LONG-TERM CARE RESIDENT TRANSFER TO THE EMERGENCY DEPARTMENT

THE ASSOCIATION BETWEEN LONG-TERM CARE RESIDENT CHARACTERISTICS AND TRANSFERS TO THE EMERGENCY DEPARTMENT: A POPULATION-LEVEL RETROSPECTIVE COHORT STUDY

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Lay Abstract

Long term care (LTC) provides residents with 24-hour nursing and personal care. When the care or clinical needs of the resident cannot be met in the LTC facility, they may be transferred to the Emergency Department (ED). However, the ED's are poorly situated to manage the distinct needs of older adults, given the sole focus on medical acuity rather than geriatric complexity. Unwarranted ED transfers are burdensome for LTC residents and increase their risk for adverse health events, such as nosocomial infections, delirium, and injuries. Understanding characteristics associated with ED transfers can help identify which residents may be at a risk of an ED transfer. The objective of this thesis was to identify which LTC resident characteristics at admission are associated with ED transfers in Ontario, Canada. A recent change in medical orders, previous ED visitation, female sex, the presence of an indwelling catheter, and the need for oxygen therapy were informative predictors for ED transfers.

Abstract

Introduction: Long term care (LTC) residents require complete or extensive support, including 24-hour nursing and personal care. LTC residents contribute a greater number of emergency department (ED) visits when compared to community-dwelling older adults. Little is known about which resident-level characteristics at admission are predictive of LTC resident transfer to the ED. The objective of this thesis was to identify which admission characteristics are associated with ED transfers in Ontario, Canada.

Methodology: I conducted a population-level retrospective cohort study using the Resident Assessment Instrument Minimum Data Set Version 2.0 (RAI-MDS). The cohort included 56,433 LTC resident admission assessments from January 1, 2017, to December 31, 2018. Logistic regression and 10-fold cross-validation were used to identify adjusted associations between characteristics routinely collected during LTC admission assessment and ED transfers. Model performance was assessed using the area under the receiver operating characteristics curve (AUC). Outcomes of interest included any ED use, potentially preventable, and low acuity ED transfers.

Results: A recent change in medical orders, previous ED visitation, female sex, the presence of an indwelling catheter, and the need for oxygen therapy were informative predictors for any, potentially preventable, and low acuity ED transfers. Deterioration in cognitive status and change in behavior was influential to any ED transfers only. Urinary tract infections, pneumonia, indictors of delirium, and change in mood are unique to potentially preventable ED transfers, and antibiotic resistance is unique to low acuity ED transfers. Similar discrimination was reached for any ED use (AUC = 0.630), potentially preventable transfers (AUC = 0.659), and low acuity transfers (AUC = 0.645).

Conclusion: The factors associated with ED transfers may be modifiable, and closer attention to these factors may help reduce ED transfers. Although the discriminability of the models was poor, advanced knowledge of informative characteristics can support upstream decision-making for clinicians. Future studies are required to validate these findings, derive risk scales, and demonstrate the utility of this model in health service planning.

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List of All Abbreviations and Symbols

LTC	Long-Term Care
ED	Emergency Department
DNH	Do Not Hospitalize
DNR	Do Not Resuscitate
CTAS	Canadian Triage and Acuity Scale
CIHI	Canadian Institute for Health Information
CCRS	Continuing Care Reporting System
NACRS	National Ambulatory Care Reporting System
ICES	Institute for Clinical Evaluative Sciences
IKN	Institute for Clinical Evaluative Sciences Individual Key Number
RAI-MDS 2.0	Resident Assessment Instrument Minimum Data Set 2.0
ICD-10-CA	International Classification of Disease version 10 (Canadian)
CHF	Congestive Heart Failure
COPD	Chronic Obstructive Pulmonary Disease
UTI	Urinary Tract Infections
ADL	Activities of Daily Living
CAPs	Clinical Assessment Protocols
QIs	Quality Indicators
OR	Odds Ratio
aOR	Adjusted Odds Ratio
AUC	Area Under the Curve

ROC	Receiver Operating Characteristic
AIC	Akaike Information Criterion
BIC	Bayesian Information Criterion
SAS	Statistical Analysis System

Declaration of Academic Achievement

I, Komal Aryal, declare my thesis to be my own research work. I am the sole author of this thesis document and was involved in all stages of the research project under the supervision of Dr. Andrew Costa. The following individuals contributed to the editing and refinement of my thesis work and acted as the members of my thesis committee: Dr. Andrew Costa, Dr. Lauren Griffith, Dr. Michelle Howard, Dr. Andrea Gruneir, and Dr. Peter Tanuseputro. To my knowledge, the content of this document does not infringe on any copyrights.

1. Introduction

1.1 Long-Term Care

Long-term care (LTC) facilities, also known as, nursing homes, house residents that require complete or extensive support, including 24-hr nursing and personal care and help with most or all daily activities. In 2019, 115,000 LTC residents were living in an LTC facility, in Ontario.[1] Ontario has 627 licensed LTC facilities with a total of 77, 324 long-stay beds and 1,438 short-stay beds in the province.[1] Due to increasing demand for LTC facilities in Ontario, as of February 2019 there is a 161-day (5 months) average wait time for potential placement into LTC facility and there are 34, 834 citizens in Ontario waiting for long-stay LTC beds.[1, 2] The Ontario government is working towards adding 30,000 LTC beds over the next 10 years. In 2010 Ontario placed stricter regulations for admission to LTC. This means that the population of LTC residents at admission are more likely to be frailer, have multimorbidity, be at a later stage in cognitive or physical impairment, and greater overall instability.[2]

LTC residents have a complex health history that clinicians need to assess effectively to prevent LTC resident deterioration or need for emergency services. Recent data reports that up to 90% of Canadians living in LTC facilities have some form of cognitive impairment and 86% of these residents need extensive assistance with activities of daily living (ADL).[3] Symptoms of depression and response behaviors such as residents being physically or verbally abusive, wandering, or require restraints, are also common in LTC populations.[4, 5] Further, LTC homes have reported numerous falls and fractures which require additional attention.[6] The complex health history of LTC residents and changes in care providers that break relational continuity, pose challenges in providing appropriate care at admission.[7]

1.2 Long-Term Care Resident Transfers to the Emergency Department

Despite having access to 24/7 nursing services, LTC residents transferred to the ED have higher ED visits and repeat ED visits than community-dwelling residents.[8] One-quarter of LTC residents visited the ED at least once in six months and the average time spent in the ED was 11 hours and 30 minutes.[9, 10]

1.2.1 Decision-Making for an ED Transfer

If the needs of an LTC resident cannot be met in the facility in a timely manner, LTC staff will decide whether the residents should be transferred to the ED. The decision to transfer an LTC resident to the emergency department (ED) is based on whether the transfer will help improve clinical outcomes, maintain a better quality of life, or because the facility has insufficient resources available to care for residents in the facility.[11] Limited staffing capacity such as access to a same-day physician might increase the risk of a LTC residents transfer to the ED.[12, 13] LTC residents and their family members perspectives can also influence transfer decisions.[14] If decisions at admission using this information are made, potentially avoidable ED transfers may be prevented.

1.2.2 Challenges in Providing ED Care for LTC Residents

Although LTC residents do not contribute to a substantial portion of overall ED visits, their complex health history presents challenges when providing emergency care. ED providers are less familiar with the needs of frail, LTC residents posing difficulties in providing acute care.[15] In many cases, residents, out-of-hospital care providers, and ED or LTC facilities are not provided with sufficient patient information or communication methods when transferred to the

ED.[15-23] This places distress on ED staff when diagnosing or treating the resident and can lead to poor resident outcomes.[24] Therefore, when possible, mitigating potentially preventable or non-urgent visits and improving care in LTC facilities is often imperative.[25, 26]

There is a large cost to transfer LTC residents or older adults to the ED. A U.S. study highlighted that an ED transfer for an older adult can cost between $4,000-$6,000 per ED visit.[27, 28] Between 2005-2006 in Ontario, an ED visit alone was $148, with higher costs associated with LTC residents.[29] Excessive low acuity or potentially preventable visits may strain the limited resources present within the health care system.

The ED is often a reasonable choice of transfer for LTC residents in need of acute care. However, opportunities to avoid the ED would probably serve them better and be less disruptive since the LTC resident transfer does not only burden the ED but also the residents.[30] For example, there is a risk that residents can become confused and disoriented because of the intensive diagnostic screening tests, imaging studies, and procedures.[31] Transfers from the LTC facilities to the ED can result in resident impairment in unfamiliar environments, resulting in confusion for cognitively impaired residents.[32] Further, residents are seen by physicians who may not know their health history presenting challenges in providing care specific to the needs of the residents.[32] Residents can also be exposed to compromised quality of care, safety risks, and hospital-borne infections or diseases.[33] Specifically, there was a three-fold increase in the risk of new and most likely hospital-acquired gastrointestinal or respiratory tract infection for LTC residents transferred to the ED.[34] In addition, LTC residents receiving palliative care have a pre-specified care plan; however, 56% of palliative LTC residents are still transferred to the ED.[35] Reasons for palliative care residents transfer include the lack of clinical expertise, discomfort with end-of-life communication, family availability, and lack of resources.[35] Although it may be

challenging to provide appropriate care in the LTC facilities, understanding the risk of an ED transfer is imperative so alternative solutions can be investigated.

1.2.3 Intervention to Reduce LTC Resident Transfers to the ED

Evidence suggests that transfer checklists, tool, and telemedicine protocols can reduce ED transfers.[36-40] The use of tools to assess whether the transfers could have been mitigated with early primary care intervention or better management of acute needs have shown to be promising in limiting ED transfers.[41, 42] Most facility-level interventions require complicated consensus-building between ED and LTC staff, ambulance services, and interorganizational relationships.[43, 44] Better management of diseases and preparing advance care directives during admission can reduce such avoidable transfers.[45] To overcome this, researchers have been working on developing an instrument to understand whether LTC residents are transferred inappropriately to the ED. This instrument highlights the poor quality of care and the assumption that the needed care would be received at the ED were two primary factors in avoidable transfers.[41]

1.3 Literature Review of Characteristics of LTC to ED Transfers

1.3.1 Search Methods

A literature review was conducted to understand the resident characteristics that previous studies have investigated which have the greatest risk or odds of LTC resident transfer to the ED. The literature was conducted using the following electronic databases: (a) Medline Epub Ahead of print, In-Process, and Other Non-Index citations (1946 to February 2019) and EMBASE (1974 to February 2019).[46] To ensure that all the literature on ED transfers was gathered, an academic-affiliated librarian was consulted to support the development of the search strategy and

the extraction of literature. No restrictions were placed on time, language, or sample size. The syntax applied to both search engines can be found in *Appendix A.* A total of 529 articles were identified from Medline (1947 to present) and 1229 articles were identified from EMBASE (1974 to present). There were 1327 articles for screening after removing duplicates. Upon title and abstract screening, there were 260 articles reviewed for full-text analyses.

1.3.2 LTC Resident Characteristics Associated with ED Transfers

LTC residents transferred to the ED are younger, more likely to be male, and have a do not hospitalize order.[31] Pneumonia, infections including Urinary Tract Infections (UTI), cellulitis, pressure sores, and leg ulcers, stroke, falls/injuries, bleeding, cancer complications, and feeding tube complications gastrointestinal symptoms, mental status changes, and dyspnea are highlighted as variables most commonly present in LTC residents who are transferred to the ED.[47-50] The most common cause of injury resulting in ED transfer was slipping and falling, leading to traumatic brain injury.[51] Specifically, in Canadian studies, respiratory problems, chest pain, and falls have been suggested to be the main reasons for transfer.[31, 52, 53] Cognitive impairment and dementia have been found to be protective for transfers to the ED.[54] Specifically, residents with mild cognitive impairment are at higher risk of an ED transfer compared to those who are cognitively in tack, or those with more severe cognitive impairment.[55, 56] ED visit rates do not differ much between Canada and the US indicating that health insurance coverage may not have a substantial impact on emergency care.[57]

Advance care directives, including do not hospitalize orders, are inconsistently documented, and can decrease the likelihood that the LTC resident wishes are understood or followed.[58, 59] When a do not hospitalize (DNH) is reported, residents had fewer ED visits (2.8%

vs 3.6%, *p*= 0.03) in the last 90 days compared to those who do not have a DNH, suggested that their resident wishes influence transfers.[60] LTC residents transferred to the ED are more likely to receive resuscitation (OR of 1.559 95% CI: 1.409-1.725, p<0.001) compared to other older adults.[61] Residents who have a DNR or a DNH have a lower odds of dying in acute care.[62] The literature suggests that NH residents are transferred for end-of-life care as NH access to a physician is inadequate and cooperation between LTC facilities and the ED is often poor.[63] Therefore, end-of-life care and advance care directives within LTC facilities need to be examined as a factor of an ED transfer.

1.3.3 LTC Facility Characteristics Associated with ED Transfers

Factors associated with an ED transfer are not limited to resident characteristics but also facility characteristics. Being in close proximity (approximately 5 minutes) to the ED, having a larger facility size, and having a higher number of residents transferred to ED from the facility is associated with greater odds of ED transfer.[5] A concern with ED transfers is that the ownership model where public ownership has been associated with lower ED transfer rates compared to for-profit ownership (incidence rate ratio = 0.65, 95% CI 0.59 to 0.71) and non-profit ownership (incidence rate ratio = 0.68, 95% CI 0.62 to 0.74).[64-67] Facility characteristics should be examined as a factor of ED transfer whenever possible.

1.4 Low Acuity or Potentially Preventable Emergency Department Transfers

Literature suggests that 20%-30% of transfers are perceived to be avoidable or low acuity.[68-73] However, defining low-acuity and potentially preventable transfers poses challenges since both these definitions are complex and are used at the ED level to determine whether the

transfer was necessary or appropriate. For example, a low acuity ED transfer is a potentially non-urgent visit, defined as a transfer where the LTC resident transferred to the ED receives a score of four or five on the Canadian Triage and Acuity Scale (CTAS).[10] However, this score is given based on what the ED perceives as a non-urgent visit which does not factor in the availability of resources at facilities or patient choices.[74] Potentially preventable or ambulatory care sensitive ED visits are defined as ED transfers associated with conditions that may be prevented entirely or managed within LTC facilities.[75] Prior literature has identified ED transfers for injury, transfers with normal triage vital signs, and transfers associated with diagnostic testing to be potentially preventable.[76] However, defining preventability poses challenges as each resident diagnosis and symptoms may require individualized assessment.[77] Although these definitions may not be completely accurate in all cases, they allow clinicians and researchers to identify areas of improvement or avoid potential transfers to the ED in the future.

Female sex, nonmedicalized transport, publicly owned LTC, and lack of access to a geriatric consultation have been associated with inappropriate transfers to ED.[78] The most commonly reported potentially preventable resident characteristics were pneumonia, urinary tract infection, and congestive heart failure, and the most common cause of low-acuity ED visits was having a feeding tube and fall-related injury.[10, 79] Most potentially preventable visits by LTC residents involve ambulance transport.[10, 80] A Canadian study identified that the most common CTAS score for LTC residents transferred to ED was 4, which is defined as a low acuity visit.[81]

1.5 Multivariable Models of LTC Resident Transfers to the ED

The literature has identified similar LTC resident characteristics associated with a transfer to the ED. For example, Xu et al. conducted a study using data collected from the

Minimum Data Set (MDS) 3.0 between 2011-2013 in the US where they reported a 43-variable model for any ED visit and a 39-variable model for potentially avoidable ED visits.[82] Xu et al., also reported a McFadden's pseudo R^2 of 0.20 and 0.15, indicating good model performance. Key predictors highlighted to be influential for transfer are sociodemographic variables including age and binary sex, infections, falls, internal bleeding, shortness of breath, anxiety, or cardiovascular events, and vomiting. However, many of these variables were not significant due to large confidence intervals crossing one and *p*-values greater than 0.05. Similarly, another study conducted by Wang et al., assessed all ED visits and LTC resident characteristics from 2005-2008.[83] Wang et al., reported that the most significant characteristics associated with LTC resident transfer to the ED were a fever (odds ratio (OR) = 1.9, 95% CI = 1.5–2.4) or hypotension (systolic blood adjusted odds ratio (aOR) = 1.8, 95% CI = 1.5–2.2).[83]

Another study looked at the relationship between LTC resident characteristics and potentially avoidable hospitalization, which included admission and ED transfer. This study outlined that there was a higher odds ratio for a potentially avoidable hospitalization if the resident had a history of Chronic Obstructive Pulmonary Disease (COPD) or Congestive Heart Failure (CHF), or an infection a reoccurring UTI, with a c-statistic of 0.644 for this model.[77] In contrast, a US study focused on LTC characteristics that had a quicker time to hospitalization or ED visit. Specifically, previous hospitalizations, the presence of infections including cellulitis, abscess, and/or skin ulcers, and the presence of comorbidities had significant hazard ratios.[84] The literature consistently highlights COPD, male sex, younger age, CHF, having no DNH order, the absence of dementia or Alzheimer symptoms, and the increasing number of prescriptions to be associated with greater odds of being transferred to the ED or hospitalized from the LTC facilities.[85, 86] However, LTC characteristics such as, urban areas, absence of an internal

pharmacy, and not having a personalized care project in NH's also contributed to greater odds of transfer.[87]

In a study conducted by Chang et al., machine learning models that use neural network learning algorithms were conducted using electronic medical records to predict which LTC residents would decompensate within 72 hours and require an emergency department transfer or hospitalization.[88] The AUC of the proposed model on the testing dataset was 0.895, indicating excellent diagnostic accuracy, showing promising results for this model. The use of similar analyses to understand if the risk of an ED transfer can be predicted will allow for specific interventions to be assessed.

1.6 Need for This Study

Frequent use of the ED by LTC residents is commonly reported in Canada and internationally. Multiple studies have highlighted that a sizable proportion of these visits can be categorized as non-urgent or potentially preventable, such that circumstances, where LTC residents require immediate care, can be managed outside of the ED. A plethora of studies have identified the different demographic, facility and clinical characteristics for residents transferred appropriately and inappropriately to the ED and which resident level characteristics put residents at a greater odds ratio of transfer to the ED. However, there are no available comprehensive, population-level explanatory models that describe which resident level characteristics are most predictive of any, a potentially preventable, and a low acuity ED transfer.

2. Objectives, Research Questions, and Hypotheses

The objective of this study was to derive explanatory models to determine which resident level characteristics at admission are most informative of transfers to ED and to determine the absolute potential to predict ED transfers upon admission using available data. Specifically, this study sought to answer the following research questions:

1. For all LTC residents in Ontario admitted to an LTC facility from 2017-2018, which LTC resident characteristics are associated with a risk of transfer to the ED for any, potentially preventable, or low acuity ED transfer?

    Hypothesis: Having more chronic conditions, the number of medications, and less cognitive impairment are resident level factors most associated with ED transfers. Resident level factors most associated with potentially preventable and low acuity ED transfers are infections and respiratory or cardiovascular symptoms and conditions.

2. What is the absolute potential to predict ED transfers within 92-days of admission using information already available to LTC staff in Ontario?

    Hypothesis: The potential to predict ED transfers within 92-days of admission will be similar to that already reported in the limited literature and will not exceed a receiver operating characteristic (ROC) area under the curve (AUC) of 0.7.

3. Methods

3.1 Study Design and Settings

A population-level retrospective observational cohort study was conducted. This study identified baseline characteristics of LTC residents' that are most predictive of ED transfer from LTC facilities across Ontario, Canada between 2017-2018. This study was reviewed and approved by the Hamilton Integrated Research Ethics Board (HiREB; approval number 40906). This study is reported in accordance with the Strengthening the Reporting of Observational Studies Initiative.[89]

3.2 Data Sources and Measurement

The cohort for this study was developed from different databases which collected, stored, or linked, clinical data from all LTC facilities across Ontario, Canada.

3.2.1 The Continuing Care Reporting System

The Continuing Care Reporting System (CCRS) is a national reporting system that contains clinical and administrative data from most LTC facilities across Canada and all facilities in Ontario.[90, 91] It is based on the validated Resident Assessment Instrument Minimum Data Set (RAI-MDS) 2.0, a standardized clinical assessment which was developed by a non-for-profit international research network, interRAI.[90] Residents are assessed using the RAI-MDS 2.0 tool at admission, quarterly, and when any significant health status change occurs. Data collected using the RAI-MDS 2.0 included resident demographics, functional status, and clinical status.

Additional information that is collected is facility demographics and advance care directives. This repository contains high quality and complete data on LTC facilities throughout Ontario.[92]

The RAI-MDS 2.0 has decision-support algorithms that summarizes the information in the assessment to guide clinical and organizational decision making. There are four unique domains of these algorithms including, outcome scales, Clinical Assessment Protocols (CAPs), Quality Indicators (QIs), and case-mix systems. There are two outputs that were included in the development of the model. Outcome scales will combine variables from the RAI-MDS 2.0 assessment to summarize a specific clinical domain for residents. Relevant scales include changes in health, end-stage disease and symptoms scale, revised cognitive performance scale, depression rating scale, Activities of Daily Living (ADL) Hierarchy, pain scale, and detection of indicators and vulnerabilities for emergency room trips scale. QIs are summary measures that reflect the presumed quality of care across key domains such as safety, health status, appropriateness, and effectiveness.

3.2.2 The National Ambulatory Care Reporting System

The National Ambulatory Care Reporting System (NACRS) database at the Canadian Institute for Health Information (CIHI) is a national database that captures visits to facility-based or community-based mandatory ambulatory care. This data is collected for all ambulatory care services including ED visit use information. Data pertaining to LTC resident transfer to the ED from LTC facilities are captured in this database and are regularly used for research purposes. This ED transfer data is then screened and linked to the CCRS data. Researchers can then identify LTC residents who were transferred to the ED.[57]

3.2.3 Institute for Clinical Evaluative Sciences

The analytic cohort for this study is comprised of the CCRS and NACRS. The Institute for Clinical Evaluative Sciences (ICES), across Ontario stores health care data from these sources for analysis. This data is linked to an individual participant's file using their ICES Individual Key Number (IKN), a unique identifier that anonymizes the individual's identity for analysis across all databases. To access this data ethical approval must be sought to maintain participant confidentiality and prevent a data breach.

3.3 Participants

Participants were selected for this study from the CCRS if they were admitted to the LTC facilities between January 1st, 2017 to December 31st, 2018. This study focused on the admission assessment since the risk of an ED transfer is higher for newly admitted LTC residents.[93] Therefore, all LTC residents residing in Ontario with a completed admission assessment were assessed for inclusion in the study (*Table 1*). Any LTC facilities that did not require the completion of an RAI-MDS 2.0 admission assessment and new residents for whom an admission assessment was not completed were not included in the study. Reasons for an incomplete admissions assessment include, but are limited to, death and emergent or immediate care required at that time. To ensure that the study population was for Ontario residents, any visiting LTC residents or residents, not from Ontario were excluded from the analyses.

Table 1: Summary of Inclusion Criteria Participant Selection

Inclusion Criteria	**Rationale**
Completed admission (index) assessment	Participants must have a full and completed RAI-MDS 2.0 admission assessment.
Ontario resident	Participants must be a legal resident of Ontario.

After selecting the records of individuals who had a complete RAI-MDS 2.0 admission assessment and resided in Ontario, a set of exclusion criteria were applied, and the final cohort was created (*Table 2*). Residents with an invalid ICES Key Number (IKN) were excluded to ensure no privacy breach would occur and residents remained deidentified. Short stay residents were excluded as their care needs and management requirements are different from long-stay residents. Long-stay residents were selected as they account for most of the care provided in the facilities. Small LTC facilities, defined as facilities with less than 25 beds, were excluded as some of these facilities do not operate in the same manner as the larger facilities and are usually a unit or a subsection of a hospital or another care facility.[5] Thus, ED transfer for this population is different than the general LTC population and this group of LTC residents were excluded.

Table 2: Summary of Exclusion Criteria Participant Selection

Exclusion Criteria	**Rationale**
Short stay residents	Short stay residents are residents with a predefined duration of stay in the facility (less than 3 months).
Small-sized LTC facilities (<25 beds)	Smaller LTC facilities tend to be connected to a hospital or part of a hospital ward so their transfer policies are not the same LTC facilities that are independent from hospitals.
Invalid IKN	To ensure resident identities remain confidential and accurate information is linked between databases.

Residents transferred to another LTC facility, transferred to palliative care or hospice, discharged to the community, or residents who died in the LTC facility before the 92-day period were included. Previous literature suggests that residents transferred to the ED compared to residents who are not transferred to the ED are more likely to experience hospitalization or mortality within the hospital setting.[31] Thus, including transferred residents, accounted for all

LTC residents who were admitted to the LTC facility increasing generalizability and preventing potential bias when generating estimates for this population.

3.4 Variable Selection and Handling

The CCRS data includes all variables from the RAI-MDS and interRAI derived scales that are validated for LTC residents.[90] For this study, all variables were equally considered in the model building process.

3.3.1 Variable Categories

The variable categories for this model were assigned using Gruneir's conceptual framework illustrating factors that influence ED use by older adults, which was adapted from the Andersen and McMusker model (*Figure 1*).[94] The RAI-MDS2 2.0 variables are primarily considered to be need factors, which are medical diagnosis or health conditions.[95] In the Gruneir et al., reconceptualized model, the need factors were reconceptualized to the necessity of care in the ED at the time of the ED visit.[94]

Variables from the RAI-MDS 2.0 that were categorized as need variables for ED care are *falls or injuries*, specifically recent falls or injuries in the last thirty days. Change variables or deterioration variable included, which would require acute care services are, *change in ADL performance, change in behaviors, change in mood, deterioration in cognitive status, change in the amount of food consumed, change in physician orders, change in lab values, change in medication,* and *change in urinary continence.* Complication or exacerbations resulting from illnesses would require acute care services and would be defined as need factors. The diagnostic variables that were included are, *CHF or other cardiovascular diseases, asthma* or *COPD,*

Alzheimer's or dementia, renal failure, or infections, such as *pneumonia, cellulitis, antibiotic resistance, and UTI*. The use of apparatuses can present complications and may also result in the need for ED transfers for LTC residents. These variables were *indwelling or intermittent catheter* or therapies such as, *chemotherapy, dialysis*, *oxygen therapy, radiation, transfusions*, and being on *ventilators or respirators*. Characteristic variables were categorized as need variables such as *age,* greater than 65 years. Finally, health service use variables such as, whether the resident had *visited the ED in the last 30 days*, or whether they had *visited the hospital in the last thirty days* were defined as need factors for the ED variables.

Although limited, the RAI-MDS 2.0 contains preventative ED utilization variables that require management of patient needs within the LTC setting. These variables were the residents having a *do not hospitalize* or *do not resuscitate* order. The RAI-MDS 2.0 reports one variable that is defined as a marker of health system failure to meet the needs of older adults already exposed to the ED. This variable was living in a *rural* community, which results in difficulties to access ED services because of scarce resources disparities in health care services.

Although all these variables were categorized into three unique categories, the interpretation of the variable definition and reason for ED transfer may change. For example, if the reason for LTC resident's visit the ED is because of poor management at a primary care level, then this could be categorized as a health systems failure variable. However, data pertaining to the reason of transfer and previous management strategies would be required. Since additional information regarding ED transfers is not currently available the variables from this study were distinctly categorized based on their definition in the RAI-MDS 2.0.

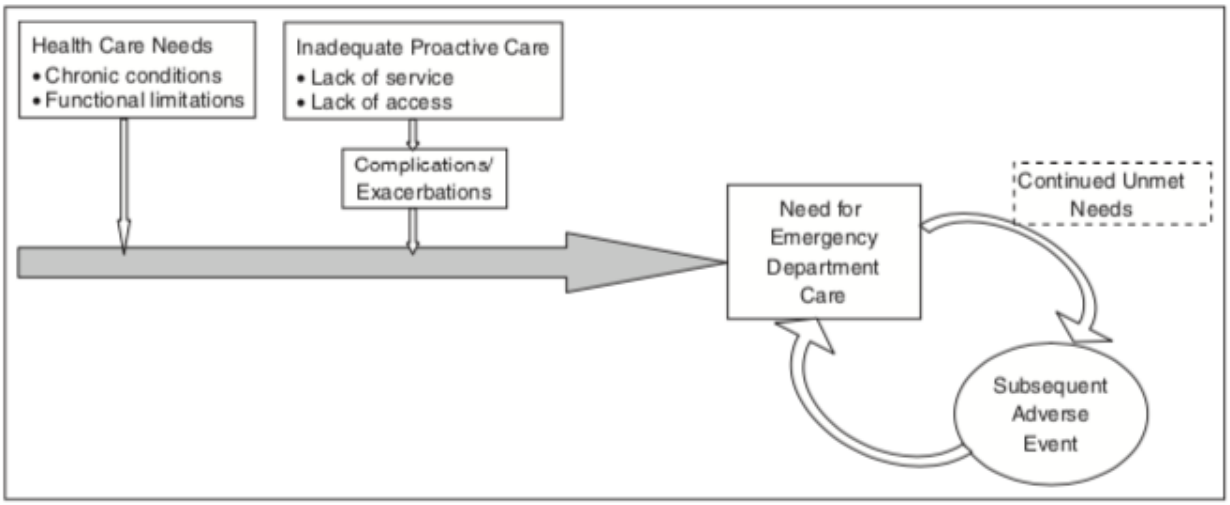

Figure 1: Gruneir's Conceptual Model Illustrating Factors That Influence ED Use by Older Adults Adapted from the Andersen (1995) and McCusker et al. (2003) Models[94]

3.3.2 Variable Selection Process

The literature, clinical insight, and statistical significance from univariate and multivariable analyses were combined to create the most clinically meaningful model. With many variables reported on the RAI-MDS 2.0, a systematic approach was taken for variable selection. First, each variable was individually analyzed and assessed. The frequency and missingness of each variable were reported. Variables not pertaining to the admission assessment or variables that could not be assessed at admission were eliminated. interRAI scales were included in the variable selection process. These scales use a combination of variables from the RAI-MDS to allow for more interpretable results.[90] The scales and the individual variables that make up the scale were assessed using univariate and multivariate analysis, clinical expertise, and previous literature before selecting the variable of interest. Scales that do not pertain to the outcome of transfer to the ED were excluded from the model.

When developing clinically relevant explanatory models, it is imperative that previous literature and clinical expertise is used for guiding variable selection. Thus, an ED clinician and an LTC geriatrician were recruited to discuss potential variables that have clinical significance in

this model.[96] Variables that are highly correlated were combined or removed based on clinical judgment and previous literature. Then variables were dichotomized or grouped into binary categories to efficiently assess the variables. When developing clinically relevant explanatory models, it is imperative that previous literature and clinical expertise are used for guiding variable selection. Thus, an ED clinician and an LTC geriatrician were recruited to discuss potential variables that have clinical significance in this model.[96]

Steyerberg states that 10-20 variables make an effective prediction model.[96] A hybrid model was employed for clinically relevant feature selection that focused on statistical significance and clinical selection as researchers report the importance of clinically driven models.[96] Two clinicians independently selected the topmost influential variables selection in the model and collaborated about the final clinical decision. This clinical decision making will add clinical strength to the model. For statistical analysis, the most influential variables in the model were selected using chi-square scores of all predictors. The final variables were selected after combining the results of the statistical and clinical analysis of variables.

3.3.3 Outcome Measurements

Three outcomes were assessed to understand unique resident level characteristics that influence transfer to the ED. All outcomes were reported as a binary outcome of 1, experiencing a transfer to the ED, or 0, having experienced no transfer to the ED. Any ED visit was measured as any number of transfers to the emergency department with the 92-day follow-up period. Potentially preventable visits, also known as ambulatory care sensitive conditions, are defined as transfers that could have been avoided if primary care had managed the condition at an earlier stage.[10] This definition has been validated for the LTC population and the International

Classification of Disease version 10 (Canadian) (ICD-10-CA) codes for potentially preventable conditions are found in *Appendix B.*[10] This definition is given to resident conditions at the ED level and is intended to identify areas where primary care and medical management can help minimize potentially preventable ED transfers. Low acuity visits were defined as any ED visits where the transferred resident scores a 4 out of 5 or 5 out of 5 on the CTAS, indicating a non-urgent transfer and the resident had returned to the LTC facility after the ED visit.[97] This score is given to residents when transferred to the ED at the time of triage. This scoring system is used to prioritize the urgency of seeing a medical provider in the ED. Transfer to the ED was assessed as opposed to hospital admission as previous literature revealed that 45% of LTC resident transfers to the ED did not lead to hospitalizations.[10]

For this cohort, any ED visits are transfers to the ED for any reason, including a potentially preventable or low acuity visit. The first ED visit by an LTC resident within 92-days was recorded as the LTC resident having an any ED visit outcome. If the first ED transfer was a potentially preventable visit, then this resident was included in the any ED visit outcome group and the potentially preventable outcome group. This was the same for any ED transfers and low acuity ED transfers. An ED visit that could be defined as both, low acuity and potentially preventable were included in both outcomes and if it was the first ED transfer then it was included in the any ED visit outcome as well. If multiple ED transfers occurred within the 92-day follow-up period, the first any, potentially preventable, and low acuity ED transfer to occur was recorded for each outcome.

3.5 Potential Biases

The primary bias for this study was the loss of follow-up period for the cohort. Specifically, residents that died or were transferred out of the LTC facility before the three-month follow-up period were included in the cohort. This was to promote the generalizability of the results and ensure the results were not biased to residents without competing risks. However, since these events have competing risks it might diminish the true effect of the transfer. A sensitivity analysis was conducted to account for any potential differences in the outcomes, where LTC residents who died or were transferred were removed.

A retrospective study design can limit the variables that can be assessed as secondary data is being used. There are variables that would improve the accuracy of the model, such as resident choices, resident family involvement, and LTC staff dynamics. Since these variables are not included in the CCRS, they were not available for data analysis. However, the selection of routinely collected data was used to analyze previous trends that are reported across the province using a standardized assessment to potentially use that to inform future decisions. Further, the retrospective design cannot fully rule out confounding as only known confounders can be controlled for.[98] This potentially presented biases in this study. Without these unknown confounders being controlled, the results may have been skewed.

3.6 Sample Size

All admission assessments reported from LTC facilities across Ontario, Canada between 2017-2018 were examined. This includes not-for-profit homes, private, and municipal facilities. Although sample size calculations were not completed, Steyerberg's recommended guidelines of a generous sample size including 250 events and 250 non-events for the sample was followed.[96] The Prediction model Risk Of Bias Assessment Tool suggests that an event per variable of

greater than 20.[99] A large dataset was examined with a hypothesized sample size of over 50,000 observations and over 10,000 events. Both considerations would be met with the hypothesized sample size and the large dataset would, therefore, not require a specific sample size calculation.

3.7 Statistical Methods

3.7.1 Descriptive Analysis

The total number of LTC residents transferred to and not transferred to the ED from the cohort were tabulated. The total number of LTC residents who had experienced an any, potentially preventable, or low acuity ED transfer were reported as independent outcomes. The descriptive statistics for all three groups were analyzed: age, sex, diagnoses, number of chronic conditions, ADL's, cognitive impairment, accidents/falls, new medications, abnormal lab values, presence of advance care directives (DNR or DNH), and rural facilities. Continuous or ordinal variables were recategorized as binary variables and assessed for frequency using chi-square tests to understand the differences between residents that were transferred to the ED compared to those that were not transferred. Descriptive statistics of residents that were transferred out of the facility or died before the completion of the follow-up window were reported separately to understand potential characteristic differences in the population.

3.7.2 Regression Analysis

The internal validity of the data was first assessed to understand the frequencies and missingness of the outcome variables using both univariate and multivariate regression methods. Variables with greater than 10% missingness were removed as imputing a large amount of data can potentially bias the results in large datasets.[100] When 5-10% of the data is missing then multiple imputation using K-Nearest Neighbour was used to impute the missing data and this was conducted within the resampling method. When less than 5% of the data is missing pairwise deletion was employed.

Multicollinearity was assessed before the development of the model. Variables that were strongly correlated with a correlation matrix value of 0.8 or more, a VIF 10 or more and a tolerance statistic of 0.2 or less were independently assessed. Univariate analyses were conducted to understand the importance of each variable in the model. Clinical expertise and previous literature were used to guide the selection of which correlated variable should be included in the model.

Statistical significance, clinical insight, and previous literature were used to determine the most important predictors for this model. The best subset model was employed to see the top 20 statistically significant predictors. Two independent clinicians, an ED trauma nurse, and an LTC geriatrician, independently selected the top 20 most important variables to clinical practice. The predictors included in other ED transfer explanatory models in the literature were recorded separately. Results from all three selection methods were analyzed and consolidated to select the top predictors to be included in the model building process.

Binary logistic regression was used due to understand the association of the independent variables to all three independent outcomes. Backward variable selection methods were used to determine the independent predictors associated with LTC resident transfer to the ED.

Researchers have reported that regression methods and machine learning algorithms have very little to no difference on populations with large datasets therefore, this regression method was selected.[101] Backward elimination modeling was used since it is less likely to have suppression effects, where a predictor is only significant when another predictor is held constant and backward elimination tends to have greater validity.[96] Other models such as forward modeling increase the chance for type two error.[102] To understand the model fit, the AUC was analyzed. An AUC of 0.6-0.7 would be defined as having a poor discriminatory ability, 0.7-0.8 is acceptable, 0.8-0.9 is excellent, and 0.9 indicating a model with outstanding abilities to correctly distinguish transferred resident characteristics.[103] Further, the Akaike Information Criterion (AIC) and Bayesian Information Criterion (BIC) were analyzed to understand whether adding predictors to the model contributes to the overall model fit and it helped identify the most parsimonious model.

Predictive accuracy was tested using a 10-fold cross-validation technique. This process randomly split the data into a 90% training sample and a 10% validation sample ten times. This generated the average performance measure from the ten rounds to prevent model fit.

All analyses were completed using SAS version 9.4.

3.7.3 Sensitivity Analyses

Two sensitivity analyses were conducted to better understand the model and the data. First, the best subset regression with the largest chi-square score was assessed to see if it created a more parsimonious model compared to a backward elimination process. This was then compared to a backward selection with a significance level of <0.01 to identify the stronger model. If adding more predictors was not influential to the model, then this was highlighted

through the best subset regression. Traditionally, best subsets go through iterative processes of model testing which can easily result in overfitting.[96] However, cross-validating and analyzing large data may overcome this barrier and allow for a more parsimonious model. Sensitivity analysis was used to determine which model better represented the data using the AIC, BIC, and the ROC curve.

Another sensitivity analysis was conducted to understand the influence of resident death or transfers out of the facility on the model. This study wanted to investigate whether the baseline characteristics changed for the cohort since this population could not be followed for the complete follow-up period and had competing risks. The AIC, BIC, and ROC values were reported and analyzed for backward regression models and for a model where the population did not include these residents.

4. Results

4.1 Cohort Selection

The cohort construction is summarized in *Figure 2*. Between January 1st, 2017 to December 31st, 2018, there were a total of 685,061 assessments in the CCRS. The 684,439 assessments were linked to a valid IKN whereas the 622 assessments with invalid IKN's were removed from the study cohort. To ensure short-stay residents were excluded from the cohort, the 11,127 that had been reported as a short-stay resident were removed from the cohort. There were 428,766 assessments that did not indicate the duration of the stay and were included in the cohort, to ensure that those who stay for the follow-up duration are included. Residents from the unknown length of stay category who have a short duration of stay (less than 92 days), would be captured in a transferred out of the LTC facility variable and were kept in the cohort at this stage. All annual, significant change in status and quarterly review assessments were excluded (n=616,449). Small LTC facilities, that may be connected to hospitals or use different transfer systems, were excluded from the study to ensure that the care received by LTC residents at their respective facilities was consistent (n=215).[5, 104, 105] Since there was a small population of residents from smaller facilities, removing this population will not have a large effect on the cohort size. Residents could be discharged to other LTC facilities such that they would contribute to two admission assessments. In this scenario, the first assessment was included. When assessed, there were no transfers from one facility to another where two admission assessments for the same resident were conducted therefore, the total cohort included 56,433 LTC residents.

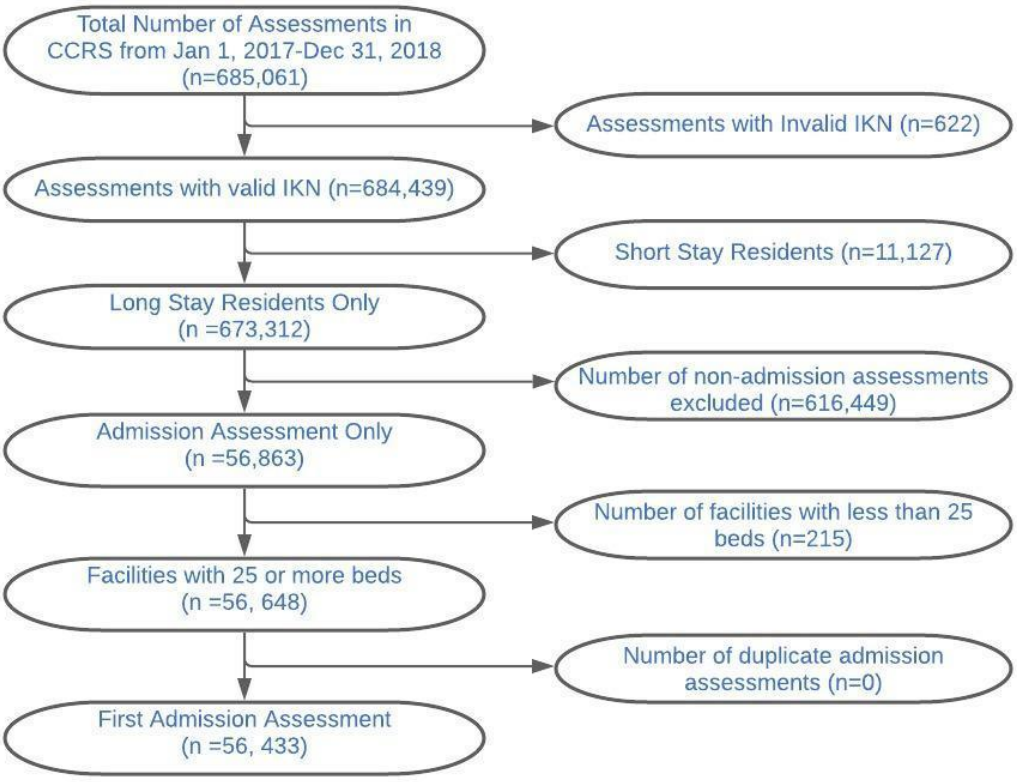

Figure 2: Flowchart Outlining the Creation of the Cohort Based on Inclusion and Exclusion Criteria

4.2 Descriptive Findings

Table 3 provides an overview of resident level characteristics stratified by residents who were transferred and not transferred to the ED within the first three months after admission, including residents in the cohort who died or were transferred. *Appendix C* provides an overview of the clinical characteristics for the cohort of residents who had died (n=5,975) and residents who were discharged (n=13,055) from the LTC facility without return, before the 92-day follow-up period. Age, sex, living in a rural community, and polypharmacy are similar in both groups. There are fewer residents transferred to the ED if they have a DNR or DNH, had a fall or accident in the last 30 days, have any of the listed diagnoses, and experience pain. Most change

variables also had a higher percentage of residents not transferred to the ED except residents experiencing deterioration in cognitive status which is higher for transferred residents.

Table 3: Characteristics of Ontario Long-Term Care Resident's Transferred and Not Transferred to the ED within 92-days of Admission

Variable	**Groups**	
	Transferred to ED (*n*=12,829)	**Not Transferred to ED (*n*=43,604)**
Advance Care Directives		
DNR	8,462 (14.99)	30.172 (53.47)
DNH	2,527 (4.48)	11,243 (19.92)
Demographic Variables		
Female	7,493 (58.41)	28,175 (64.62)
Age **< 64** **65+**	 824 (6.42) 12,005 (93.58)	 2,220 (5.09) 41,384 (94.91)
Living in a Rural Community	1,755 (13.68)	6,557 (15.04)
Medications		
Polypharmacy **=/<5 meds** **>5 medications**	 1,464 (11.41) 11,365 (88.59)	 7,343 (16.84) 36,261 (83.16)
Accidents		
Falls/Injuries in the Last 30 days	3,442 (6.10)	9,415 (16.68)
Change Variables		
Deterioration in Cognitive Status	7,493 (58.41)	2,358 (5.41)
Deterioration in Behaviors	914 (1.62)	2,811 (4.98)
Decline in Mood	914 (1.62)	2,860 (5.07)
Deterioration in ADLs	1,694 (3.00)	5,294 (9.38)
Change in Urinary Continence	775 (1.37)	2,472 (4.38)
Leaves 25% of Food Uneaten	4,426 (7.84)	13,254 (23.49)

Pain		
Experiencing Pain	1,389 (2.46)	3,920 (6.95)
Diagnoses		
Alzheimer's or Dementia	7,392 (13.10)	27,637 (48.97)
Neurological Diseases	4,724 (8.37)	15,381 (27.26)
Congestive Heart Failure	2,410 (4.27)	5,745 (10.18)
Cardiovascular Disease	9,947 (17.63)	32,761 (58.05)
Asthma or COPD	2,968 (5.26)	7,736 (13.71)
Musculoskeletal Diseases	3,611 (6.40)	13,257 (23.49)
Renal Failure	1,906 (3.38)	4,630 (8.20)
Depression	3,330 (5.90)	11,182 (19.81)
Pressure Ulcers	2,266 (4.02)	5,741 (10.17)
Treatments, Procedures, and Devices		
Bed Rails or Restraints	4,900 (8.68)	16,374 (29.01)
Indwelling or Intermittent Catheter	1,330 (2.36)	2,567 (4.55)

4.3 Variable Selection

All the variables from the CCRS were assessed in this study. There were 728 variables that were recorded in the CCRS from 2017-2018. From this, 90 variables were excluded as they were fully missing where no observations were reported for that variable. Then, 78 variables were removed as they had partial missingness, defined as a variable with greater than 85% of missing observations and thus would not be a significant predictor. 60 variables were excluded as they were variables that were not on the MDS assessment, were quality indicator variables that could not be assessed at admission or were change variables that could not be assessed at admission. Then, 17 variables were excluded as they were Clinical Assessment Protocol (CAPs) which are derived from the individual MDS variables and having both the CAPs and individual variables in the variable pool would be redundant. Another 73 variables were removed as they

were variables that were duplicated in the cohort creation process, date variables that did not contribute to the model or were variables not pertaining to the admission assessment. The remaining 410 MDS variables or scales were then assessed. After collaborating with biostatisticians and clinicians, variables were regrouped and narrowed down to 117 variables. Multicollinearity was assessed and 22 variables were correlated. The 11 variables that were highly correlated were removed and 106 variables remained in the selection process. Then the best subset regression and univariate analysis were conducted to determine the top 20 most statistically significant predictors from the 117 variables.

The 106 variables were then independently assessed by two clinicians, an ED trauma nurse and an LTC geriatrician. The two clinicians independently selected the top 20 predictors that they felt were most clinically informative in the model. These clinicians highlighted variables on independent surveys that they thought were insignificant to ED transfers and that would not be indicative of an ED transfer. To get the top 20 most clinically influential predictors, the clinicians discussed which variables they felt were most influential in the model. After collaboratively selecting the top 20 variables and resolving any conflict, the statistically significant variables and the variables from previous literature were revealed. There were 15 variables that were consistent between the statistical, clinical, and previous literature selections. To be conservative, 25 variables were included to run the final logistic regression model where variables were included if they were statistically or clinically influential. When reviewing the top 25 variables, the two clinicians highlighted that the therapy variable and infection variable consisted of many therapies and infections in one variable. The clinicians suggested that these variables should be assessed separately. Therefore, a total of 30 variables (*Appendix D*) were selected for the model building process (*Figure 3*).

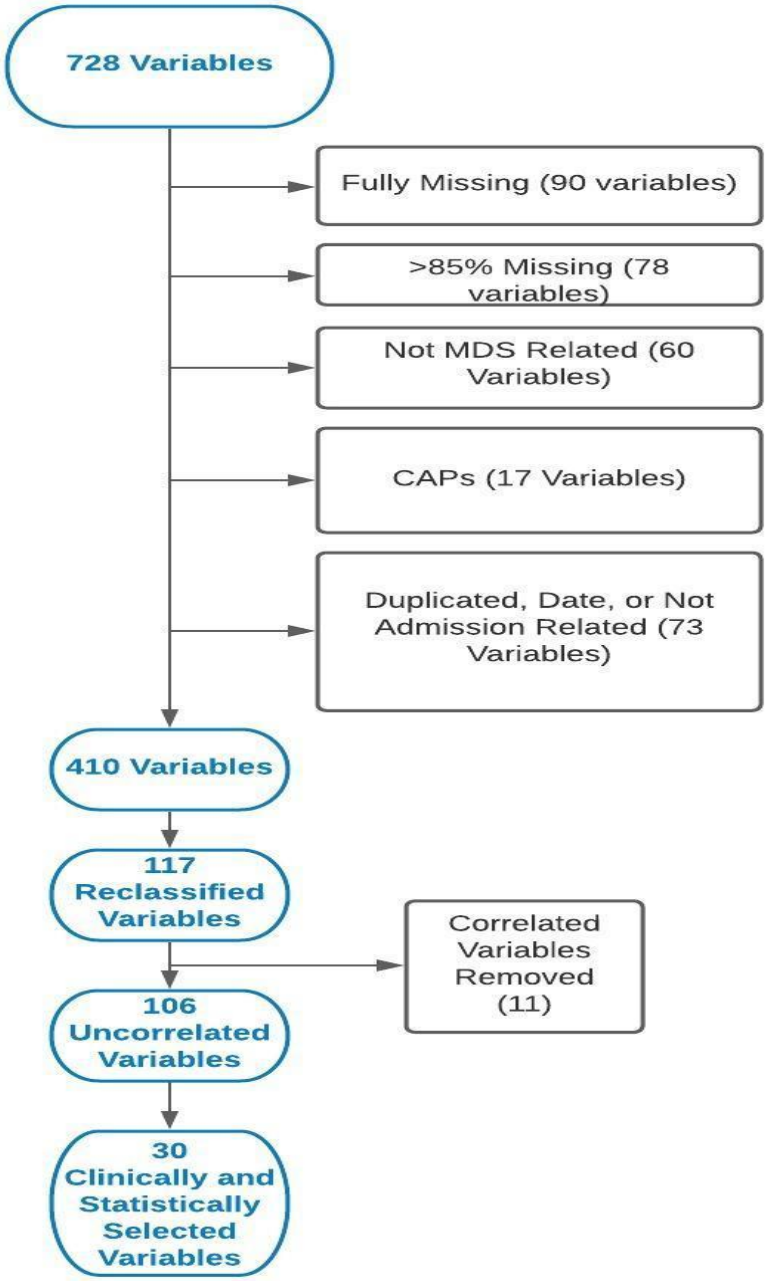

Figure 3: Flowchart Demonstrating the Included and Excluded Variables for the Logistic Regression Model Predictor Selection

4.4 Resident Characteristics at Admission Associated with Transfer to the ED

The results of the final models for any ED transfer are presented in *Table 4.* Twenty-three variables were found to be independent predictors for any transfer to the ED. All variables were

statistically significant with a p-value of <0.01. The variables with the lowest odds of transfer to the ED were being older than 65 years (Adjusted Odds Ratio [aOR]=0.861; 95% CI=0.790-0.940), signing a DNH directive (aOR=0.691; CI=0.657-0.726) relative to not having a DNH or having an unknown response, being a resident in a rural LTC facility in Ontario (aOR=0.900; CI=0.849-0.954), being a female resident (aOR=0.804; CI=0.771-0.838), and experiencing deterioration in ADLs (aOR=0.913; CI=0.853-0.977). The variables with the greatest odds of transfer to the ED are dialysis (aOR=2.318; CI=1.921-2.798), transfusions (aOR=2.527; CI=1.950-3.275), having an indwelling catheter (aOR=1.546; CI=1.436-1.666), being on oxygen therapy (aOR=1.371; CI=1.265-1.486), and having cellulitis (aOR=1.495; CI=1.255-1.782).

Table 4: Multivariate Logistic Regression Model for Any ED Transfers

Variable	**β**	***SE***	***P***	**OR (adjusted)**	**CI**
Advance Care Directives					
Do not hospitalize (DNH)	-0.370	0.025	<0.0001	0.691	0.657-0.726
Demographic					
65+	-0.149	0.044	0.0008	0.861	0.790-0.940
Female	-0.219	0.022	<0.0001	0.804	0.771-0.838
Rural	-0.105	0.030	0.0004	0.900	0.849-0.954
Medications					
Polypharmacy (>5)	0.258	0.032	<0.0001	1.295	1.217-1.377
Accidents					
Falls/injury in last 30 days	0.248	0.024	<0.0001	1.282	1.223-1.344
Change Variables					
Deterioration in cognitive status	-0.136	0.051	0.0079	0.873	0.790-0.966
Change in behaviours	0.114	0.044	0.0098	1.121	1.028-1.222
Deterioration in ADL	-0.095	0.035	0.0090	0.913	0.853-0.977

Change in physician orders (14 days)	0.064	0.007	<0.0001	1.067	1.052-1.082
>25% Food uneaten	0.163	0.022	<0.0001	1.178	1.127-1.230
Health Service Use					
Hospitalization (last 90 days)	0.175	0.018	<0.0001	1.191	1.149-1.235
ED (last 90 days)	0.191	0.021	<0.0001	1.211	1.163-1.261
Diagnoses					
CHF	0.241	0.029	<0.0001	1.272	1.203-1.345
Renal failure	0.143	0.032	<0.0001	1.153	1.083-1.228
COPD/Asthma	0.190	0.026	<0.0001	1.208	1.149-1.271
Alzheimer's & Dementia	-0.099	0.020	<0.0001	0.906	0.868-0.945
Treatments, Procedures, and Devices					
Bed or rail restraints	-0.056	0.021	0.0084	0.945	0.907-0.986
Indwelling catheter	0.440	0.038	<0.0001	1.546	1.436-1.666
Dialysis	0.840	0.096	<0.0001	2.318	1.921-2.798
Oxygen therapy	0.315	0.041	<0.0001	1.371	1.265-1.486
Transfusions	0.930	0.132	<0.0001	2.527	1.950-3.275
Infection					
Cellulitis	0.402	0.089	<0.0001	1.495	1.255-1.782

There were nineteen variables that were found to be independent predictors of potentially preventable transfers to the ED (*Table 5*). All variables were statistically significant with a p-value of <0.01. The variables with the lowest odds of transfer to the ED for a potentially preventable visit were a change in mood (aOR=0.798; 95% CI=0.685-0.929), signing a do not hospitalize directive (aOR=0.595; CI=0.543-0.653), showing any indicators of delirium (aOR=0.855; CI=0.793-0.922), being a female resident (aOR=0.809; CI=0.752-0.870), and having an Alzheimer's or dementia diagnosis (aOR=0.811; CI=0.754-0.873). The variables

associated with the greatest odds of a potentially preventable ED transfer are having a CHF diagnosis (aOR=1.572; CI=1.443-1.712), having a COPD or asthma diagnosis (aOR=1.523; CI=1.406-1.650), having an indwelling catheter (aOR=1.712; CI=1.531-1.915), being on oxygen therapy (aOR=1.938; CI=1.734-2.167), and having cellulitis (aOR=1.854; CI=1.453-2.366).

Table 5: Multivariate Logistic Regression Model for Potentially Preventable ED Transfers

Variable	**β**	***SE***	***P***	**OR (adjusted)**	**CI**
Advance Care Directives					
Do not hospitalize	-0.519	0.047	<0.0001	0.595	0.543-0.653
Demographic					
Female	-0.211	0.037	<0.0001	0.809	0.752-0.870
Medications					
Polypharmacy (>5)	0.404	0.064	<0.0001	1.497	1.321-1.696
Change Variables					
Change in mood	-0.226	0.078	0.0036	0.798	0.685-0.929
Change in physician orders (14 days)	0.048	0.012	<0.0001	1.049	1.026-1.074
>25% Food uneaten	0.137	0.039	0.0004	1.146	1.063-1.236
Health Service Use					
Hospitalization (last 90 days)	0.119	0.027	<0.0001	1.126	1.067-1.188
ED (last 90 days)	0.107	0.030	0.0003	1.113	1.050-1.179
Diagnoses					
Delirium	-0.157	0.038	<0.0001	0.855	0.793-0.922
CHF	0.452	0.044	<0.0001	1.572	1.443-1.712
Renal failure	0.204	0.051	<0.0001	1.226	1.109-1.356
COPD/Asthma	0.421	0.041	<0.0001	1.523	1.406-1.650
Alzheimer's & Dementia	-0.209	0.038	<0.0001	0.811	0.754-0.873
Treatments, Procedures, and Devices					

Indwelling Catheter	0.538	0.057	<0.0001	1.712	1.531-1.915
Dialysis	0.384	0.138	0.0053	1.469	1.121-1.924
Oxygen therapy	0.662	0.057	<0.0001	1.938	1.734-2.167
***Infection*s**					
Cellulitis	0.618	0.124	<0.0001	1.854	1.453-2.366
Pneumonia	0.420	0.084	<0.0001	1.522	1.292-1.794
Urinary Tract Infection (UTI)	0.209	0.0622	0.0008	1.233	1.091-1.393

There were eleven variables that were found to be independent predictors of low acuity transfers to the ED (*Table 6*). All variables were statistically significant with a p-value of <0.01. The top four variables that put residents at lower odds of a low acuity ED transfer were being older than 65 years (aOR=0.734; CI=0.595-0.906), being a female resident (aOR=0.857; CI=0.766-0.959), being on oxygen therapy (aOR=0.714; CI=0.555-0.919) and experiencing a deterioration in ADLs (aOR=0.760; CI=0.639-0.904). The variables with the greatest odds of a low acuity transfer to the ED were experiencing a fall or injury in the last 30 days (aOR=1.446; CI=1.281-1.631), being a resident in a rural LTC facility in Ontario (aOR=2.620; CI=2.323-2.954), having an indwelling catheter (aOR=1.771; CI=1.487-2.110), transfusions (aOR=2.871; CI=1.753-4.704), and having antibiotic resistance (aOR=1.361; CI=1.100-1.683).

Table 6: Multivariate Logistic Regression Model for Low Acuity ED Transfers

Variable	**β**	***SE***	***P***	**OR (adjusted)**	**CI**
Demographics					
65+	-0.310	0.107	0.0039	0.734	0.595-0.906
Female	-0.155	0.057	0.0069	0.857	0.766-0.959
Rural	0.963	0.061	<0.0001	2.620	2.323-2.954
Accidents					
Falls/Injury in last 30 days	-0.369	0.062	<0.0001	1.446	1.281-1.631

Change Variables					
Change in Physician Orders (14 days)	0.053	0.019	0.0044	1.054	1.017-1.093
Deterioration in ADL	-0.274	0.088	0.0019	0.760	0.639-0.904
Health Service Use					
ED (last 90 days)	0.213	0.037	<0.0001	1.237	1.151-1.331
Treatments, Procedures, and Devices					
Indwelling Catheter	0.572	0.089	<0.0001	1.771	1.487-2.110
Oxygen Therapy	-0.337	0.129	0.0089	0.714	0.555-0.919
Transfusions	1.055	0.252	<0.0001	2.871	1.753-4.704
Infections					
Antibiotic Resistant Infection	0.308	0.109	0.0046	1.361	1.100-1.683

4.5 Model Fit

The ROC, AIC, and BIC were examined for all three outcomes to understand the model fit. For any ED transfers the AUC is 0.630, the AIC is 58,430, and the BIC is 58,644. For potentially preventable ED transfers, the AUC is 0.686, the AIC is 24,795, and the BIC is 24,973. Finally, for low acuity ED transfers, the AUC is 0.649, the AIC is 12,263, and the BIC is 12,374.

4.6 Absolute Potential to Predict ED Transfers within 92-days of Admission

The three outcomes were cross validated using 90% of the data to train and 10% to test. This resulted in the production of 10 cross-validated outputs with varying ORs and CIs. Each OR and CI was individually assessed, and every variable was significant across all 10 outputs. The average AUC's after cross validation for each outcome are shown in *Table 7*.

Table 7: Cross Validated Average AUC's for Any, Potentially Preventable, and Low Acuity ED Transfers

Outcome	Backwards Selection
Any ED Visit	0.630
Potentially Preventable	0.659
Low Acuity	0.645

4.7 Sensitivity Analyses

4.7.1 The Best Subset Regression Model

The backward regression model was compared to the best subset regression model to understand model fit using another variable selection process. To cross-validate a best-subset regression model, the variables were pre-selected and manually entered. The results of the best subset model are presented in *Appendix E-G*.

For each outcome, there were fewer variables in the best subset model. For example, ten variables for any ED visit, including falls/injuries in the last 30 days, binary sex, hospitalization in the last 90 days, ED visit in the last 90 days, change in physician orders in the last 14 days, having a CHF diagnosis, having an indwelling catheter, being on dialysis and being on oxygen therapy. There were five variables that were most influential in the best subset regression for a potentially preventable ED transfer, including polypharmacy, hospitalization in the last 90 days, being diagnosed with CHF, COPD/Asthma, having an indwelling catheter, and being on oxygen therapy. Finally, there were four variables that were defined as most influential for the low acuity ED transfers including, falls/injuries in the last 30 days, living in a rural environment, having an ED visit in the last 90 days, and having an indwelling catheter.

When assessing the model fit statistics (*Appendix H*), the AUC for the best subset model for all three outcomes were lower. The AIC and BIC were stronger for the backwards selection method although additional variables were added. The stronger AIC and BIC indicate that

including the additional variables strengthens the accuracy of the model. Similarly, the cross-validated AUC (*Appendix I*), was lower for the best subset model when compared to the backward selection model, indicating stronger accuracy of the backward selection method.

4.7.2 Death or Permanent Transfer Out of the LTC Facility Model

A logistic regression model was assessed after removing LTC residents who died or were transferred out of the LTC facility and did not have an outcome. The results of the sensitivity analyses for all three outcomes are reported in the *Appendix J-L*.

Eighteen variables were significant in the any ED transfer model and the remaining were excluded. The excluded variables include living in a rural environment, having renal failure, or experiencing a deterioration in ADLs. Although three variables were not significant when death or permanent transfers were removed from the cohort, the ORs and CIs for the remaining variables were similar for this outcome. The AUC for this model was lower than for the model with the entire cohort.

For potentially preventable ED visits, two variables were added to the model when the cohort with residents who died or were transferred out of the LTC facility was removed. The two variables added to this model were having a pneumonia diagnosis and a UTI diagnosis. The addition of these variables did not contribute to the model as this model had a decreased AUC value. The remaining variables had similar ORs and CIs when compared to the total cohort.

The low acuity visit outcome was modeled with fewer variables when compared to the model with the total cohort. There were three variables removed from this model including, binary sex, oxygen therapy, and antibiotic resistance. Like the previous outcomes, the remaining

variables, their ORs and their CIs remained similar to the previous model. Likewise, the AUC for this model decreased when compared to the overall model.

The model fit statistics for this sensitivity analysis are reported in *Appendix M.*

5. Discussion

5.1 Main Findings

This study explored the LTC resident characteristics that put residents at risk of transfer to the ED. The findings from this study demonstrate the resident characteristics that may influence ED transfers. The main findings from the three outcomes are discussed below.

5.1.1 Any ED Transfers

All variables included in this model were significant and demonstrated that they were associated with LTC residents having greater odds or lower odds of transfer to the ED. These results are consistent with previous literature which summarizes how LTC residents with a DNH, rural resident status, male sex, Alzheimer's or dementia and increasing age are at a lower risk of transfer to the ED.[85, 86] However, this study also identified that experiencing deterioration in cognitive status, having bed restraints or rails, and deterioration in ADLs, puts residents at lower odds of transfer to the ED. In our model, although a change in ADLs or cognitions may be conditions that have greater odds of transfer to the ED, it is possible that LTC facilities in Ontario are managing these conditions well or preventative care is provided for residents who are more ill. Investigating this relationship to understand why these changes in ADLs and cognition are protective may determine if these characteristics are associated with a lower risk profile, or whether they influence transfer decision-making.

There were many variables that increased the odds of being transferred to the ED that was consistent with the literature. These variables include falls or injuries in the last 30 days, change in behaviors, experiencing renal failure, being diagnosed with CHF, COPD/Asthma, cellulitis, having an indwelling catheter, being on dialysis, oxygen therapy, or transfusions, and

polypharmacy (greater than five medications at a time), and leaving 25% of meals uneaten. Interestingly, hospitalization or ED visit in the last 90 days and having a change in physician orders int he last 14 days, were indicative of greater odds of transfer to the ED. Although primary or acute care was received, the odds of transfer to the ED was not lower for these residents.

With this data, it is unclear whether these results pertain to the diagnosis of these illnesses or being placed on these therapies, or whether it is a result of the complication or exacerbations of these diseases or therapies. This highlights the markers of health system failures to meet the needs of residents resulting in a cyclic use of the ED. Identifying resident ED transfer reasons and ensuring that residents are closely monitored after discharge is critical to prevent the use of potentially preventable acute care. Further, since polypharmacy is associated with a higher odds of transfer to ED, understanding methods to reduce potentially inappropriate prescriptions may help reduced preventable ED visits.[106] Overall, it is evident that residents with greater comorbidities, use of therapies, and increase frailty are at greater risk of transfer to the ED for any ED visit.

5.1.2 Potentially Preventable ED Transfers

The results of the potentially preventable ED transfer also reflected the explanatory models in the literature. Variables that decrease the odds of transfer to the ED for a potentially preventable ED visit are having a DNH directive, change in mood, being female, having any indicators of delirium, or having a diagnosis of Alzheimer's or dementia. Changes in mood have been identified by clinicians as a reason for transfer however, this study identified this variable as a clinical characteristic of LTC residents that may not require acute care. Therefore, better

LTC facility services to manage mood symptoms or change in mood is required to help prevent potentially preventable visits. Delirium is highly prevalent in hospital settings, however, understanding that this is a predictor for a potentially preventable ED transfer will allow LTC clinicians to implement decision-making tools, to better identify and care for delirious residents in the facility.[107]

The variables that increase the odds of a potentially preventable transfer to the ED were hospitalization or ED visit in the last 90 days, having a change in physician orders in the last 14 days, being diagnosed with renal failure, CHF, COPD/Asthma, cellulitis, pneumonia, UTI, having an indwelling catheter, being on oxygen therapy, and polypharmacy, and leaving 25% of meals uneaten. These results are similar to the any ED transfer outcome, indicating the difficulty in identifying residents that may need acute care services compared to characteristics that may be preventable of an ED transfer. Since UTI's, cellulitis, and pneumonia were common conditions for a potentially preventable ED transfer, using educational programs at the ED to allow clinicians to better treat LTC residents with these conditions would be appropriate.[108]

5.1.3 Low Acuity ED Transfers

The low acuity ED transfers for LTC residents had fewer predictors that were significant. Variables that highlighted decreased odds of transfer to the ED for a low acuity visit were increasing age, female sex, being on oxygen therapy, and deterioration in ADLs. Although, most of these variables are consistent with the previous two outcomes, being on oxygen therapy is a protective factor. Further, investigation of LTC resident transfer to the ED for patients on oxygen therapy is required to understand this difference.

Experiencing a fall or injury in the last 30 days, being a resident in a rural LTC facility, being hospitalized or having an ED visit in the last 90 days, having a change in physician orders in the last 14 days, having an indwelling catheter or transfusions, and experiencing antibiotic resistance put residents at greater odds of transfer to the ED for a low acuity visit. The infection that is highlighted for the greatest risk of transfer for this outcome is antibiotic resistance. Employing strategies to minimize antibiotic-resistant infections, or managing such infections, may help reduce low acuity transfers.

These baseline characteristics would identify residents who were previously been defined as high-risk residents. When comparing this outcome to any ED visit, all the low acuity predictors are included in the any ED visit model and many are included in potentially preventable ED visits. Therefore, investigating the reason behind the low acuity transfer and understanding the difference between resident profiles whose transfers are required compared to residents whose conditions could have been managed in the facility is imperative. Targeting preventative interventions in the LTC facility can help mitigate a low acuity ED transfer but will require further analysis on patients' reason for transfer and comparison to other residents.

5.1.4 Sensitivity Analyses

5.1.4.1 Best Subset Regression

The best subset regression may display parsimony with fewer variables; however, the increase in the AUC is reflective of the important contribution the added predictors have in this model. Although the AUC between the two models is not significantly different, the increase in the AUC value and decrease in the AIC and BIC for the backward model indicates the importance of the selection of this model. Further, the low AUC may reflect that that health

behaviors can't be predicted adequately at a population level and the results of this study were consistent with previous findings using population-level data.[77]

5.1.4.2 Death or Permanent Transfer out of the LTC Facility

LTC residents that had died or were transferred out of the facility prior to the 92-day period were removed from the cohort to understand the changes this would have to the model. For all three outcomes, there was two to three variables that were added or removed. Although, the regression models for each outcome are slightly different for the sensitivity analysis, most of the variables are consistent, and it can be concluded that the original model is not heavily influenced by LTC residents who were permanently transferred out of the facility or passed away before the 92-day follow-up period.

5.2 Implications

The results of this study are consistent with the literature highlighting LTC resident's clinical characteristics that are most influential of any, potentially preventable, or low acuity ED transfer. This study also identified the variables that are predictive of an ED transfer to highlight potential LTC resident clinical characteristics that should be considered at admission so an appropriate care plan can be created that can potentially minimize low acuity or preventable visit frequencies.

5.2.1 Clinical Implications

This study identified LTC resident level characteristics that are predictive of any, potentially preventable, and low acuity ED transfer. Clinicians and stakeholders should be aware of these characteristics to be able to better assess, plan, and or prevent LTC resident transfer to

the ED. Previous studies have identified clinical concerns with current LTC to ED transitions, primarily highlighting the lack of communication.[109, 110] If clinicians are able to identify these high-risk patients then, proactive measures can be taken to prevent transfer. This includes providing essential information which inevitably will improve ED care.[111] This will allow for appropriate transfer to the ED if required and potentially mitigate congestion in the ED. This will also allow for LTC residents and their families to seek additional care with interdisciplinary teams to help prevent a potential transfer.

Knowing which patient characteristics influence ED transfer at admission can help educate nurses and other clinicians on methods to create care plans, build stronger resident provider relationships, and prevent low acuity or potentially preventable emergency visits.[112, 113] Previous literature has suggested staff education, facility leadership, physician engagement, and additional assessment of residents who experience changes in conditions can reduce the rate of LTC resident transfers to ED.[114] This will also decrease the poor resident outcomes resulting from transfer and ensure appropriate care is provided to the resident. Poor resident outcomes from transfer to the ED are resident confusion, falls, bedsores, functional decline, and premature mortality.[115, 116]

Hospital ED's are often overcrowded and ill-equipped to care for older adult patients and can require longer durations of stay.[117] Understanding the characteristics of transfer to ED and allowing for LTC physicians and nurses to provide better care for residents will improve ED outcomes. Therefore, novel clinician interventions and methods can be explored to help mitigate transfer. Previous studies have explored clinical education methods, clinician collaboration, and transfer forms which may compliment the results of this study and help minimize the risk of ED transfer.[118-122]

5.2.2 Policy Implications

The results of this study may be examined by policymakers to help improve outcomes for LTC residents and clinicians. This study identified LTC resident level characteristics for transfer to ED where the visits may be potentially preventable or low acuity. Understanding these characteristics and implementing policies in LTC homes that promote preventative care plans for residents at high-risk of an ED transfer can help alleviate LTC resident and ED burden. Specifically, the cost of transfers to the ED can be avoided if preventative measures are taken. For example, policymakers should focus on alternate solution implementation such as consistent physician and team assignments and continuity of care, which is designed to reduce ED transfers from LTC by 34% by improved onsite primary care.[123] Further, this information can be used to adjust quality metrics which can help guide policy development. A suggested method is to use financial incentives to reduce ED transfers.[124] Although these changes will help minimize low-acuity or potentially preventable transfers to the ED, it is challenging to implement these changes in LTC homes across Ontario due to the strained working environments.[125] Therefore, policy changes that take LTC facility staff demands into consideration should be prioritized first.

5.2.3 Research Implications

Gruneir's model helped outline the need factors that must be considered when older adults are transferred to the ED. This helped in understanding the literature, outlining the variable categories, and complimenting the clinical decisions. Understanding this framework has guided this study to investigate how some variables are predictive of potentially preventable or non-urgent ED transfers. The structure of the framework allows for a more appropriate assessment of factors influencing health services, specifically, ED use by older adults. The

advantage of this study is that the use of population-based, RAI-MDS 2.0 data, prevent the prevalence of recall bias.

This is one of the first studies that investigate both explanatory and predictive methods of LTC resident transfer to the ED in both urgent and non-urgent cases. However, the retrospective nature of this study prevented the collection of clinical variables that might be more influential to improve predictive accuracy. This is similar to the effects of previous predictive models built using population-level data that predict risk.[126, 127] In future studies, a prospective cohort study might help identify additional variables that are influential in LTC resident transfer to the ED. Similarly, employing mixed methods or qualitative research methods will allow non-statistical variables to be captured and assessed. Additionally, the results of the study should be externally validated to understand the similarities and differences among various populations. Methods for exploring telemedicine in this population have shown a potential reduction in ED transfer.[128] Combining facility characteristics, care models, and medical staff organization can help develop stronger models.[129] Additionally, this study can be used to work towards the creation of a risk scale that can complement clinical decision making. Therefore, there are many unique research implications of this work that can help improve risk prediction.

5.3 Limitations

Due to the secondary nature of this study, certain variables that may be more explanatory or predictive of LTC resident transfer to the ED were not collected and thus, could not be included in the study. These variables include, but are not limited to, perceived patient needs, health beliefs, cultural or religious background, skills and dynamics of nursing staff, and family involvement or dynamics.[130]

Another limitation of this study is that the exact reason for transfer to the ED is not known from this data. Without knowing the primary reason for transfer and using LTC resident's baseline characteristics to predict an ED transfer presents a challenge when making clinical suggestions. Specifically, the definitions of potentially preventable and low acuity are based on the conditions reported at the ED. The necessity of transfer is not captured and is a limitation that may have resulted in overestimation or underestimation of the outcome. To improve generalizability a cross-sectional design for this study with all short stay, newly admitted, and long-stay residents could have been included in our analysis. However, this was out of the scope of this study as new admissions to LTC are more likely to be transferred to the ED and contribute to the largest population of LTC residents.[93]

The RAI-MDS 2.0 admission assessment is the most comprehensive assessment which helps the physician and LTC staff learn the most about the patient. Finally, the cohort created did not allow for the identification of residents that were transferred from another LTC facility before the cohort start date. This prevented the identification of resident characteristics that may have been addressed in their previous facility.

6. Conclusion

This study identified the most influential LTC resident characteristics that increase or decrease the risk of transfer to the ED. The results were derived from a two-year population-based cohort in Ontario that identified how secondary data can be used to predict the risk of future ED transfer for LTC residents at admission. This study demonstrates resident characteristics that place them at risk for low acuity or potentially preventable ED transfers. Using this model to assist in decision making can help reduce ED burden through the prevention of non-urgent transfers. These results allow for policy, clinical, or patient-level changes that can contextualize methods to ensure unnecessary ED transfers do not occur, or residents and clinicians are better prepared for needed transfers. Future studies are required to validate these findings, derive risk scales, and demonstrate the utility of this model in health service planning.

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8. Appendices

Appendix A: ICD-10-CA Codes for Potentially Preventable ED Visits

Conditions	ICD-10-CA	Exclude
Angina pectoris	I20 I2382 I240 I248 I249	Cases with surgical procedure (CCI procedure: 1, 2, 5)
Asthma	J45	
Cellulitis	L03	Cases with surgical procedures (CCI: 1, 2, 5)
Chronic obstructive pulmonary disease	J41–J44 J47 J20 (only when "other diagnosis" of J41–J44, J47 is present) J12–J16, J18 (only when "other diagnosis" of J41–J44, J47 is present)	
Congestive heart failure	I50 J81	Cases with surgical procedures (CCI: 1IJ50, 1HZ85, 1IH76, 1HB53, 1HD53, 1HZ53, 1HB55, 1HD55, 1HZ55, 1HB54, 1HD54)
Dehydration	E86	
Diabetes mellitus	E101 E106, E107 E109 E110, E111 E116, E117 E119 E130, E131 E136, E137 E139 E140, E141 E146, E147 E149	
Gastroenteritis	K52	

Grand mal seizure disorders	G40 G41	
Hypertension	I100 I101 I11	Cases with surgical procedures (CCI: 1IJ50, 1HZ85, 1IJ76, 1HB53, 1HD53, 1HZ53, 1HB55, 1HD55, 1HZ55, 1HB54, 1HD54)
Hypoglycemia	E162	
Kidney or urinary tract infection	N10 N151 N11 N136 N390	
Pneumonia	J12–J16 J18	
Severe ear, nose, or throat infection	J02, J03 J312	

Appendix B: Syntax for Literature Searches (EMBASE and Medline)

Database: Embase <1974 to 2020 April 08>
Search Strategy:

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1 assisted living facility/ (2356)
2 home for the aged/ (10791)
3 nursing home/ (50983)
4 assisted living.ti,ab,kw. (2838)
5 care home*.ti,ab,kw. (4872)
6 nursing home*.ti,ab,kw. (38364)
7 long term care.ti,ab,kw. (26546)
8 1 or 2 or 3 or 4 or 5 or 6 or 7 (89096)
9 emergency ward/ (141338)
10 emergency health service/ or hospital emergency service/ (98688)
11 emerg* department*.ti,ab,kw. (137498)
12 9 or 10 or 11 (261604)
13 patient transport/ (25764)
14 transfer*.ti,ab,kw. (752499)
15 visit*.ti,ab,kw. (362179)
16 13 or 14 or 15 (1125859)
17 8 and 12 and 16 (1229)

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Database(s): OVID Medline Epub Ahead of Print, In-Process & Other Non-Indexed Citations, Ovid MEDLINE(R) Daily and Ovid MEDLINE(R) 1946 to Present
Search Strategy:

#	Searches	Results
1	Assisted Living Facilities/	1344
2	Homes for the Aged/	13694
3	Long-Term Care/	25637
4	exp Nursing Homes/	38712
5	assisted living.ti,ab.	2058
6	care home*.ti,ab.	3806
7	nursing home*.ti,ab.	29235
8	LTC.ti,ab.	3585
9	1 or 2 or 3 or 4 or 5 or 6 or 7 or 8	79796
10	Emergency Service, Hospital/	66654
11	emerg* department*.ti,ab.	88526
12	10 or 11	117676
13	9 and 12	983
14	Patient Transfer/	8237
15	transfer*.ti,ab.	629703
16	visit*.ti,ab.	224247
17	14 or 15 or 16	854727
18	13 and 17	528

Appendix C: Characteristics of Ontario Long-Term Care Residents Who Had Died or Residents Who Were Discharged from the Home within 92-days of Admission

Variables	**Groups**	
	Residents Who Died Before 92-day Follow-Up (*n*=5,975)	**Residents Who Were Transferred Before 92-day Follow-Up (*n*=13,055)**
Advance Care Directives		
DNR	4,745 (79.41)	8,983 (68.81)
DNH	2,527 (4.48)	3,304 (25.31)
Demographics		
Female	3,330 (55.73)	7,530 (57.68)
Age **< 64** **65+**	 192 (3.21) 5,783 (96.79)	 765 (5.86) 12,290 (94.14)
Living in a Rural Community	997 (16.69)	2,059 (15.77)
Medications		
Polypharmacy **=/<5 medications** **>5 medications**	 754 (12.62) 5,221 (87.38)	 1,703 (13.04) 11,352 (86.96)
Accidents		
Falls/Injuries in the Last 30 days	1,756 (29.39)	3,433 (26.30)
Change Variables		
Deterioration in Cognitive Status	590 (59.87)	937 (7.18)
Deterioration in Behaviors	522 (8.74)	1,003 (7.68)
Decline in Mood	561 (9.39)	1,043 (7.99)
Deterioration in ADLs	1,247 (20.87)	9.38 (5,294)
Change in Urinary Continence	563 (9.42)	2,472 (4.38)
Leaves 25% of Food Uneaten	3,301 (55.25)	5,421 (41.52)
Pain		
Experiencing Pain	825 (13.81)	1,572 (12.04)
Diagnoses		

Alzheimer's or Dementia	3,367 (56.35)	27,637 (48.97)
Neurological Diseases	2,085 (34.90)	4,741 (36.32)
Congestive Heart Failure	1,526 (25.54)	2,652 (20.31)
Cardiovascular Disease	4,767 (79.78)	10,132 (77.61)
Asthma or COPD	1,471 (24.62)	2,971 (22.76)
Musculoskeletal Diseases	1,727 (28.90)	3,639 (27.87)
Renal Failure	1,090 (18.24)	2,062 (15.79)
Depression	1,401 (23.45)	3,234 (24.77)
Pressure Ulcers	1,786 (29.89)	2,909 (22,28)
Treatments, Procedures, and Devices		
Bed Rails or Restraints	2,470 (41.34)	5,073 (38.86)
Indwelling or Intermittent Catheter	859 (24.62)	1,495 (11.45)

Appendix D: Top 30 Variables Selected Based on Clinical and Statistical Importance

Variables	**Clinically Selected**		**Statistically Selected**	**Top 30 Predictor?**
	Clinician #1	**Clinician #2**		
Female	Yes	Yes	Yes	Yes
Age Group	Yes	Yes	Yes	Yes
DNR	Yes	Yes	Yes	Yes
DNH	Yes	Yes	Yes	Yes
Marital Status	Yes	No	No	No
Language	Yes	No	No	No
Faith/Religious Values	Yes	Yes	No	No
Deterioration in Cognitive Status	Yes	Yes	Yes	Yes
Deterioration in Behaviors	Yes	Yes	Yes	Yes
Decline in Mood	Yes	Yes	Yes	Yes
Deterioration in ADLs	Yes	Yes	Yes	Yes
Change in Urinary Continence	Yes	Yes	Yes	Yes
Polypharmacy	Yes	Yes	Yes	Yes
Living in a Rural Community	No	Yes	Yes	Yes

Falls/Injuries in the Last 30 days	Yes	Yes	Yes	Yes
Hospitalization (last 90 days)	Yes	Yes	Yes	Yes
ED (last 90 days)	Yes	Yes	Yes	Yes
Change in Physician Orders (14 days)	Yes	Yes	Yes	Yes
Experiencing Pain	Yes	Yes	No	No
Alzheimer's or Dementia	Yes	Yes	Yes	Yes
Indicators of Delirium	Yes	Yes	Yes	Yes
Congestive Heart Failure	Yes	Yes	Yes	Yes
Cardiovascular Disease	Yes	Yes	No	No
Asthma or COPD	Yes	Yes	Yes	Yes
Renal Failure	Yes	Yes	Yes	Yes
Depression	Yes	Yes	No	No
Presence of Pressure Ulcers	Yes	Yes	No	No
Bed Rails or Restraints	Yes	Yes	Yes	Yes
Indwelling or Intermittent Catheter	Yes	Yes	Yes	Yes
Leaves 25% of Food Uneaten	Yes	Yes	Yes	Yes
Dialysis	Yes	Yes	Yes	Yes
Oxygen Therapy	Yes	Yes	Yes	Yes
Transfusions	Yes	Yes	Yes	Yes
Cellulitis	Yes	Yes	Yes	Yes
Pneumonia	Yes	Yes	Yes	Yes
Urinary Tract Infection (UTI)	Yes	Yes	Yes	Yes
Antibiotic Resistant Infection	Yes	Yes	Yes	Yes

Appendix E: Multivariate Logistic Regression Model for Any ED Transfer for the Best Subset Regression Model

Variables	**β**	***SE***	***P***	**OR**	**95% CI**
Demographic					
Female	-0.205	0.021	<0.0001	0.814	0.782-0.849
Medications					
Polypharmacy (>5)	0.297	0.031	<0.0001	1.345	1.265-1.430
Accidents					
Falls/injury in last 30 days	0.226	0.024	<0.0001	1.254	1.197-1.314
Change Variables					
Change in physician orders (14 days)	0.071	0.007	<0.0001	1.074	1.059-1.089
Health Service Use					
Hospitalization (last 90 days)	0.186	0.018	<0.0001	1.205	1.163-1.248
ED (last 90 days)	0.189	0.020	<0.0001	1.208	1.161-1.258
Diagnoses					
CHF	0.275	0.028	<0.0001	1.316	1.246-1.389
Treatments, Procedures, and Devices					
Indwelling catheter	0.449	0.038	<0.0001	1.566	1.455-1.686
Dialysis	1.042	0.091	<0.0001	2.836	2.371-3.393
Oxygen therapy	0.384	0.040	<0.0001	1.469	1.359-1.587

Appendix F: Multivariate Logistic Regression Model for Potentially Preventable ED Transfer for the Best Subset Regression Model

Variable	**β**	***SE***	***P***	**OR**	**95% CI**
Medications					
Polypharmacy (>5)	0.496	0.063	<0.0001	1.641	1.450-1.857

Health Service Use					
Hospitalization (last 90 days)	0.186	0.027	<0.0001	1.204	1.143-1.268
Diagnoses					
CHF	0.513	0.043	<0.0001	1.671	1.536-1.817
COPD/Asthma	0.450	0.041	<0.0001	1.569	1.449-1.699
Treatments, Procedures, and Devices					
Indwelling catheter	0.659	0.055	<0.0001	1.933	1.735-2.153
Oxygen therapy	0.759	0.055	<0.0001	2.137	1.920-2.378

Appendix G: Multivariate Logistic Regression Model for Low Acuity ED Transfer for the Best Subset Regression Model

Variable	**β**	***SE***	***P***	OR	CI
Demographics					
Rural	0.935	0.061	<0.0001	2.548	2.262-2.871
Accidents					
Falls/injury in last 30 days	0.362	0.061	<0.0001	1.436	1.274-1.619
Health Service Use					
ED (last 90 days)	0.217	0.036	<0.0001	1.243	1.158-1.333
Treatments, Procedures, and Devices					
Indwelling catheter	0.652	0.087	<0.0001	1.918	1.619-2.273

Appendix H: Model Fit Statistics for the Best Subset Regression Model

Model Fit Statistics	**Any ED Visit**	**Potentially Preventable ED Visit**	**Low Acuity ED Visit**
AUC	0.616	0.659	0.633
AIC	58,910	25,157	12,314
BIC	59,008	25,220	12,359

Appendix I: Cross Validated Average AUC's for the Best Subset Regression Model

Outcome	Best Subset Selection
Any ED Visit	0.615
Potentially Preventable	0.659
Low Acuity	0.633

Appendix J: Multivariate Logistic Regression Model for Any ED Transfers Excluding LTC Residents Who Died or Were Transferred Out of the Facility Before the 92-day Follow-Up Period: A Sensitivity Analysis

Variable	β	*SE*	*P*	OR	CI
Advance Care Directives					
DNH	-0.321	0.028	<0.0001	0.725	0.687-0.766
Demographics					
65+	-0.264	0.052	<0.0001	0.768	0.694-0.850
Female	-0.114	0.024	<0.0001	0.892	0.851-0.935
Medications					
Polypharmacy (>5)	0.161	0.035	<0.0001	1.174	1.096-1.258
Accident					
Falls/injury in last 30 days	0.231	0.027	<0.0001	1.260	1.195-1.328
Change Variables					
Change in physician orders (14 days)	0.063	0.008	<0.0001	1.065	1.048-1.081
>25% Food uneaten	0.166	0.025	<0.0001	1.181	1.124-1.240
Health Service Use					
Hospitalization (last 90 days)	0.181	0.021	<0.0001	1.199	1.151-1.248
ED (last 90 days)	0.200	0.025	<0.0001	1.222	1.163-1.284
Diagnoses					
CHF	0.134	0.031	<0.0001	1.143	1.075-1.216
COPD/Asthma	0.096	0.029	0.0009	1.100	1.040-1.165

Alzheimer's & Dementia	-0.116	0.025	<0.0001	0.891	0.849-0.934
Treatments, Procedures, and Devices					
Bed or rail restraints	-0.117	0.024	<0.0001	0.890	0.849-0.932
Indwelling catheter	0.391	0.043	<0.0001	1.478	1.358-1.609
Dialysis	0.770	0.106	<0.0001	2.158	1.754-2.655
Oxygen therapy	0.350	0.047	<0.0001	1.419	1.294-1.556
Transfusions	0.993	0.163	<0.0001	2.700	1.960-3.720
Infections					
Cellulitis	0.406	0.104	<0.0001	1.501	1.225-1.838

Appendix K: Multivariate Logistic Regression Model for Potentially Preventable ED Transfers Excluding LTC Residents Who Died or Were Transferred Out of the Facility Before the 92-day Follow-Up Period: A Sensitivity Analysis

Variable	**β**	***SE***	***P***	**OR**	**CI**
Advance Care Directives					
DNH	-0.478	0.049	<0.0001	0.620	0.563-0.682
Demographics					
Female	-0.154	0.039	<0.0001	0.857	0.794-0.925
Medications					
Polypharmacy (>5)	0.285	0.066	<0.0001	1.329	1.168-1.512
Change Variables					
Change in mood	-0.215	0.081	0.0079	0.807	0.688-0.945
Change in physician orders (14 days)	0.057	0.013	<0.0001	1.058	1.033-1.085
>25% Food uneaten	0.188	0.041	<0.0001	1.206	1.114-1.306
Health Service Use					
Hospitalization (last 90 days)	0.206	0.031	<0.0001	1.229	1.157-1.305
ED (last 90 days)	0.112	0.035	0.0013	1.119	1.045-1.197
Diagnoses					

Delirium	-0.156	0.040	<0.0001	0.855	0.791-0.925
CHF	0.373	0.046	<0.0001	1.451	1.326-1.588
Renal Failure	0.184	0.054	0.0006	1.202	1.081-1.335
COPD/Asthma	0.333	0.043	<0.0001	1.395	1.282-1.519
Alzheimer's & Dementia	-0.248	0.040	<0.0001	0.780	0.722-0.843
Treatments, Procedures, and Devices					
Indwelling catheter	0.544	0.061	<0.0001	1.722	1.528-1.942
Dialysis	0.411	0.150	0.0062	1.508	1.124-2.023
Oxygen therapy	0.720	0.061	<0.0001	2.054	1.821-2.317
Infections					
Cellulitis	0.692	0.136	<0.0001	1.998	1.530-2.609
Pneumonia	0.497	0.092	<0.0001	1.643	1.372-1.967
UTI	0.210	0.066	0.0016	1.233	1.083-1.404

Table L: Multivariate Logistic Regression Model for Low Acuity ED Transfers Excluding LTC Residents Who Died or Were Transferred Out of the Facility Before the 92-day Follow-Up Period: A Sensitivity Analysis

Variable	**β**	***SE***	***P***	**OR**	**CI**
Demographics					
65+	-0.511	0.110	<0.0001	0.600	0.484-0.744
Rural	0.988	0.063	<0.0001	2.686	2.373-3.040
Accidents					
Falls/Injury in last 30 days	0.362	0.063	<0.0001	1.436	1.269-1.624
Change Variables					
Change in Physician Orders (14 days)	0.056	0.019	0.0037	1.057	1.018-1.098
Deterioration in ADLs	-0.265	0.090	0.0033	0.767	0.642-0.915
Health Service Use					
ED (last 90 days)	0.274	0.043	<0.0001	1.316	1.210-1.341

Treatments, Procedures, and Devices					
Indwelling Catheter	0.600	0.090	<0.0001	1.823	1.528-2.175
Transfusions	1.097	0.272	<0.0001	2.995	1.759-5.102

Appendix M: Model Fit Statistics Excluding LTC Residents Who Died or Were Transferred Out of the Facility Before the 92-day Follow-Up Period

Model Fit Statistics	**Any ED Visit**	**Potentially Preventable ED Visit**	**Low Acuity ED Visit**
AUC	0.612	0.677	0.647
AIC	43,246	19,567	10,039
BIC	43,406	19,731	10,112