studies came from multiple states, and one was a consensus panel consisting of experts from a few states. The others were conducted in LTCHs situated in the following states: California (n=1), Colorado (n=1), Florida (n=1), Maryland (n=1), Massachusetts (n=1), Minnesota (n=1, New York (n=2), North Carolina (n=1), Pennsylvania (n=1), Rhode Island (n=1), South Carolina (n=1), Texas (n=1) and Wisconsin (n=1). Ten studies were conducted in Canada; none were epidemiological studies - all ten were descriptive studies conducted in Canadian LTCHs situated in the following provinces: British Columbia (n=3), Ontario (n=6), Alberta (n=1) and Quebec (n=1) – one study recruited participants from two provinces. The articles included studies of various methodologies including mixed methods (n=8), qualitative descriptive (n=13), quantitative descriptive (n=2), retrospective cohort (n=5), cross-sectional (n=1), consensus panel (n=1), and computer-based modelling (n=2). The populations studied included LTCH staff, medical professionals, residents, and their families.

Characteristics of technology use in long-term care

The studies in the literature reported that there was greater telehealth rollout in LTCHs in USA during the COVID-19 pandemic. However, this was not homogenous throughout USA. For example, 64% of nursing homes reported increases in telehealth use while 32% reported declines in technology use. There were no studies found that reported Canadian data on telehealth rollout in the LTCH sector during COVID-19 pandemic.

Table 2. Documentation - search terms

Themes	Subsidiary search terms	
Long term care	+ nursing home + assisted living facility*	+ residential facilit* + retirement home
Technology	+ technolog* + electronic* + internet + tablet* + comput*	+ comput* + telecommunication +video conferenc* + telemedicine
COVID-19	+ COVID-19	

LTCH characteristics have been found to have an impact on telehealth use - LTCHs in rural locations used less telehealth, and were less likely to have the capability to transmit and receive laboratory results electronically; and smaller nursing homes were less likely to use electronic reporting for lab results compared to medium and larger LTCHs. However, the details regarding the characteristics and locations of the LTCH such as urban or rural setting, size of LTCH, as well as funding models were not consistently reported in the literature nor described in detail. For example, Kuepfer included information as to whether the LTCHs were in rural or urban settings, Connelly et al. included information as to the size of the LTCH in the form of the number of beds, and Chu et al. included information as to whether the LTCHs were publicly or privately funded.

In the literature, a variety of technologies were described including robots (n=3), web-based websites and games (n=1), and computer-based models that predict COVID-19 transmission in LTCH (n=2), but the bulk of the studies in the literature described the use of Information and Communication Technologies (ICTs) in LTCHs to help connect people within LTCHs to those outside LTCHs – these technologies include internet connection via Wi-Fi and access to content online, and devices with audio (the telephone), audio-visual as well as video conferencing capabilities (smartphones and tablets). Within the LTCH setting during COVID-19, technology was deployed in support of programs and policies that addressed five major areas of need: Quality of life of LTCH residents in the context of social isolation (n=14); Telehealth and virtual services and multidisciplinary collaborations (n=10); Continuing education and training (n=7); Infection prevention and control services and activities (n=4); Computer-based modelling for the LTCH setting (n=2). The same programs or technologies were often deployed in multiple areas of need and served different groups of people within LTCHs. *Table 3* shows the characteristics of technologies used in LTCHs categorized by area of need served, type, and examples of use cases. These five areas of need, as well as the corresponding technologies, will be elaborated further in the following sections.

Smart devices that can connect to the internet, typically have audio, visual, and/or audio-visual capabilities. Many smart devices support video-telephony and chat services through software such as FaceTime, Zoom, and Teams. Through these devices, LTCH residents were able to

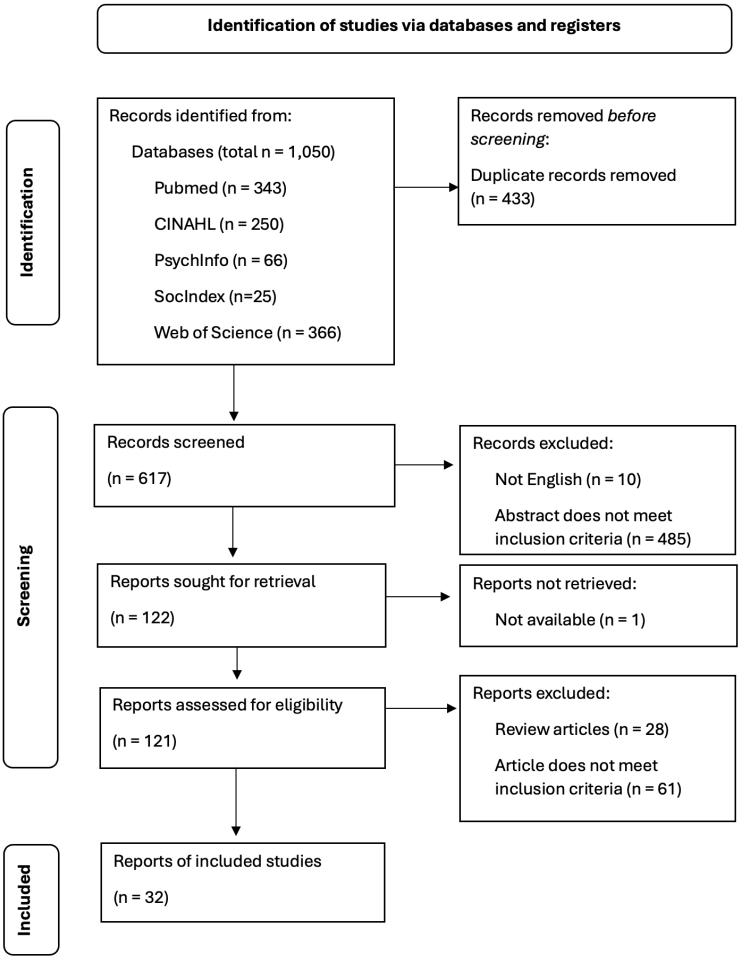

Figure 1. PRISMA flow diagram. Figure adapted from "The PRISMA 2020 statement: an updated guideline for reporting systematic reviews" by M.J. Page, J.E. McKenzie, P/M/ Bossuyt, I. Boutron, T.C. Hoffmann, C.D. Mulrow, et al., 2021, BMJ, 372(71). doi: 10.1136/bmj.n71. Copyright 2021 by the Authors under the terms of the Creative Commons Attribution License, which permits unrestricted use, distribution, and reproduction in any medium, provided the original author and source are credited.

connect with people outside LTCH and access sources of entertainment and stimulation on the internet, such as music, movies, and news.

Five studies mentioned the use of video-conferencing technologies to support LTCH residents and their families to connect virtually. The studies did not all specify which devices were used, that is, whether participants used smartphones, tablets, a combination of both, or other devices, though some studies did. For example, Hardy et al. investigated video-conferencing on tablets; and Prophater et al. described the use of tablets installed with proprietary software with added security features that served multiple functions, one of which was a direct video call app that allowed LTCH residents to connect with families safely. Researchers found that LTCH residents, families, and caregivers appreciated and expressed positive statements about the availability of ICTs for communication when LTCHs were under strict visitation restrictions. Video-conferencing technologies allowed families and residents to see each other which "made all the difference", and while families noted that video-conferencing technologies could not replace face-to-face meetings, they remained "the most effective way to maintain quality contact". Even for residents with severe cognitive impairments, LTCH staff reported that these residents reacted positively by smiling and clapping when they saw or heard their families on the screen. Tablets were perceived to be easier and faster for families; many families already had their own digital devices that they used for video-conferencing with residents. For some families that found frequent in-person visits to be physically demanding or those that lived far from the LTCH and could not visit their loved ones in LTCH often, they appreciated the availability of virtual visits on tablets as an option.

Quality of life of residents in the context of social isolation

In response to COVID-19, strict social isolation protocols were implemented in LTCHs, which resulted in LTCH residents experiencing drastic increases in social isolation. On analyzing National Health and Aging Trends Study (NHATS) data, Freedman et al. (19) found that there was a significant decline in in-person or phone contact for older adults in residential care settings in the USA, and these were more substantial than for those living in the community.

Recognizing the risks of social isolation and the separation of LTCH residents from their families when strict social isolation protocols in LTCHs were implemented, many LTCHs turned to technology as a solution. Freidus et al. noted in their

Table 3. Characteristics of technologies used in LTCH setting categorized by area of need and type

Area of need served by technology	Technologies deployed	Use case examples
Quality of life of LTCH residents in the context of social isolation	Internet-enabled devices with video-conferencing applications	• Virtual visits with families and loved ones outside LTC (16,18, 20, 22-23) • Participation in virtual recreation activities (16, 23-24)
	Robots	• Robotic pets to support social connections (20, 25-26)
Delivery and facilitation of health services	Telehealth programs and applications	• Access of medical information including labs, vital signs and progress notes (15,32) • Interprofessional and multidisciplinary communications and collaborations (15, 30-33) • Access of care plans, recording care activities (31)
	Internet-enabled devices with video-conferencing applications	• Virtual clinical services (27, 28, 30)
	Internet-enabled, voice and touch-screen controlled speakers	• Communication between caseworkers and guardianship clients (29)
Infection prevention and control services and activities	Internet-enabled devices with video-conferencing applications	• Synchronous and asynchronous education and training and implementation of infection control practices (23, 34-36)
	Telephone- and video-based infection control assessment and response tool	• Remote infection prevention and control assessments, telephone-based checklist, virtual visits (38-40)
	Robots	• Autonomous screener (41)
Continuing education and training	Internet-enabled devices with video-conferencing applications	• Synchronous virtual training workshops for clinicians (28)
	Online game accessible via internet-enabled devices	• Online game-based dementia education (37)
Predictive analytics	Computer-based modelling	• Prediction of COVID-19 related disease transmission parameters in LTCH (42-43)

North Carolina study that "the use of technology to address social isolation was an issue for most long-term care communities". ICTs allowed socially isolated LTCH residents to connect virtually with their loved ones outside the LTCH and participate in virtual recreation activities. Additionally, it was important for families to have multiple options when communicating with LTCHs. Straker and Choi found that families with multiple communication channels available to reach their loved ones in LTCH reported greater peace of mind, so much so that "after adding communication variables, the variable of COVID-19 cases was not a significant predictor for peace of mind" (p6). Analysis of the literature showed that the number of research articles where devices used in the context of social isolation of LTCH residents included smart devices (n=9), telephones (n=2), and robots (n=3). These devices were used by residents for virtual visits, ICT-mediated social interactions and recreation activities.

Technologies-mediated social interactions and recreation activities

Long-term care residents used ICTs to connect with people other than families, participated in individual as well as group activities virtually, and accessed online content. Sheperis et al. described a program that allowed medical and healthcare professional students to connect with and provide social support to residents in LTCH or retirement homes at risk of social isolation via telephones, mobile phones, and videoconferencing technologies. Wi-Fi enabled tablets with proprietary software installed that was used as described in the preceding section that allowed LTCH residents to video call families also included a simple interface that allowed residents to access entertainment and spiritual content curated for older adults. Kuepfer reported the use of worship presentations on PowerPoint with links to hymns on YouTube that recreation staff could deliver as a program, organized memorial services on Zoom, played residents' Christmas music requests via the LTCH internal broadcasting system, and even a virtual piano recital. Virtual group activities were able to provide LTCH residents with common experiences that they could talk about when they met in person. For many LTCH residents, ICTs also played a role in spiritual care activities. The study by Kuepfer reported that LTCH chaplains supported residents in their use of ICTs to participate in real-time virtual church

services, virtual bible studies, virtual reflection times, and virtual synchronous and asynchronous worship services. Other technologies described in the literature that allowed residents to have social interaction include "Seniors With Out Walls" which allowed residents to call in or receive calls and connect as a group via their telephones and in-house systems that some LTCHs that were well-equipped and had resources set up that allowed these facilities to stream programming to the residents in their rooms.

Robots were also used in LTCHs during COVID-19 to support social connection. These robots took on a variety of forms, including robotic cats and dogs, a robotic baby seal and mobile telepresence robot that was "mobile and offer video-enabled virtual visits". Both studies reported that the LTCH staff had positive responses on the use of such devices for LTCH residents. Van Orden et al. reported that robotic pets not only provided companionship and comfort to the veteran residents with dementia, the pets also promoted social interactions with other staff and residents as the veteran residents chatted about their "pets". Likewise, the participants in the study by Hung et al. agreed that robots offered a supportive role in social connection in LTCHs, and noted in particular that telepresence robots reduced the workload of LTCH staff in supporting residents for social connection. However, funding was a concern for some LTCHs for access to robots – Freidus et al. described the provision of grant writing assistance to LTCHs that did not have staff with this expertise to allow them access to funding that enabled them to purchase robotic pets for the LTCH residents in the context of social isolation.

Getson and Nejat described the implementation of an autonomous robot screener at a LTCH in Toronto, Canada. The robot was placed at the front entrance and was able to detect and record body temperature, cue people to put on masks and detect if the mask was worn correctly, and ask health screening questions and record answers. The researchers found that "staff were engaged and complied with the robot during the entire screening task". The robot increased the efficiency of the screening process, which was particularly helpful "during times when a surge of staff and visitors arrive to start their shifts or visit residents".

Telehealth technologies and areas of use

To minimize the risks to LTCH residents of COVID-19 exposure while maintaining continued provision of medical care, LTCH turned to ICTs, including telehealth technologies. Powell et al. define telehealth as "the delivery and facilitation of health and health-related services including medical care, provider and patient education, health information services and self-care via telecommunication and digital communication technologies" (p2). Eight articles discussed telehealth rollout in LTCHs due to the COVID-19 pandemic, of which seven investigated the perspectives of LTCH stakeholders on telehealth, virtual services, and multidisciplinary collaborations, including medical and allied care professionals providing services to LTCH residents from outside LTCHs, as well as LTCH staff connecting with other medical and allied health care professionals outside LTCHs and caring for LTCH residents.

The technologies and devices used for telehealth purposes in the literature included videoconferencing technologies, voice, and touchscreen-controlled smart speakers, and a tablet-compatible web-based mobile app. Videoconferencing technologies were used to allow medical professionals to see patients living in LTCHs virtually, and allow inter-professional meetings and collaborations. Voice and touchscreen controlled smart speakers were used to allow caseworkers to communicate with their guardianship clients in LTCHs during the COVID-19 pandemic when caseworkers were not allowed into LTCHs. A tablet-compatible web-based mobile app, Mobile Smart Care System (mSCS) – that allowed health care aides to access care plans, record observations and chart completed care activities, and nurse managers to monitor the activities of care aides' care activities – was trialed in a LTCH. The researchers found that overall acceptance of the mSCS was high – care aides found the mSCS useful, easy to use, fit with their needs, and expressed willingness to continue using the mSCS in the future. Interestingly, the demographics of the care aides as reported in Cruz et al. showed that the care aides reported high comfort levels with use of digital technologies.

The benefits of telehealth technologies include increased access by LTCH residents to medical specialists and other health care professionals in some circumstances and lowered time and cost associated with transportation of LTCH residents off-site. Researchers found that program adaptions via telehealth technologies that allowed clinicians flexibility in treatment modality "did not diminish the effectiveness of the intervention". Researchers also noted that telehealth technologies could be used to provide care to medically complex older adults with brain diseases and/or mental health issues. To support this, Shaughnessy et al. described the convening of a multidisciplinary consensus panel that put together a list of recommendations for best practices of "using telemedicine to assess and manage psy-

chosis in neurodegenerative diseases in LTCH" (p1145). As well, Beaudreau et al. described program adaptions to train clinicians to deliver Problem Solving Training, an evidence-based therapy "for depression and other psychiatric disorders and psychosocial stressors", to their patients by telephone and/or video-conferencing as well as in-person.

Continuing education and training

Continuing education and training are integral in the provision and maintenance of quality healthcare services. This became especially critical during the COVID-19 pandemic, where healthcare workers needed to be trained on how to safely provide care and limit infection of a novel virus within a context of rapidly changing information and system practice changes. Staff training was an important facilitator of technology adoption in LTCHs – in Powell et al., the researchers noted that the only LTCH that reported a sustained increase in telehealth use after two years were those that reported training for staff.

However, face-to face-workshops were not feasible for staff during the COVID-19 pandemic due to staff shortages as well as adherence to socially distancing guidelines. There were two virtual education formats described in the literature – synchronous sessions, where participants met online at the same time and interacted live, and asynchronous education delivery methods, where learners attended the education sessions at their own time and pace.

Of the five studies that described education activities via synchronous delivery, three described the adaptation and adoption of Project ECHO®, a program to improve implementation of evidence-based infection control practices regarding COVID-19 prevention, outbreak management, and return-to-work policies in LTCHs. Project ECHO® was a video-conferencing program consisting of 16 weeks of virtual education sessions where multidisciplinary experts and community-based partners met in "regularly scheduled collaborative learning sessions to participate in case-based discussions and hear experts present on best-practice care" (p3). The research studies described the implementation of Project ECHO® in Ontario, Canada, and Massachusetts and Florida, USA. The study by Beaudreau et al. described program adaptions to a previously in-person workshop that trained clinicians providing care to veterans – the workshop to virtual with trained psychologists "facilitating small-group roleplays" (p4) and "leading weekly group learning calls after the virtual training" (p4). In another study, Penna et al. described and evaluated a United States Centers for Disease and Prevention Control (CDC)-designed virtual course to train public health staff core healthcare Infection Prevention and Control (IPC) principles and apply the CDC COVID-19 healthcare IPC guidance for nursing homes. Learners were required to attend all live virtual training sessions that were led by CDC Subject Matter Experts that facilitated group discussions, and were encouraged to perform on-site and remote COVID-19 IPC assessments within a few weeks of completing the course. All five studies that described virtual synchronous education activities reported that LTCH staff valued these sessions which were effective at transmitting valuable information that was relevant to their work, and increased the ability of staff to integrate knowledge into practice. The sessions were effective in increasing the knowledge and confidence of LTCH staff and were also well-accepted by LTCH staff.

Two studies that described asynchronous education sessions were both self-paced online programs targeted towards professional caregivers – one was described as providing four hours of educational material that "covered foundational information on Alzheimer's and dementia" (p3) and the other was an online game-based dementia education accessible on a variety of platforms (including mobile phones, tablets, and computers) that taught practical person-centered communication techniques to interdisciplinary health care workers. The researchers of both studies found that these asynchronous education activities were also well-received by the participants of the training.

Infection prevention and control services and activities

Like continuing education and training, IPC is an integral part of the provision and maintenance of quality healthcare services, especially during the COVID-19 pandemic when there was early recognition that LTCH were settings at high risk of transmission, and LTCH residents were more vulnerable to infectious diseases and disproportionately more likely to experience severe outcomes in the event of infection due to their advanced ages, multiple comorbidities, and living in close proximity. Four articles described technology use in IPC services and activities – three discussed the use of telephone- and video-based infection control assessment and response (tele-ICAR) strategies to conduct remote IPC assessments, and one discussed the implementation of an autonomous robot screener.

Telephone- and video-based infection control assessment and response

The studies that discussed telephone- and video-based infection control assessment and response (tele-ICAR) were done in the USA. New

York was the first state in which tele-ICAR was trialed, and this was adopted in other US states. The remote IPC assessment consisted of three components – a screening tool for public health and nursing facilities for situational awareness; a telephone IPC checklist that "captured facilities' self-reported assessment of the implementation of COVID-19 IPC recommendations"; and virtual visits to LTCHs for COVID-19 IPC assessments using video-conferencing tools in smartphones (COVIDeo). All three studies that investigated the implementation of tele-ICAR noted similar benefits – the screening tool was able to identify major gaps in IPC practices, facilitate discussions of clinical presentations of COVID-19 in LTCH residents, and enable "more tailored, concrete and observation-based recommendations", and was suitable for proactive surveillance in LTCHs.

Computer-based modelling for the long-term care setting

Two articles described the creation and/or use of computer-based modelling to predict parameters related to the COVID-19 pandemic. Fosdick et al. described the development of an agent-based model – a "powerful tool for understanding complex dynamic process" and able to "simulate key daily behaviours and events that impact disease transmission in a facility"(p464). Using this agent-based model, the researchers created an online dashboard that a LTCH administrator could access, enter facility-specific parameters into, obtain forecasts on infection rates and worker days missed that was specific to that LTCH, thus able to "evaluate the relative impact of various strategies" and make policy decisions more suited for their particular context. Fosdick's work was not implemented in practice. In contrast, Miller et al. described a process by which an isolation space was designed, implemented and validated in a skilled nursing facility through the modification of the facility's existing heating, ventilation and air conditioning systems. These modifications were successful at maintaining a pressure differential between the isolation space and the surrounding hallways, and the authors reported that no transmissions of SARS-CoV-2 occurred between residents in the isolation space to the staff and other residents.

Challenges encountered with technology use in long-term care

Despite the variety of roles and numerous benefits that technology has had in the LTCH setting during the COVID-19 pandemic, there were also substantial challenges that were reported. The subtopics include: Supporting LTCH residents with physical and cognitive challenges; Technology challenges in LTCHs, Low technology literacy within the LTCH setting; Scheduling conflicts, staff shortages and high staff workload; Privacy and other ethical concerns.

Information and communication technologies helped bridge connections between LTCH residents their families outside the LTCH, but researchers noted that the use of these technologies also led to negative emotional experiences for LTCH residents, their families, and LTCH staff. Families of LTCH residents struggled emotionally with keeping LTCH residents engaged via ICTs when the LTCH residents were not able to engage in conversations or participate effectively, and with watching residents become agitated at the end of the virtual visits. Other staff reported that for residents with dementia, not only did mobile robots have the potential to trigger responsive behaviours for LTCH residents, robots could also be used as a weapon during a behaviour episode. LTCH staff and families of residents that were interviewed expressed discomfort over the loss of privacy, and this will be elaborated upon in a later section that discusses privacy concerns in general.

The use of ICTs was challenging for LTCH residents, many of whom had physical or cognitive impairments, and using technologies that did not meet the residents' needs –limited their ability to participate fully in virtual activities. LTCH residents with physical limitations required the assistance of LTCH staff to help with proper body positioning as well as the position of the devices, ensuring that assistive devices be in place (such as hearing aids for residents), that tablets be held up by the staff themselves or with tablet stands. The researchers reported interviewees who questioned the usefulness of ICTs for residents with dementia who were often confused, disoriented, and showed irritation by the tablet interface or for LTCH residents who had severe visual or hearing impairment or were nonverbal.

Researchers noted that LTCHs had poor technological infrastructure, unstable Wi-Fi connectivity, and inadequate number of devices to support virtual visits, other online recreation activities in LTCHs, as well as the provision of telehealth services and LTCH staff having access to digital training. That led to frustrations for LTCH residents, their families as well as LTCH staff and health care professionals providing services to LTCH residents via telehealth technologies. To facilitate LTCH residents' virtual visits with their families, Freidus et al. noted that LTCH staff often used their own personal devices. Even when technology was set up properly, the chosen technologies were often localized to specific rooms such as a personal Wi-Fi connection or telephone line to a resident's room – the relocation of the LTCH resident to other rooms in response to outbreak and IPC pro-

tocols resulted in the LTCH resident losing access to technology. Healthcare professionals within and outside LTCHs, who were providing services via telehealth technologies, reported challenges related to systems interoperability and poor data integration, which resulted in clinicians having to deal with multiple logins to different systems remotely to access medical information such as lab results, vital signs and progress notes. Technology also led to difficulties related to learning how to do previously technology-free activities with the mediation of technology, such as communicating with LTCH residents with dementia during virtual visits or conducting physical examinations in telehealth sessions, especially when the technology was not quite suited for the purpose. For example, Hardy et al. described challenges faced by families on the effort required to participate in one-sided conversations with their loved ones in LTCHs via tablets "especially when the resident is unable to understand or uphold the conversation" (p68), and Ford et al. reported that "participants noted that telemedicine modality was less desirable for the conduct of sub-specialty encounters where the physical exam played a dominant role in decision making" (p3). In the study by Davitt et al. on the use of voice and touchscreen controlled smart speakers with Wi-Fi connection, caseworkers described specific technology difficulties related to using a single user Amazon account (the caseworker) to manage multiple devices belonging to multiple clients, such as user tracking, and that when a LTCH resident used these smart speakers to call other people, the call appeared to come from the caseworker.

For some technologies, technical challenges remained such that the device was not yet ready for a full-scale deployment; the autonomous screening robot stationed at the front entrance of a LTCH is an example of this. Getson and Nejat noted that several technical challenges (speech recognition, navigation and autonomy) remained, in particular with speech recognition in noisy environments where the robot would be expected to detect speech even when many people were talking at the same time. Getson and Nejat also noted the importance of robots being able to handle different kinds of inputs (speech, touchscreen and gestures) to improve the experience of human-robot interactions.

Low technology literacy in LTCH residents who were not familiar with the technology devices often required staff assistance, and also in LTCH staff, which contributed to situations such as setting up of ICT devices in noisy locations with video cameras improperly positioned leading to poor virtual visit experiences for the families, poor telehealth experiences for the residents and for the physicians doing the assessment and staff expressions of discomfort and concerns of safety when working with robots. Low technology literacy of LTCH staff was noted as a barrier in using technology and gamification in clinical education.

Researchers noted that the scheduling of virtual visits was another source of challenge for LTCH staff and families; LTCH staff scheduled virtual visits during daytime working hours which did not work for families that also worked full time. As well, both LTCH staff and families discussed the difficulties that LTCH staff faced in trying to manage residents' usual nursing and caregiving needs, assist with virtual visits, and teach the use and care of tech devices on top of additional IPC duties at a time of severe staff shortages in the LTCH sector. The problems of nursing staff being tasked with additional responsibilities related to technology use and the lack of training, in addition to scheduling of telehealth visits, were echoed in survey studies that investigated telehealth implementation in LTCHs. Powell et al. (2022) noted that none of the LTCHs studied "reported adding staff to accommodate for the increased use of telehealth" (p8). Even if the devices only required installation for residents' use and did not require active involvement by LTCH staff on day-to-day use, staff shortages within LTCHs also led to delays. Staff shortages and high staff workload also had a detrimental impact on training – Hung et al. noted that the lack of time was a large contributing barrier to the lack of "willingness in healthcare workers to spend time in dementia care education" (p8).

Long-term care staff and families of residents who were interviewed expressed discomfort over the loss of privacy due to the consistent intrusive presence of LTCH staff during private family virtual visits, even though LTCH staff were there to support LTCH residents with technology use. LTCH staff and families of residents also worried about the potentiality of ICTs to survey, monitor, take pictures and record audio and video. Especially for mobile robots that were self-navigating, there was concern that a malfunction could result in the robot moving to private places such as bathrooms. Privacy concerns also arose in studies of researchers investigating other technologies in LTCHs; for example Bogin et al. noted that there were large state-wide variations but no unified federally mandated guidelines on privacy for telehealth use in the USA, and Davitt et al. noted that caseworkers as well as the LTCH staff were concerned about privacy risks of unannounced virtual visits using voice and touchscreen controlled smart speakers placed in LTCH residents' rooms on the residents as well as their roommates. Other ethical concerns raised about technology use in LTCHs included

cost, equity of access to equipment, purpose (for LTCH residents' quality of life or for convenience of LTCH staff or the families of LTCH residents) of robots, as well as ownership, usage, and access of appropriate content on voice and touchscreen controlled smart speakers.

Discussion

The COVID-19 pandemic was a period of time where there was a rapid and unprecedented demand for solutions, including technology, that allowed LTCHs to continue to operate in the context of social isolation and physical distancing requirements that resulted in movement restrictions of those living and those working in LTCHs. The scoping review assessed the use of technology in LTCH settings in North America during the COVID-19 pandemic to understand what technologies and where they were adopted, as well as the activities these technologies were used for, as well as reporting benefits and challenges that were experienced.

The analysis revealed several key findings. Technology adoption was not uniform across LTCHs. A variety of technologies such as ICTs for video conferencing, internet-accessible smart devices, and robots were employed to maintain connections between residents and their families, support clinical and nursing care, and support IPC activities. The review highlighted five primary areas of need where technology was used: 1) quality of life for LTCH residents, 2) delivery and facilitation of health services, 3) IPC services and activities, 4) continuing education and training, and 5) predictive analytics. Internet-accessible devices with video conferencing, such as tablets, were valued for facilitating communication and connection for residents, staff, and clinicians in LTCHs. The technologies provided numerous benefits, though there were also significant challenges experienced that affected the adoption of technology in LTCH settings, such as poor internet and WIFI infrastructure, technology limitations, lower technology literacy amongst staff, high staff workload, and cognitive impairment of some residents. Few studies reported details regarding the characteristics and geographical locations of the LTCH, and no studies specifically focused on technology use in LTCH in rural and remote settings. This is of concerns as there is a known urban-rural divide in terms of internet connectivity in Canada as well as USA.

The findings of this study have several implications for policy and practice. There is potential for greater use of technology and other virtual tools to improve access of healthcare resources as well as to improve efficiency and effectiveness of IPC activities. Attention by policy makers on the state of internet infrastructure, provision of staff training, the choices as to the kinds of technology chosen for implementation in LTCHs that are appropriate for the population as well as the impact of technologies on residents' quality of life and and staff workload would be warranted. Future research that addresses identified gaps such as improving technology for residents with cognitive impairments, enhancing system interoperability, and developing better privacy safeguards would also be warranted. These steps would help to enhance increased technology use in the LTCH setting.

There are several limitations in this study. In terms of methodology in the literature search, the decision was made to cast an as wide a net as possible in terms of kinds of technology that were investigated. As such, there were no exclusion criteria that addressed types of technology used in LTCH settings, only in the geographical locations of the LTCHs that were limited to N. America. Future reviews should investigate the role of technology in LTCHs in other areas of the world during the COVID-19 pandemic to determine if there are similarities or differences in the findings. Another option for future research is a more focused approach in the investigation of a particular kind of technology and its practical applications in LTCH settings as well as the impact on its implementation on LTC homes, residents and staff, so as to achieve deeper insights. As well there is a need for more North American studies to fill a research evidence gap with a focus on technology use in LTCHs in rural and remote areas so as to provide more relevant findings and actionable insights to promote the adoption of new technologies in LTCHs in these regions.

Conclusion

In summary, the findings in this scoping review highlight the increased use of technology in LTCHs in North America to facilitate the provision of communication, care, and connection despite physical distancing measures during the COVID-19 pandemic. Technologies were used for various purposes in LTCHs including the provision of virtual activities to enhance LTCH residents' quality of life, telehealth and virtual services, continuing education and training activities, IPC activities, and others. However, there were considerable challenges faced by residents and staff in LTCHs in the adoption of technological tools, such as inadequacies in infrastructure and technology literacy in the LTCH settings, as well as limitations in technology and staffing levels.

The addressing all of these challenges will be essential to promote the adoption of new technologies in LTCHs and ensure that technologies that are chosen for implementation in the LTCH setting fully meets the needs of residents and staff.

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Appendix

S1. Search strategy for PubMed database

Theme	Title/abstract keywords
Long term care	("nursing homes"[Title/Abstract] OR "care homes"[Title/Abstract] OR "long term care"[Title/Abstract] OR "long-term care"[Title/Abstract] OR "residential care"[Title/Abstract] OR "aged care facility"[Title/Abstract]) OR ("nursing homes"[MeSH Terms] OR "long-term care"[MeSH Terms] OR "long-term care"[MeSH Terms] OR "homes for the aged"[MeSH Terms])
Technology	technolog*[Title/Abstract] OR electronic[Title/Abstract] OR internet[Title/Abstract] OR tele*[Title/Abstract] OR comput*[Title/Abstract] OR virtual[Title/Abstract]
COVID-19	((COVID-19[Title/Abstract]) OR (pandemic[Title/Abstract])) OR (COVID-19[MeSH Terms])

S2. Search strategy on EBSCOhost research databases for CINAHL Complete, APA PsycInfo & SocIndex

Theme	Title/abstract keywords
Long term care	TI ("nursing homes" or "care homes" or "long term care" or "long-term care" or "residential care" or "aged care facility") OR AB ("nursing homes" or "care homes" or "long term care" or "long-term care" or "residential care" or "aged care facility") OR SU ("nursing homes" or "care homes" or "long term care" or "long-term care" or "residential care" or "aged care facility")
Technology	TI (technolog* or electronic or internet or tele* or comput* or virtual) OR AB (technolog* or electronic or internet or tele* or comput* or virtual) OR SU (technolog* or electronic or internet or tele* or comput* or virtual)
COVID-19	TI (covid-19 or pandemic) OR AB (covid-19 or pandemic) OR SU (covid-19 or pandemic)

S3. Search strategy for Web of Science database

Theme	Title/abstract keywords
Long term care	TI =("nursing homes" or "care homes" or "long term care" or "long-term care" or "residential care" or "aged care facility") OR AB =("nursing homes" or "care homes" or "long term care" or "long-term care" or "residential care" or "aged care facility") OR SU =("nursing homes" or "care homes" or "long term care" or "long-term care" or "residential care" or "aged care facility")
Technology	TI =(technolog* or electronic or internet or tele* or comput* or virtual) OR AB =(technolog* or electronic or internet or tele* or comput* or virtual) OR SU= (technolog* or electronic or internet or tele* or comput* or virtual)
COVID-19	TI =(covid-19 or pandemic) OR AB =(covid-19 or pandemic) OR SU =(covid-19 or pandemic)