RESEARCH PAPER

Nursing Home Residents' Use of Radiography in New Brunswick: A Case for Mobile Radiography?

Utilisation de la radiographie pour les résidents des foyers de soins au Nouveau-Brunswick : un argument en faveur de la radiographie mobile?

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Abstract

Introduction: Identifying ways to eliminate unnecessary transfer of nursing home (NH) residents to hospitals provides an opportunity to improve outcomes and use scarce healthcare resources more efficiently. This study's goal was to better understand where NH residents access X-ray (XR) and computed tomography (CT) scans and to determine if there was a case for mobile radiography policies in New Brunswick.

Methods: A retrospective analysis of all the visits to the emergency department (ED) and outpatient imaging departments in two hospitals in Saint John, New Brunswick, in 2020, that involved XR or CT investigations was conducted.

Results: There were 521 visits by 311 unique NH residents and 920 investigations (688 XR and 232 CT scans). Most investigations were ordered in the ED (696 of 920; 75.6%; confidence interval: 72.8–78.3%). Of the NH residents who visited the ED and received either an XR or a CT scan, 33.2% received only XR imaging and were discharged back to the NH after a mean ED stay of 5.15 hours.

Discussion: The pattern of NH residents' use of the ED for their imaging needs supports the creation of mobile XR policies to deliver more safe and efficient care in a Canadian medium population urban centre.

Résumé

Introduction : L'identification de moyens pour éliminer le transfert inutile des résidents des maisons de soins infirmiers (MSI) vers les hôpitaux permet d'améliorer les résultats et d'utiliser plus efficacement les ressources de santé qui sont plutôt limitées. L'objectif de cette étude est de mieux comprendre l'endroit où les résidents des MSI peuvent accéder aux rayons X (XR) et à la tomodensitométrie (TDM) et de déterminer s'il y a lieu de mettre en place des politiques pour la radiographie mobile au Nouveau-Brunswick.

Méthode : Nous avons effectué une analyse rétrospective de toutes les visites aux services des urgences (SU) et aux services d'imagerie en consultation externe, pour des examens par XR ou TDM, dans deux hôpitaux de Saint John (Nouveau-Brunswick) en 2020.

Résultats : Il y a eu 521 visites de 311 résidents de MSI pour 920 examens (688 XR et 232 TDM). La plupart des examens avaient lieu aux services des urgences (696 sur 920 ; 75,6 % ; intervalle de confiance : 72,8–78,3 %). Parmi les résidents des MSI qui se sont rendus à l'urgence pour un XR ou une TDM, 33,2 % n'ont reçu qu'une imagerie par XR et ont été renvoyés à leur MSI après une attente moyenne de 5,15 heures à l'urgence.

Discussion : Le modèle d'utilisation du service des urgences par les résidents des MSI pour une imagerie plaide en faveur de l'élaboration de politiques de radiographie mobile pour fournir des soins plus sûrs et plus efficaces dans un centre urbain canadien à population moyenne.

Introduction

The transfer of nursing home (NH) residents to hospitals and emergency departments (EDs) has been a topic of discussion for decades (Aryal et al. 2021; Castle and Mor 1996;

McCloskey and van Den Hoonaard 2007) but more so since the COVID-19 pandemic (Atkinson et al. 2022; Curtis et al. 2021; McNamara et al. 2022; Pathak et al. 2021; Pulst et al. 2021; Sundaram et al. 2021). It is acknowledged that NH residents are generally frail, have multiple chronic health conditions and are at a high risk for injury and the development of new illnesses (Carron et al. 2017; Zhang et al. 2019). Therefore, transferring them to hospitals for health services can be problematic for both residents and the healthcare system (Lemoyne et al. 2019; McCloskey and van Den Hoonaard 2007). For NH residents, hospital transfers increase the risk of harm such as delirium and infections and can compromise safety (Boncea et al. 2021; Lemoyne et al. 2019). Moreover, transfers back and forth between NHs and hospitals consume considerable human and financial resources. Since most NH residents are sent to hospitals by ambulance, transfers can be emotionally difficult and can involve several hours of waiting time for paramedic services to become available to transport residents back to the NH (McCloskey 2011). Identifying avoidable hospital transfers offers the potential to prevent unnecessary harm to residents and utilization of scarce healthcare resources.

Background

Discussions regarding resident transfers between NHs and hospitals are often part of the greater discourse around hospital and ED crowding and the negative outcomes associated with the hospitalization of older adults (Dozet et al. 2016; Wang et al. 2011). There are reports stating that 16–62% of NH residents are transferred to a hospital each year, with upwards of 40% potentially avoidable (Lemoyne et al. 2019; Rolland et al. 2021) transfers. Primary reasons for transporting NH residents to the hospital are accessing radiography services, confirming a suspected diagnosis or monitoring the status of pre-existing conditions (Kjelle and Lysdahl 2017). Wang et al. (2011) reported that 90% of NH residents transferred to an ED receive a chest X-ray (XR).

The COVID-19 pandemic has increased pressure to improve NH care and to increase capacity to respond to changing health needs on site. Calls for protective measures to safeguard the health and well-being of NH residents include the increased availability of preventative, supportive, diagnostic and curative healthcare within NHs (Grabowski and Mor 2020; Webster 2021; WHO 2020). Improving access to care within NHs is thought to not only enhance care but also reduce the need to transport residents to hospitals for services that could be provided in NHs (Razak et al. 2020). Yet, limited medical coverage and a lack of diagnostic services in the homes create challenges in providing care on site when changes arise in residents' health status (Brühmann et al. 2019; Curtis et al. 2021). Residents themselves often prefer to have their care focus primarily on quality of life and wish to avoid hospital transfers (Arendts et al. 2015).

Mobile radiography services have been used in some jurisdictions to improve NH residents' access to diagnostic imaging services and to improve diagnostic accuracy (Kjelle and Lysdahl 2017; Kjelle et al. 2019). Mobile radiographic services involve a certified radiography

technician bringing a portable XR machine into the NH to perform diagnostic imaging. The XR performed by the portable equipment is then sent electronically to an appropriate medical service to be analyzed. Currently, this service is available in many countries including Norway, Australia, Italy, Sweden and Switzerland (Kjelle and Lysdahl 2017) and in some areas of Canada (Kobes et al. 2020). The earliest documented use of mobile XR in Canada was in 2006 when Loeb and colleagues (2006) conducted a cluster of randomized control trials in 22 NHs in Ontario. Although results showed an estimated cost savings of $1,046 per resident enrolled in the study and a 12% reduction in hospital transfers, it is unknown if the mobile service remained after the trials were over. A grey literature search of mobile XR in Canada does suggest the service is available in Ontario, Alberta and British Columbia; however, it is unclear whether these services are publicly funded, how they operate and who can access them; no academic literature is available on these services. A systematic review of international studies on the outcomes associated with mobile XR has shown reduced hospitalizations, enhanced outpatient examinations and treatments, reduced hospital transfers and wait times, increased access to diagnostic imaging services and more efficient use of resources (Kjelle and Lysdahl 2017). A cost analysis of diagnostic services for NH residents was conducted in Norway, and a 30% cost reduction was found when radiography was provided in NHs compared to the same service provided in a hospital (Kjelle et al. 2019).

Limited Canadian data on NH residents' use of radiography services – mobile or otherwise – make it difficult to determine the magnitude of demand or potential benefit that a mobile service might provide. The most recent data on the use of the ED by NH residents in Atlantic Canada are from 2004; however, this study did not examine outpatient radiography patterns (McCloskey 2004). While mobile radiography services are offered in larger Canadian cities such as Calgary, Edmonton and Ottawa, there is no academic literature on the scope or nature of the use of these services. Mobile computed tomography (CT) and magnetic resonance imaging (MRI) scans are currently used throughout Canada but operate mostly as travelling "fixed" locations that are set up in communities for a week at a time (CADTH 2021). Therefore, these modalities operate in a very different way than the mobile radiography services that bring diagnostics to the bedside of NH residents.

There are still many situations where transporting NH residents to hospitals is appropriate, and strategies aiming at addressing hospital transfers must acknowledge that some transfers are unavoidable. Trahan et al. (2016) argued that attempts to eliminate all transfers of NH residents to hospitals are unrealistic. Efforts to identify the demand for mobile radiography services must therefore consider emergent transfers that would likely be unavoidable, even if a mobile service existed. Likewise, transfers that result in residents being admitted to the hospital for a level of care unavailable in the NH must be considered. Therefore, the aims of this study were twofold. First, to understand the use of radiography services by NH residents in one city in New Brunswick. Second, to characterize the outcomes of NH residents who received diagnostic imaging services in the ED, including length of stay, disposition, discharge diagnosis and specialized medical services consulted.

Methods

A retrospective review of radiography services obtained by NH residents in two hospitals in one city in New Brunswick from January 1, 2020, to December 31, 2020, was conducted. The review analyzed the radiography services of every NH resident who received either an XR or a CT scan at either hospital during this time as either an outpatient (including those who had imaging conducted during a visit to an ambulatory clinic) or an ED patient. Imaging investigations that were ordered after the resident was admitted were not included in the analysis. If a resident visited the ED and was later admitted, only the XR and CT scans that were ordered in the ED were included.

Participants

All participants who resided in an NH and received an imaging service at one of the city's two hospitals between January 1, 2020, and December 31, 2020, were included in the study. NHs in the province where this study took place are licensed facilities for people who are medically stable but who need full-time nursing services 24 hours a day. Participants were 37.2% male and 62.8% female, with no attempts made to select for or correct typical demographic sex or gender demographics of this age group.

Setting

The study took place in one medium population urban centre in New Brunswick (Statistics Canada 2021). The census metropolitan area has a population of 130,613 (Statistics Canada 2021) and two hospitals; one is a large tertiary care hospital with outpatient radiography services, approximately 444 in-patient beds and an ED that operates 24 hours each day; the second is a community hospital with outpatient radiography services, approximately 104 in-patient specialized geriatric beds and an urgent care centre that offers non-emergency medical services to the general population 11 hours each day. There are 14 NHs within the hospitals' catchment area with a total of 944 residents. All the NHs in the catchment area are publicly funded, not for profit and run by independent boards of directors. They must have at least one registered nurse on duty at all times and medical coverage by a physician (Province of New Brunswick 2014).

Data collection

Data were obtained from the Health Authority's administrative database of patients who registered from one of the NHs located in the region. Data extracted from the record of each visit included the NH, age, sex, "current care level" (outpatient or ED/urgent care) and the "current location," which described the location of the hospital that the patient was discharged from. In the case of residents who obtained imaging in the ED or at an urgent care centre, additional information was collected, such as presenting complaint, medical consultations and discharge diagnosis.

Data analysis

Data were presented to the team in a Microsoft Excel 365 file, and all analyses were conducted in this file. Descriptive statistics were used to describe study data. Categorical data were summarized using frequencies and percentages. Continuous data were summarized using means and standard deviations.

Results

There were 521 visits for radiography services from 311 NH residents. Although 128 residents visited the hospital and/or ED more than once, each visit was examined as a separate unit of analysis. Residents ranged in age from 36 years to 100 years (mean = 80.9 years; median = 80.0 years) and 62.8% were female. Residents were from 14 different NHs, with four of these homes accounting for 52% or 271 of the visits.

The number of XR or CT scans performed on each resident ranged from 1 (n = 183) to 10 (n = 10), with a mean of 1.7 per resident. There was a total of 920 XR and CT scans performed, with 688 XR and 232 CT scans. As indicated in Table 1, of the 521 visits, 359 (68.9%) were ED visits, 160 (30.7%) were outpatient visits and two (0.4%) occurred in the urgent care clinic. Of the ED visits, 171 (47.6%) resulted in the resident returning to the NH and 188 (52.4%) resulted in the resident being admitted to the hospital. Of the 160 visits classified as outpatient, 121 (74.7%) occurred in a radiography department, and 39 occurred in an ambulatory outpatient clinic (24.1%).

TABLE 1. Location of resident visits and orders made

Location of visit	Total visits (n = 521)	Total radiography orders (n = 920)	Types of orders	
			XR scans (n = 688)	CT scans (n = 232)
ED visits	359 (68.9%)	695 (75.5%)	528 (76.7%)	167 (72.0%)
Returned to NH	171 (47.6%)	303 (32.9%)	233	70
Admitted to hospital	188 (52.4%)	392 (42.6%)	295	97
Outpatient visits	160 (30.7%)	222 (24.1%)	157 (22.8%)	65 (28.0%)
Radiography department*	121 (23.7%)	172 (18.7%)	116	56
Ambulatory outpatient clinic	39 (7.5%)	50 (5.4%)	41	9
Urgent care visits	2 (0.4%)	3 (0.4%)	3 (0.4%)	0 (0.0%)

*Radiography department in hospital A and hospital B combined.
CT = computed tomography; ED = emergency department; NH = nursing home; XR = x-ray.

Radiography performed in ED

XR and CT scans performed on residents were placed in 18 different categories, including 11 categories of XR scans and 7 categories of CT scans (Table 2). Of these categories, the most common was chest XR (n = 307) and hip/pelvis XR (n = 142) scans, which made up nearly half (n = 449; 49.3%) of all radiography orders. Of the CT scans performed, the majority were of the head (n = 114; 49.3%). A total of 120 of the ED visits (33.4%) resulted in an XR but no CT scan or hospital admission.

TABLE 2. Imaging order counts by category

Imaging order counts	
General category	**Count**
Chest XR	307 (33.4%)
Hip/pelvis XR	142 (15.4%)
Head CT scan	114 (12.4%)
Upper limb XR	79 (8.6%)
Lower limb XR	77 (8.4%)
Hip/pelvis/abdomen CT scan	47 (5.1%)
Abdomen XR	41 (4.5%)
Spine XR	28 (3.0%)
Spine CT scan	23 (2.5%)
Carotids/Circle of Willis CT scan	22 (2.4%)
Chest CT scan	21(2.3%)
Foreign body extraction XR	5 (0.5%)
Radiology isolation XR	5 (0.5%)
Lower limb CT scan	3 (0.3%)
Soft tissue neck XR	2 (0.2%)
Upper limb CT scan	2 (0.2%)
Skull XR	1 (0.1%)
Urodynamics XR	1 (0.1%)

CT = computed tomography; XR = x-ray.

Reason for ED visit

Data were obtained and analyzed on the reasons for the ED (n = 359) visits. The most common reason for NH residents' visits was shortness of breath (n = 56; 15.6%), lower extremity injury (n = 49; 13.6%) and general weakness (n = 49; 13.6%). The top 10 reasons for ED visits account for 73.8% of the total visits and include shortness of breath, lower extremity injury, general weakness, extremity weakness/symptoms of cerebrovascular accident, head injury, altered level of consciousness, upper extremity injury, fever, lower extremity pain and nausea and vomiting.

Discharge diagnosis from ED

Discharge diagnoses for NH residents who were admitted to the hospital (n = 188) or sent back to the NH (n = 171) after visiting the ED are outlined in Table 3. The most common diagnosis assigned to residents in the ED was fracture or dislocation (n = 61), followed by pneumonia (n = 31), cerebrovascular accident/transient ischemic attack (TIA) (n = 17) and congestive heart failure (n = 15). Unfortunately, 32 records had no diagnosis documented. Nearly 17% of the diagnoses ranging from intracerebral hemorrhage to social problems were assigned to no more than two residents.

TABLE 3. Discharge diagnosis from the emergency department

Discharge diagnosis	Total	Discharged	Admitted	Percentage (%) admitted
Fracture/dislocation	61	28	33	55.1
Pneumonia	31	7	24	77.4
Congestive heart failure	15	3	12	80
Cerebrovascular accident/transient ischemic attack	17	4	13	76.5
Septicemia	10	1	9	90
Urinary tract infection	12	4	8	66.7
Weakness/fatigue	11	7	4	36.5
Bowel obstruction/cholecystitis/ constipation/liver	11	4	7	63.7
Altered level of consciousness	9	5	4	44.4
Delirium	9	0	9	100
Chest pain	5	4	1	20
Seizures/convulsions	8	7	1	87.5
Laceration/contusion	8	8	0	0
Chronic obstructive pulmonary disease	9	3	6	66.7
Medical device issue	8	8	0	0
Shortness of breath – dyspnea	8	5	3	37.5
Cardiac – myocardial infarction, bradycardia, pericarditis	9	5	4	44.4
Dementia	5	3	2	40
Concussion	5	4	1	20
Back pain	5	4	1	20
Neoplasm	4	3	1	25
Pleural effusion	3	0	3	100
Gastrointestinal hemorrhage	3	1	2	66.7
Misc ≤2 residents with the Dx*	61	43	18	10.3
No diagnosis listed	32	10	22	68.8
Total	**359**	**171**	**188**	**52.4**

*Miscellaneous diagnosis (Dx) assigned to no more than two residents included issues such as dysphagia, renal failure, subdural hematoma, social problems, COVID-19 concerns, mobility problems, Parkinson's disease, intracerebral hemorrhage and pulmonary hypertension.

Specialists consulted

Of the 359 visits to the ED, only 24.0% (n = 86) visits resulted in one or more specialists being consulted for a total of 101 consults. Of these consults, orthopaedic surgery was the most common, accounting for 23.5% (n = 24) of the total consults, with general surgery (n = 16), internal medicine (n = 13) and cardiology (n = 11) resulting in a combined 39.6% of the other consults.

Time in ED

NH resident stays in the ED ranged from 1 to 18 hours, with the mean length of stay being five hours. More than half of the residents remained in the ED for three to six hours (n = 102; 59.9%), 11.7% (n = 20) were in the ED for less than two hours, 19.8% (n = 38) remained for 7 to 10 hours, 4.1% (n = 7) remained for 11 to 14 hours and 1.8% (n = 3) remained in the ED for 15 to 18 hours.

Discussion

Identifying ways to improve healthcare for frail older adults is important. Long-term care, including NH care, is excluded from the *Canada Health Act* (1985), which only ensures coverage for necessary medical services that are provided in a hospital or by a physician. Coverage for services beyond physician and hospital services, such as those that take place in an NH, is left to the discretion of individual provinces. While NH residents can be assessed by physicians without leaving the NH, many essential diagnostic services, such as XRs, require transportation to a hospital. While the allocation of health and long-term care services falls under provincial jurisdictions, finding ways to improve system efficiencies, enhance quality of care and be responsive to the needs of frail older adults is a national concern (Hajdu 2021). There are calls for a more holistic approach to meeting the needs of vulnerable older adults (Stall et al. 2019) including using assistive technologies to deliver more care in community environments that do not disrupt the daily routines and help prevent episodes of delirium (Wang and Wilson 2022). Such an approach requires policy makers and clinicians to reimagine how care is organized and delivered in NHs, given the high prevalence of dementia in these settings.

Findings show that nearly 70% of residents receive radiography in the ED, and that nearly half of these residents are later transported back to the NH. The fact that the most common categories of imaging received (chest, hip/pelvis, upper limb and lower limb XRs) are often performed by portable XR services for in-patients suggests that some NH residents' transfers to the hospital could have been avoided if a mobile radiography service was available. It is also possible that NH residents who were transported and later admitted could have received their imaging in the NH prior to the transfer, thus expediting their ED care, or alternatively, could have been admitted directly to the hospital and bypassed the ED altogether.

The possibility that some ED and outpatient hospital visits could likely be avoided is significant and worthy of exploration. Over the past decade, several reports and investigations have documented the prevalence and severity of overcrowding in Canadian hospitals and in EDs (CIHI 2014; Jeyaraman et al. 2021). Overcrowding is defined as a situation where the demand for services exceeds the ability of hospitals and EDs to provide high-quality care within a reasonable time-frame (Affleck et al. 2013). Overcrowding is recognized as one of the most pressing issues faced by the Canadian healthcare system. Overcrowding not only compromises access to high-quality care but can also be stressful for healthcare providers and can create challenges with the recruitment and retention of staff (Fraser Institute 2021).

While NH residents may represent only a small proportion of all hospital and ED visits, their use of these essential healthcare services is nonetheless significant. NH residents are generally frail with multiple and overlapping health conditions (Dwyer et al. 2014). The care provided in Canadian NHs is considered extended healthcare services and is not insured under the *Canada Health Act* (1985) (Government of Canada 2004). As a result, residents are often required to transfer to hospitals for medical services. Earlier research conducted in the jurisdiction where this study took place reported that each visit consumes an average of 110 minutes of ambulance and paramedic time (McCloskey 2004). Once at the hospital, vulnerable NH residents often experience anxiety, increased confusion, falls and iatrogenic illnesses (Cunha et al. 2019; Dwyer et al. 2014). In addition, hospitals and EDs are often ill equipped to care for NH residents due to the challenges associated with communicating with individuals with cognitive impairment, difficulties in determining residents' goals of care and a lack of specialized knowledge in geriatric care (Gettel et al. 2019; Houghton et al. 2016; Trahan et al. 2016). There is a need to rethink traditional approaches to delivering medical services to NH residents.

While our data show a demand for XR and CT scans by NH residents, our primary interest is in XR, as it is viewed that this service could be offered with current resources in the jurisdiction where the study took place. To this end, it is certain that mobile radiography machines on their own will not be successful and will require a complementary policy. We believe that policies that seek to provide mobile or decentralized diagnostic services can address issues such as overcrowding and excessive healthcare spending, while also improving outcomes for NH residents. While NHs in New Brunswick are non-profit, the care is overseen primarily by physicians who spend a designated number of hours per week overseeing NH residents. Our study chose to examine NHs because they currently offer limited services on site and often rely on hospital transport for diagnostic services.

For mobile XR to be implemented, policies would need to ensure that the images are read by radiologists with the appropriate level of urgency for the situation, as well as ensure that the ordering practitioner is prompted to remotely respond to the imaging results. These policies would also need to provide procedures for after-hours ordering and treatment of NH residents who have mobile imaging performed — most commonly those with falls. Especially in after-hours cases, policies that might allow registered nurses to order these images in specific circumstances should be considered as many nurses who already practise with expanded scopes can order XRs.

Implementation of a mobile radiography policy is a significant change from current practice in providing urgent care in NHs, and the barriers to such policies have been described in the literature as organizational, financial and structural (Toppenberg et al. 2020). We recently had direct experience with this by being involved in a mobile radiography pilot project for NH residents in Saint John, New Brunswick. Starting this program involved acquiring the upfront funds required for equipment and training radiography staff, recruiting local NHs for the project, securing buy-in from the local radiology department, coordinating technological interfaces between NHs and the local health authority and educating local providers about the presence of the service. These essential components of the service had to be addressed

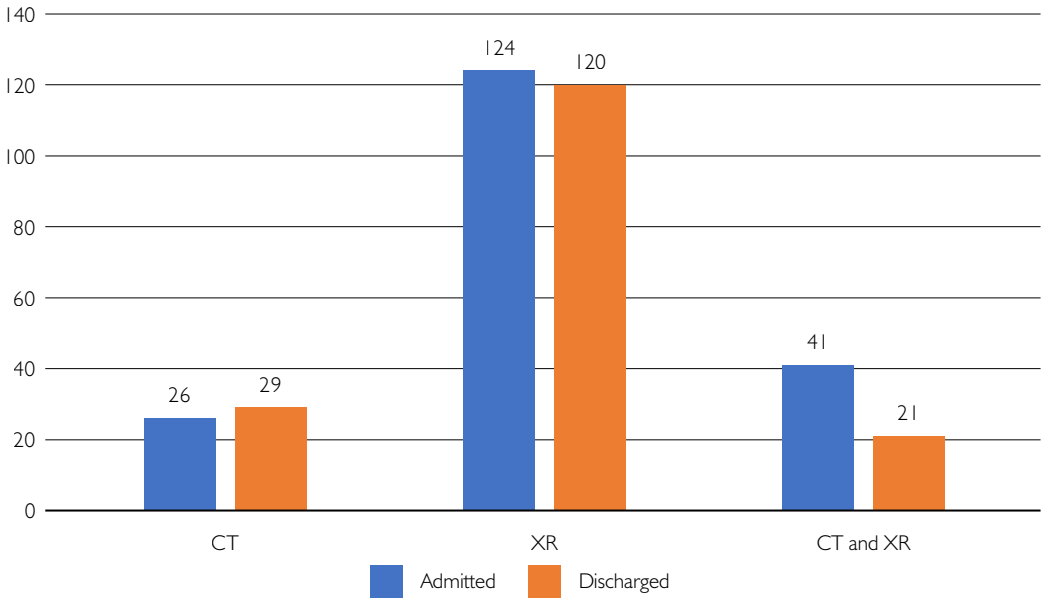
and, in some cases, took several months to accomplish. However, once the service was in place, stakeholders quickly embraced the program, and initial feedback has been very positive. Residents, families, physicians and front-line staff have seen the potential for improvements in care and were eager to utilize the service. This momentum has been recognized by the local government, which is currently struggling with ED overcrowding and access blocks to long-term care. Toppenberg et al. (2020) concluded in their study that good relations between the mobile radiography provider and NHs are important, and we attribute much of our success in overcoming the barriers to cultivating these organizational relationships.

When investigating the radiography services performed on NH residents and the reasons for the ED visits, we found that shortness of breath, lower extremity injuries and general weakness were the most common presenting complaints, with chest and hip/pelvis XR scans being the most frequent diagnostic images ordered. These findings are consistent with previous studies reporting that the main reasons for NH resident transfers to hospital are shortness of breath, falls/accidents/injuries, infections and fever (Blackburn et al. 2020; Pulst et al. 2021). Unlike the investigation conducted by Pulst and colleagues (2021), our study did not examine the involvement of physicians in transfer decisions. While a medical order is required for a resident to receive XR, it is not required for an ED transfer. This means that at least 30% of residents in this study were transferred to the hospital as per an outpatient medical order, and the remaining received an order for radiography services by an ED physician who was unfamiliar with the resident. This finding is noteworthy for several reasons. First, it is likely that XRs obtained in the outpatient settings were required to assist with the medical management of residents in the NHs. This understanding underscores the need to augment diagnostic supports in NHs and assist physicians in their efforts to provide high-quality care to residents in their own environments. Second, it is unclear if the ED transfers were initiated by physicians, NH staff, residents or families. It is possible that some of these visits could have been avoided with appropriate medical oversight. Previous investigations report a direct relationship between physician and/or nurse practitioner access and ED transfers (Jeyaraman et al. 2021; Kobewka et al. 2020), with increased access resulting in fewer hospital transfers. Other studies report that unnecessary ED transfers can occur because of inadequate staffing in NHs, staff inexperience and/or lack of training and unrealistic expectations by families (Lemoyne et al. 2019). Irrespective of the origin, NH residents have been reported to be among the most complex, time consuming and resource intensive of all ED patients (Ringer et al. 2018; Snider et al. 2017). With a focus on rapid assessment and flow of patients, it is possible that ED physicians' efforts to provide high-quality care resulted in NH residents' use of radiographical services that would otherwise not be required. Future studies should examine decisions around radiographical orders and NH residents.

Perhaps the most striking finding in this study is the fact that 33.2% of all NH residents who visited the ED received an XR scan but neither did they receive a CT scan nor were they admitted to the hospital. Furthermore, many residents spent less than two hours in the ED. Given that residents must wait for ambulances to be available to transport them

back to the NH, it appears that these residents obtained an ED assessment with imaging investigation and then were promptly discharged back to the NH. This population was 23% of all visits by NH residents for radiography and is exactly the profile of patients who could have benefited from a mobile radiography service. The 30.7% of residents with scheduled outpatient radiography appointments also appear to have been appropriate for mobile radiography service. When combining outpatient appointments with the population of quick visits to the ED for an XR scan followed by swift discharge, we believe that a significant portion (53.7%) of all the NH residents' visits for imaging would have been appropriate for mobile radiography (Figure 1).

FIGURE 1. Investigation by disposition



CT = computed tomography; XR = x-ray.

Identifying the demand for mobile radiography in New Brunswick has national implications because other mobile radiography programs in Canada primarily serve larger urban areas such as Calgary, Ottawa and Edmonton. While Saint John is an urban area, Statistics Canada (2021) classifies Saint John as a medium population centre. Identifying the demand for mobile radiography in a medium population centre opens the door for this service to be introduced in new communities across Canada as the challenge of identifying more efficient and therapeutic ways to deliver care is ubiquitous. The findings from our study have already resulted in a research grant to fund the above-mentioned mobile radiography pilot project in Saint John, which so far has been very well utilized and received. Part of this new investigation has involved exploring the experiences of residents, providers and families who have utilized the service. Collecting the perspectives of residents, families and providers is critical

to evaluating whether mobile radiography services will be accepted by communities and/or identifying targets for future improvements. Furthermore, it is our ultimate hope that local governments will be incentivized to implement mobile radiography services for vulnerable populations, and evidence of support from patients and families is critical to this end. Finally, given mobile radiography's potential to improve important patient outcomes and it currently being established in other Canadian jurisdictions, we believe that implementing mobile radiography in medium population centres would align with *Canada Health Act's* (1985) principles of universality and accessibility.

Limitations

While our findings suggest that the region could benefit from a mobile radiography service, the study is not without limitations. Reliance on retrospective data obtained from health records limits the data available for study. This includes the omission of diagnostic data in 32 records and the absence of any rationale for why or where radiography procedures were performed. Data captured in this study reflect radiography procedures that took place during the COVID-19 pandemic. Fortunately, the region had few incidences of COVID-19 during the study period, so the pandemic may have had minimal effect on the data collected. This study focused exclusively on NH residents from one health region who utilize services in two hospitals located in the same city. It is possible that the examination of NH residents located in other regions or who access services in other hospitals would have different results. This study focuses exclusively on NH residents. Other cohorts that may benefit from mobile radiography were not included in this study, including individuals confined to private homes due to disabilities, those in palliative care or hospice, residents of special care homes or individuals detained in correctional facilities. Future studies should consider an in-depth analysis of the use of radiography by NH residents, including the rationale for having them performed and their outcomes. For example, although our study analyzed the number and types of radiography received by residents, identification of the reason for the exams or the outcome was beyond the scope of the investigation.

Conclusion

Transportation of NH residents to the hospital or ED can be challenging for residents and costly to the healthcare system. While admission to the hospital and visits to the ED/urgent care will always be an important part of care for NH residents, finding new ways to deliver services, which avoid unnecessary transport, will improve resident care and healthcare efficiency. Given the number of NH residents who received radiography in an outpatient department, or in the ED before being quickly transported back to the NH, it is reasonable to conclude that there is a demand for a mobile radiography service in the region. Further work is needed to establish protocols for a mobile service, such as the type of radiography best suited for a mobile service, the payment structure for physicians reviewing the imaging and how results are communicated back to the NH.

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