THE DEVELOPMENT AND VALIDATION OF THE EMERGENCY DEPARTMENT AVOIDABILITY CLASSIFICATION

THE DEVELOPMENT AND VALIDATION OF THE EMERGENCY DEPARTMENT AVOIDABILITY CLASSIFICATION

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Lay Abstract

A portion of patients attend the ED for conditions that could have been safely managed by non-ED care, termed avoidable visits. Avoidable visits are a contributor to ED overcrowding, and reduce care continuity. There is no validated, standard definition or criteria to identify such cases retrospectively. This thesis aimed to develop and examine the validity of a new classification that identifies avoidable ED visits in retrospective administrative data. The Emergency Department Avoidability Classification (EDAC) criteria were assembled through a consensus process involving evaluation of ED physician interventions and patient characteristics. A cluster, randomized, single-blinded study determined the EDAC was correlated with a criterion standard of ED physician judgment regarding the suitability of ED visits for non-ED care management. The EDAC outperformed previously published classifications commonly referenced in the literature in terms of accuracy to identify avoidable ED visits. Findings from my thesis demonstrated the EDAC is an accurate classifier of avoidable ED visits. The EDAC can identify opportunities for modifying health policy, implementing interventions that reduce avoidable ED visits, monitoring trends, and understanding gaps in community care that contribute to avoidable ED visits.

Abstract

Background: Overcrowding in emergency departments (EDs) due to avoidable visits places a significant strain on health systems. There is no known valid classification to identify avoidable ED visits in Canadian administrative data.

Research Questions: Which physician interventions and patient characteristics are important to classify avoidable ED visits, and does a novel classification (the Emergency Department Avoidability Classification; EDAC), which incorporated these features, demonstrate validity?

Methods: Two independent modified Delphi consensus studies determined ED physician interventions and patient characteristics that classified avoidable ED visits. These studies involved emergency and family medicine physicians across Ontario, Canada. Binary logistic regression was used to examine ED physician interventions in the National Ambulatory Care Reporting System (NACRS) database for associations with patient characteristics. These results constructed the EDAC criteria. ED physicians from an academic hospital evaluated randomly selected retrospective ED visits (n=320) which were also evaluated using the EDAC to assess their avoidability. The primary outcome of this thesis was correlation between the classification and ED physician judgements, measured using a Spearman rank correlation and ordinal logistic regression. The secondary outcome was to compare the correlations of previously published classifications with ED physician judgements. The tertiary outcome was to compare prevalence estimates of avoidable ED visits for all classifications.

Results: Consensus showed strong evidence on 146 of 150 (97.3%) ED physician interventions, with 103 (68.7%) deemed suitable for non-ED care. Consensus was

established on eight of nine patient characteristics, with four characteristics identified as useful in specifying avoidable ED visits: age (18-70 years), triage acuity (non-emergent), specialist consult in the ED (none) and ED visit outcome (discharged). An adjusted retrospective cohort study found the ED interventions had a strong association with patient characteristics determined in the consensus study: not aged over 65 years, having a non-emergent triage acuity and not being admitted to hospital. The classification was highly correlated with ED physician judgements ($r=0.64$, $p<0.01$), with a significant association to classify avoidable ED visits (OR=80.0, 95% CI=17.1-374.9) and strong accuracy (82.8%). The EDAC was the most accurate classifier of avoidable ED visits compared to previously published classifications. The EDAC identified a prevalence of 25.1% ED visits as avoidable and common patient conditions associated with such visits as traumatic injuries, symptoms/signs/abnormal findings, diseases of the musculoskeletal system, mental and behavioural disorders, and diseases of the respiratory system.

Conclusion: My thesis developed and established the EDAC as an accurate classifier of avoidable ED visits with supporting evidence of validity and superior performance to previously published classifications. The EDAC can be easily integrated with administrative ED data and has strong potential for use in defining avoidable ED visits by health policy stakeholders.

Dedication

This Ph.D. could not have been accomplished without the loving support of my family. I dedicate this thesis to my wife, Samantha, and sons, Charlie and Henry, who have patiently and lovingly supported me through this academic journey.

Acknowledgements

I wish to express my sincerest gratitude to my Ph.D. supervisor, Dr. Andrew Costa, for his unwavering guidance, encouragement, and dedication to academic excellence, all of which were instrumental in the writing of this thesis. His mentorship has undoubtedly shaped my research endeavors.

I would like to acknowledge and give my warm thanks to my thesis committee, Dr. Lauren Griffith, Dr. Andrew Worster, and Dr. Walter Tavares. Your guidance and advice throughout all stages of my thesis were instrumental to its success.

Lastly, I would like to give thanks to all graduate students I have had the pleasure of working with during this and other research projects, for their collaboration and thoughtful discussions.

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List of Abbreviations

ACSC	Ambulatory Care Sensitive Conditions
AIHW	Australian Institute of Health and Welfare
ATS	Australasian Triage Scale
AUC	Area Under the Receiver Operating Characteristic Curve
CCI	Canadian Classification of Health Interventions
CED-DxS	Canadian Emergency Department Diagnostic Shortlist
CI	Confidence Interval
CTAS	Canadian Triage and Acuity Scale
ED	Emergency Department
EDAC	Emergency Department Avoidability Classification
FPSC	Family Practice Sensitive Conditions
HIREB	Hamilton Integrated Research Ethics Board
ICD	International Classification of Diseases
ICES	Institute for Clinical Evaluative Sciences
LOS	Length of Stay
MOH	Ministry of Health
N	Sample Size
NACRS	National Ambulatory Care Reporting System
OR	Odds Ratio
PHIPA	Personal Health Information Protection Act
PriCARE	Primary Care-like Ambulance transports following Response for 911 Emergencies

RECORD	REporting of studies Conducted using Observational Routinely-collected Data
SNC	Sentinel Nonurgent Conditions
STROBE	Strengthening the Reporting of Observational Studies in Epidemiology

Declaration of Academic Achievement

I, Ryan Peter Strum, declare this thesis to be my own research. I was responsible for the conceptualization, writing, conduction, analysis, interpretation and revisions of all studies and chapters of this thesis. This thesis is composed of an introductory chapter (chapter one), two consensus studies (chapter two), two retrospective cohort studies (chapters three, five), a cluster randomized, single-blinded agreement study (chapter four) and a discussion chapter (chapter six). I conferred with my Ph.D. supervisor, Dr. Andrew Costa, and thesis committee when methodological, clinical, or contextual guidance was sought.

To conduct the consensus studies and cohort study (chapters two, three), administrative data was obtained from an ICES analyst in accordance with ICES policy and procedures for student investigators. To conduct the randomized study and subsequent cohort study (chapters four, five), administrative data were extracted from the academic hospital by a data scientist following research ethics approval and endorsement by senior members of the academic hospital. Prior to manuscript submission to scientific journals, I collaborated with several clinical and contextual experts to review and contribute to the final drafts, including Dr. Shawn Mondoux, Dr. Fabrice Mowbray, Dr. Paul Miller, and Komal Aryal.

CHAPTER ONE

Introduction

Emergency Departments and Overcrowding

Emergency departments (EDs) are facilities that provide immediate care to patients with acute injuries and severe illness requiring urgent to life-threatening medical attention.[1] ED physicians and staff are equipped to manage a wide range of medical emergencies, with capacity to rapidly diagnose, treat and stabilize patients in critical situations.[1]

ED overcrowding occurs when the demand of ED health care exceeds the available ED resources and capacity to provide adequate and timely patient care.[2] Overcrowding is not a new phenomenon, nor is it unique to Canada.[3–5] ED overcrowding is a multifactorial issue that has consequences for patients, ED staff and the broader health system.[6,7] ED overcrowding has been associated with increased death rates.[8,9] When overcrowded, the mortality rate in the ED increases by 2%, attributed mainly to older patients and those with intracerebral hemorrhage or neurological diseases.[8,10] Numerous studies have reported a reduction in quality of patient care provided when the ED is beyond its full patient capacity.[9,11,12] When overcrowded, treatment performance declines, complications of acute coronary syndromes increase (three to five times), medical errors increase, compliance with treatment guidelines decreases, commencement of treatment is delayed, and less pain relief is given.[9,11–18] Economically for the ED, the cost per patient visit is increased due to longer LOS hours.[19] Qualitatively, patient satisfaction decreases, leading to a higher rate of patients leaving without been assessed by a physician.[20,21] For ED staff, the

literature demonstrates an increased rate of burnout, stress and lowered job satisfaction when high patient volumes in the ED are consistent without adequate resources to manage patients effectively.[21] Lastly, ED overcrowding has downstream consequences on the health system, including departments within the hospital. When overcrowded, the ICU mortality rate increases (8.4% to 10.7%), and the risk of in-hospital morality at 10 days from admission increases by 34%.[9] For the hospital, overcrowded EDs increase overall patient costs per visit compared to when the ED is not over patient volume capacity.[22]

ED overcrowding has been extensively researched to understand intrinsic and extrinsic underlying causes at institutional and health system levels.[2] Boarding, a circumstance where patients admitted to the hospital are held in the ED when there is no available inpatient bed, has been identified as the leading cause of overcrowding.[6] Boarding has been linked to delayed ED discharge and congests the department.[6] Reduced staffing is also a factor to ED overcrowding, as there are not enough staff available to manage patient assignments.[23] Staff reductions can result from multiple factors, including shortages, sick leaves, burnout and budgetary cuts.[23] Poor patient flow within the ED can contribute to overcrowding for several reasons that include a lack of streaming (allocating patients with similar diseases to a specific geographical area within the ED), lack of coordination with hospital departments, and lack of integration with rapid assessment tools to distribute patients within the ED.[11,24] Extrinsically, increased patient visitation is the major contributor, specifically by patients who use the ED inappropriately for non-urgent and minor health conditions that increase ED patient volumes.[25]

Mitigating ED overcrowding has been a persistent challenge, with conventional solutions such as expanding ED resources not being linked to a reduction in overcrowding metrics and strain on ED staff.[26,27] Initiatives with promising results of on ED overcrowding are relatively slow to be implemented and have their own challenges when scaling (e.g., expanding homecare to continue treatment from the ED, increasing primary care providers in close proximity to ED's, expanding hours of general practitioner offices).[23,28] When overcrowding is reduced, the ED and in-hospital mortality rates decreases, patient satisfaction increases, patients are less likely to leave the ED against medical advice, length of stay times are shorter and staff strain lowers.[24,28–30]

The Growth of Emergency Department Visits

Over the past two decades, there has been a substantial increase in the number of patients visiting EDs both nationally and internationally.[25,31] Canada and the United States have reported over a 20% increase in ED visits in the decade prior to the COVID-19 pandemic.[25,32] While Canadian ED visitation declined during the pandemic, recent reporting by the Canadian Institute for Health Information (CIHI) found annual visitation returned to pre-pandemic levels, with indications visitation will continue to escalate.[33] This growth in ED visitation cannot be attributed solely to population growth, as rates of ED visitation per 100,000 residents continue to rise.[25] Canada's aging population is a significant factor in the upsurge of ED visits, as they are the largest consumers of ED care compared to other age groups.[34,35] Additionally, paramedic transported patients have increased significantly, contributing to ED visitation growth.[25] Patient cohorts that historically used the ED less have also increased substantially (e.g., young children, patients with access to primary are).[36] These factors, among others,

have led to EDs experiencing unprecedent pressures.[37] In Ontario, EDs are reporting extensive wait times, such as two hours for the first physician assessment, four hours length of stay (LOS) for non-admitted patients and 19-hour LOS for admitted patients (reporting from March 2023).[38] Increased visitation and an inability to flex capacity to meet demands have reached crisis points in some jurisdictions, threatening the ED's ability to provide timely, effective and equitable patient-centred care.

Ontario's ED's may succumb to even more overcrowding if ED patient volumes cannot be mitigated. Anticipated shortages in primary care and family physicians are likely to increase, given 20% of Ontario's primary care and family physicians are expected to leave the field in the next 5 years, and 30% of family residency spots reportedly went unfilled in 2023.[39,40] Patients without adequate primary care are more likely to visit the ED, which may further increase ED overcrowding.[41,42] The combination of surging patient visitation, an aging population, ED boarding heightening, ED staff burnout and decreased primary care will likely increase overcrowding going forward without policy intervention. New initiatives to offset patient volumes are needed. Though receiving less research attention, redirecting patients who do not need emergency medical attention away from the ED to non-ED care is one strategy to decrease ED overcrowding.[43–45] However, knowing who could be appropriate is poorly understood.[46]

Avoidable Emergency Department Visits

Avoidable ED visits refer to visits that could have been safely managed and effectively treated in a non-ED healthcare setting.[47] Avoidable visits are a subsection of non-urgent ED visits; ED attendance for conditions that if medical attention were delayed for several hours would not increase the likelihood of an adverse outcome.[48] In

Ontario, the majority of ED visits are used by patients with non-emergent medical conditions, some of which could be considered avoidable.[25] This evidence suggests patients use EDs to access the healthcare system, not necessarily emergency purposes, deviating from the intended purpose of EDs, which increases ED volumes and overcrowding directly.[49,50] Patients seek ED care for avoidable visits for a multitude of reasons, such as convenience, negative perceptions about primary and alternative care, confidence in emergency medicine, perceived urgency of the medical conditions and perceived need for care from a hospital.[49–51]

While patients may self- justify their need to seek ED care, in circumstances of avoidable visits, these visits have a downstream impact on patient volume, and therefore, overcrowding.[52] Additionally, treatment of primary care-like conditions in the ED are five times more expensive compared to primary care, and patients are less likely to align with primary care following ED discharge.[53,54]

Limited research has shown that redirecting avoidable ED visits to specialized primary care within the hospital or primary care offices outside of the hospital can result in shorter ED wait times for first assessment, shorter overall LOS and fewer patients leaving without being assessed.[43,44] However, some research found redirecting avoidable patients did not lower ED performance metrics, highlighting a confliction in the literature surrounding patient redirections.[45] I hypothesize one reason for the lack of successful ED redirection interventions may be due to poor patient inclusion and intervention design. Currently, there is no consensus on a definition of avoidable ED visits or its patient criteria, which urgently requires addressing.[47,49]

Patient Classifications of Avoidable Emergency Department Visits

Patient classifications are used to group patients with similar healthcare trajectories on an outcome.[55] Epidemiologically, patient classifications are used to identify patient care needs retrospectively, to inform prospective development of interventions for similar patients.[55,56] Several patient classifications have been described in the literature to delineate avoidable ED visits in administrative data, but provide wide prevalence estimates that range from 5% to 90% of ED visits.[46,57] This variation is due to the heterogeneity of classification definitions and measurement criteria.[57] In a systematic review by Durand et al. 2011, the authors reported 51 different methods to classify ED visits as preventable, with considerably wide methods to classify ED visits that include expert opinion, patient self-assessment, chief complaint, duration of complaint, triage score, diagnosis category, vital signs, treatments performed in the ED, hospitalization and several classification systems.[58] In a systematic review by Urscher-Pines et al. 2013, the authors also found numerous methodologies to delineate preventable ED visits, but remarkably, no method had the same definition or classification criteria.[48] These research studies highlight the wide array of methods used to determine which ED visits could have been managed in non-ED care, and the lack of consensus on the definition and criteria.

Defining avoidable ED visits could be exceptionally informative for extrinsic interventions that aim to mitigate ED overcrowding, but is poorly understood in the literature.[47] There are several explanations for researchers and epidemiologists lack of conceptualization of avoidable ED visits. First, researchers have conflated definitions of ‘preventable ED visits’ with the concept of ‘avoidable ED visits’, shown in Table 1.[47]

Avoidable ED visits represent ED attendance that could have been appropriately managed and treated by non-ED care, the definition used in this thesis.[57,59] Avoidable ED visits require clinical attention, but for urgent and non-urgent conditions available elsewhere.[57,60] Preventable ED visits are visits that resulted in hospital admission but could have been prevented if earlier intervention and superior condition management were implemented 'upstream' in primary and community care.[35,57] This concept developed a commonly used classification in epidemiological research called ambulatory care sensitive conditions (ACSC).[61,62] Clinically unnecessary ED visits, defined as ED attendance for situations where patients do not require any clinical care, and attend for conditions that only require self-care, social needs or non-clinical forms of care (e.g., social services).[57] Unnecessary ED visits are not well supported in the literature, given their capacity to dictate whether an ED was needed based on factors without consideration of relevant factors such marginalization, access to primary care or social determinants of health.

There is a growing skepticism about whether an avoidable ED visit can be classified epidemiologically due to researchers using preventable and unnecessary ED visit classifications interchangeably to describe avoidable ED visits.[63] This issue may be due to the lack of a valid avoidable classification in the literature. Additionally, some researchers combine definitions and classifications, causing confusion in the field (e.g., necessary preventable, unnecessary preventable).[64] This misuse has led some researchers to question the conclusions of previous studies that have incorrectly studied ED "appropriateness".[46] Conceptually this may be due to general lack of validity evidence in the literature, a key component that would demonstrate the studies

classifications conclusions are accurate.[59] Lastly, classifications rely on dichotomous outcomes to classify ED visits as avoidable or preventable, an arbitrarily cut-off when patient conditions are complex and a challenge to definitively state classified or not.[60]

The combination of all these factors may help explain why efforts to reduce ED overcrowding have been largely ineffective and interventions have not been broadly introduced to redirect avoidable patients from the ED. As Lowe and Bindman 1997 noted after they determined seven classifications of inappropriate ED visits had no-to-slightly better agreement than random chance,

> *"Limiting patients' access to EDs without the aid of a valid and reliable standard for what constitutes an appropriate ED visit could create harmful barriers to care."* [46]

This statement was written over 25 years ago, and since then, the classification criteria of an avoidable ED visit has remained undefined. Important policy modifications cannot be instituted when classifications are used equivalently and incorrectly to describe avoidable ED visits. This thesis aims to provide clarity on this ambiguity and construct a valid classification of avoidable ED visits.

Data Sources

My thesis data were leveraged from primary and secondary data sources. Primary data were collected from emergency and family medicine physicians in Ontario, Canada using electronic data collection software, *CheckMarket*. Research involving primary data collection received ethics approval by the Hamilton Integrated Research

Ethics Board (HIREB). Two different administrative ED secondary data sources were studied in this this thesis; administrative data are generated in normal operation of the ED system and not for research purposes. First, administrative ED visit records were accessed and extracted from the National Ambulatory Care Reporting System (NACRS), retained by the Institute for Clinical Evaluative Sciences (ICES). NACRS is a hospital and community-based ambulatory care administrative database that collects all patient visit data at the time of service.[65,66] ICES is a non-profit, independent corporation that supports the study of health service and population-wide outcomes in Ontario using administrative databases. ICES's collection and use of NACRS secondary data is authorized under Section 45 of Ontario's Personal Health Information Protection Act (PHIPA) as a prescribed entity, which is exempt from review by a Research Ethics Board.[67,68] The use of the data in this thesis is authorized under section 45 after approval for study by ICES's privacy and legal office. Second, administrative ED data were leveraged from an academic hospital in Hamilton, Ontario, Canada. All data were extracted by analysts at the hospital containing data fields consistent with NACRS; research involving this data was approved by HIREB.

Thesis Objectives

The primary objective of this thesis was to develop, validate and compare a novel epidemiological patient classification that can accurately identify avoidable ED visits in retrospective administrative ED data. The activities of this thesis were fourfold: (1) to address a gap in the literature by defining avoidable ED visits, (2) to gain an understanding of ED physician interventions that are conducted for avoidable ED visits, (3) to contribute a useful new classification that can support health services and

stakeholders, and (4) to provide evidence of validity on the classification's accuracy as a classifier of avoidable ED visits. This thesis introduced a novel concept by utilizing the ED physician's main intervention to construct the classification criteria, deviating from traditional classifications that rely on diagnostics. This sandwich thesis comprises two modified Delphi consensus studies, two retrospective cohort studies and a cluster randomized, single-blinded agreement study. The reporting of the consensus studies followed the Diamond et al 2014 checklist of key methodologic criteria to report in publications of Delphi studies[69], and the cohort studies followed the Strengthening the reporting of observational studies in epidemiology (STROBE)[70] and the Reporting of studies conducted using observational routinely-collected data (RECORD)[71].

Thesis Overview

Chapter two contains two published consensus studies titled *Emergency department interventions that could be conducted in subacute care settings for patients with nonemergent conditions transported by paramedics: a modified Delphi study*[72] and *Inclusion of patient-level emergency department characteristics to classify potentially redirectable visits to subacute care: a modified Delphi consensus study*[73]. To my knowledge, these studies are the first to use a scientific consensus method to determine suitable criteria that identify avoidable ED visits. This research determined 103 ED physician main interventions were suitable to be conducted in non-ED settings, and four patient characteristics are important to limit which patients could have received these interventions in non-ED care. These studies were published in the *Canadian Medical Association Journal Open* journal. Both studies adhered to the protocol titled *Development of the PriCARE classification for potentially preventable emergency*

department visits by ambulance: a RAND/UCLA modified Delphi study protocol, published in *BMJ Open*.[74]

Chapter three contains a published retrospective cohort study titled *Identifying patient characteristics associated with potentially redirectable paramedic transported emergency department visits in Ontario, Canada: a population-based cohort study.*[75] This study evaluates the association between ED physician interventions that could be conducted in non-ED care and ED patient characteristics. This study determined physician interventions were associated with the same characteristics that received consensus in chapter two to identify avoidable ED visits. This research showed the ED physician interventions identified in the consensus research have face validity with ED physician judgements on avoidable ED visits, providing evidence of validity the interventions represent the same patient characteristics physicians deemed were appropriate for treatment in a non-ED setting. This chapter was published in the journal *BMJ Open*.

Chapter four contains a cluster randomized, single-blinded agreement study titled *Validating the Emergency Department Avoidability Classification (EDAC): A Cluster Randomized Single-Blinded Agreement Study.* This study is novel as it is the first study to establish ED physicians as a reliable criterion standard to classify avoidable ED visits. This study determined the Emergency Department Avoidability Classification (EDAC) was highly correlated with ED physician judgements on 160 randomly selected ED visits from 2019 at an academic hospital in Hamilton, Ontario. This study provided evidence of validity that the EDAC is a robust classifier of avoidable ED visits in administrative data. This study is currently accepted in the *Public Library of Science*

(PLOS) One. This study adhered to the protocol titled *Validation of a classification to identify emergency department visits suitable for subacute and virtual care models: a randomised single-blinded agreement study protocol*[60], published in the journal *BMJ Open.*

Chapter five contains a retrospective cohort study titled *Comparing Epidemiological Classifications Designed to Identify Avoidable Emergency Department Visits*. This study examines prevalence estimates of avoidable ED visits using the EDAC and six additional published classifications. Additionally, this study evaluates the correlation and accuracy of all classifications to a reference standard of ED physician judgements. This study showed the EDAC was the most accurate and correlated classification, identifying 25% of ED visits as avoidable. All other classifications had poor to moderate performance, highlighting the inaccuracy of their prevalence estimates to delineate avoidable ED visits. The most accurate classifications did not incorporate diagnostics to classify visits, emphasizing the need to develop a novel classification that used an alternative approach to classify visits. This chapter has been prepared for publication in an academic journal, expected submission in February 2024.

Chapter six summarizes the findings and implications of the five research studies and two study protocols. This chapter details the strengths and limitations of the thesis, and relation to previous literature. Finally, this chapter details the future implications of the thesis to inform our understanding of avoidable ED visits for health policy stakeholders, epidemiologists, academics and clinicians.

Evolution of the Classification

The classification I developed progressed in my thesis to become a classification for broader ED epidemiological implementation. The evolution of the classification began with the development of Primary Care-like Ambulance transports following Response for 911 Emergencies (PriCARE). In the first consensus study of chapter two, 150 of the most frequently recorded ED physician interventions were extracted from NACRS on low acuity paramedic transported patients. These interventions represented 150 of the 162 most frequently recorded ED physician interventions for all ED visits, regardless of mode of arrival. Following the consensus studies of chapter two and cohort study of chapter three, the classification criteria was broadened to study all ED visits, not only for ED visits resulting from paramedic transports. The subsequent classification was called the Emergency Department Avoidability Classification (EDAC). This decision was three-fold, (1) the ED physician interventions analyzed in the consensus research are largely representative all low acuity ED visits (92.5%), (2) the decision to broaden the classification was not based on underlying knowledge of the validity of the classification (decision was made a priori to validity research), and (3) clinical judgement indicated that a broader classification could be more useful for epidemiological and health policy research as opposed to a classification specified to a cohort subsection of all ED visits. The change from classification name and population of study were described in the published protocol of chapter four.[60]

Conclusion

The issue of ED overcrowding has significant consequences for patients, ED staff and the healthcare system, of which growing ED visits are a driving factor.

Redirecting avoidable ED visits to non-ED care settings has shown promise in reducing overcrowding, but classification of avoidable visits remains poorly defined and varies widely in the literature. Lack of a classification has led to confusion and hindrance of implementing effective interventions aimed at mitigating avoidable ED visits. This thesis provides a novel patient classification to identify avoidable ED visits in retrospective administrative ED data. The chapters of this thesis build upon each other as classification research should and includes two consensus studies, two retrospective cohort studies, and a cluster randomized, single-blinded agreement study.

Tables and Figures

Table 1: Definitions of patient classifications that depict inappropriate ED attendance.

	Avoidable	Preventable	Unnecessary
Definition	ED visits that could have been safely and appropriately managed by non-ED care	ED visits resulting in hospital admission that could have been potentially prevented with earlier intervention of medical conditions	ED visits that did not require clinical care
Concept	Patients that require clinical attention in some form, but not specifically in the ED (e.g., urgent care, primary care)	Patients with treatable primary care conditions that are not managed, leading to need for hospital admission	Patients attending the ED for conditions requiring self-care, non-clinical care, alternative forms of care, or care that was beyond healthcare
Interpretation	Low prevalence is desirable	Low prevalence is desirable	Low prevalence is desirable
Example of a case	Middle-aged patients attending the ED for a headache that are otherwise medically stable	Elderly patients admitted to hospital for worsening dehydration, where effective care in the days prior could have mitigated the conditions decline	Medically stable young adult patients that attend the ED for food and shelter when community care services are not available
Example of a classification	Sentinel Nonurgent Conditions	Ambulatory Care Sensitive Conditions	-

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CHAPTER TWO

Emergency Department Interventions that could be Conducted in Subacute Care Settings for Patients with Nonemergent Conditions transported by Paramedics: a modified Delphi Study

Summary

This chapter presents two studies that examine consensus among a panel of emergency and family medicine physicians. This first study examined consensus on ED physician interventions performed on non-emergent patients that could have been conducted in non-ED, subacute care. Physicians were requested to specify if the intervention could have been conducted in an urgent care centre, family practice office, and/or nurse practitioner-led clinic. Two-rounds were required to reach consensus.

I found that approximately two-thirds of the top 150 ED physician interventions could be performed in subacute care. This study is novel in its approach to establish the criteria of a patient classification using consensus methodology. There were no deviations from the study protocol.

Citation:
Strum, R.P., Tavares, W.T., Worster, A., Griffith, L.E., Costa, A.P. Emergency department interventions that could be conducted in subacute care settings for patients with nonemergent conditions transported by paramedics: a modified Delphi study. *CMAJ Open.* 2022; 10 (1), E1-E7.

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Study Protocol:
Strum, R.P., Tavares, W.T., Worster, A., Griffith, L.E., Costa, A.P. Development of the PriCARE classification for potentially preventable emergency department visits by ambulance: a RAND/UCLA modified Delphi study protocol. *BMJ Open*; 11, e045351.

Abstract

Background: As the number of patients with nonemergent conditions who are transported by paramedics continues to increase in Ontario, redirecting specific patients to subacute settings may be more beneficial and suitable for both patients and emergency departments. We aimed to evaluate whether emergency department interventions conducted on patients with nonemergent conditions who are transported by paramedics could be conducted in subacute health centres.

Methods: We conducted a RAND/UCLA modified Delphi study in Ontario between Oct. 13 and Dec. 19, 2020. We used purposive sampling to recruit practising emergency and primary care physicians for an expert panel. We abstracted interventions given to adult patients with nonemergent conditions (18 yr of age or older) who were transported by paramedics to an emergency department from the National Ambulatory Care Reporting System (NACRS) database (Jan. 1, 2014, to Mar. 31, 2018). Participants in the expert panel rated the suitability of the 150 most frequently recorded emergency department interventions from the NACRS database, for completion in subacute health care centres. We set consensus at 70% agreement.

Results: We invited 25 physician experts, 21 of whom consented to participate; 20 physicians completed round 1, and 18 physicians completed both rounds. After 2 rounds, consensus was reached on 146 (97.3%) interventions; 103 interventions (68.7%) were suitable for subacute centres, 43 (28.7%) for only the emergency department and 4 (2.6%) did not receive consensus. For subacute centres, all 103 interventions were rated for urgent care centres; walk-in medical centres were

applicable for 46 (30.6%) interventions and clinics led by nurse practitioners for 47 (31.3%) interventions.

Interpretation: Most interventions provided to patients with nonemergent conditions transported by paramedics to emergency departments were identified as suitable for urgent care clinics, with one-third being suitable for either walk-in medical centres or clinics led by nurse practitioners. This study has potential to inform a patient classification model for paramedic-initiated redirection of patients from emergency departments, although further contextualization is required for this to be implemented in clinical practice

Study registration: ID ISRCTN22901977.

Background

Paramedic services are increasingly transporting patients with non-emergent conditions to the emergency department (ED) when primary healthcare facilities may be more beneficial for their care.[1,2] In Ontario, patients with non-emergent conditions account for 60% of all ambulance transported patients, of which 74% are discharged the same day.[3] Initiatives by paramedic services,[4] government [5] and researchers[6] have not decreased paramedic transports for non-emergent ED visits; from 2014 to 2017 usage has increased by 12% (456 510 / 511 801) in Ontario.[7] Increasing ED visits have outpaced population growth in Ontario by more than double (13.6%, vs. 6.2% respectively)[8], suggesting utilization of ED's has broadened. Broadened use of paramedic services by non-emergent patients and a legislative requirement to transport all patients to the ED regardless of acuity is exacerbating the problem.[9,10]

Redirecting non-emergent patients to sub-acute care centres instead of EDs may offer a feasible solution to prevent some non-emergent patient visits.[11] Patient redirection has been successful in Canada; a computer algorithm to direct non-emergent visits from ED to primary care centres not only left patients as satisfied with the care they received (84%), but was also described as a safe strategy (5.9% of 980 diverted patients had unexpected healthcare visits to the ED; none for severe complication).[12] Internationally, sub-acute centres such as urgent care clinics have reduced the likelihood of ED visits for lower acuity conditions, have shown that they can perform treatments equivalent to EDs for minor illnesses and traumatic injuries, and at a lower cost.[13–16] Redirection to sub-acute care centres by paramedics may have

beneficial long-term implications by reducing paramedic transport consumption and can have higher cost effectiveness than transport to an acute centre ED.[17–20]

Evidence to support redirecting patients transported by paramedics to sub-acute centres is inconclusive, and international findings may not be generalizable across Canada.[21] Part of the difficulty arises from an absence of a suitable patient classification for examining which patients transported by paramedic services could have been potentially redirected.[20] Identification of which interventions patients receive in an ED visit could be an omitted fundamental characteristic to classify patient suitability for ED redirection. Inclusion of the main ED intervention may explain the lack of consistent patient categorization as potentially preventable amongst known classifications, and could scaffold with additional contextualization to construction a novel patient classification specific for paramedic redirection. Therefore, the objective of this study was to establish consensus on a set of ED interventions performed on non-emergent patients transported by paramedics that could be conducted in sub-acute healthcare centres.

Methods

Study Design

We used a RAND/UCLA modified Delphi study design to evaluate consensus on ED physician interventions that could be conducted in alternative sub-acute health centres.[22–24] This methodology allowed us to assess a collective groups judgements on patient procedures and facilitate group discussion between rounds.[24] We generated a list of the 150 most frequently recorded Canadian Classification for Health Interventions (CCI) *main intervention* codes on non-emergent adult patients (18 years or greater)

transported to hospital by paramedics in Ontario from January 1, 2014 to March 31, 2018 from the National Ambulatory Care Reporting System (NACRS) ED database to be evaluated through two rounds of ratings.[3,25]

Participants

We used purposive sampling to select 25 primary care and emergency physicians who were currently or recently practicing in Ontario, Canada.[3] We sought physicians who had either extensive medical experience, academic experience, or a leadership role in paramedic practice oversight to ensure they could offer high quality comprehension when evaluating ED interventions. All selected experts were sent a study information package (objective, purpose, contribution), and those who participated gave informed consent prior to beginning the modified Delphi. We only recruited physicians to participate as all interventions included in this study were performed by physicians. All other types of practitioners (including paramedics) were excluded to reduce any potential bias of experts evaluating interventions that may not be within the practitioner's scope of practice. We determined *a priori* the Delphi expert committee must be composed of at least ten physicians, with representation from both emergency and primary care disciplines to increase the reliability of group judgements.[26] Once an expert was recruited, they were asked to complete a demographic questionnaire. Only physicians who completed at least one round would be included in the Delphi expert committee, and were provided a $75 e-gift card for participation.

Data Source

The included 150 most frequently recorded ED interventions represented 95.5% (1 259 998/1 319 388) of all interventions recorded in NACRS during the study period.

We determined *a priori* that our intervention list should encompass at least 95% of total interventions in the study cohort to increase face validity. NACRS contains an Ontario population-level collection of hospital administrative records. We determined non-emergent patients as having a Canadian Triage and Acuity Score (CTAS) of three (urgent) to five (non-urgent) based on clinical judgment.[27] All recorded CTAS scores were assigned upon entry to the ED by an ED or triage nurse. CTAS is an ordinal scale that ranges from one to five, with a score of one representing the most emergent (resuscitation) and five as least urgent (non-urgent).

Process

The RAND/UCLA modified Delphi method is a strategy that analyzes collective expert judgements to produce superior results than any one expert would, resulting in increased content validity.[28] We used a secure and encrypted *CheckMarket* software program to develop and administer the study questionnaires to experts. All data were stored on the investigators in encrypted servers. Interventions were presented in six subsections based on their section of the CCI Tabular List, 2018 Volume 3 categorization: (1) physical/physiological therapeutic interventions; (2) diagnostic interventions; (3) diagnostic imaging interventions, and; (6) cognitive, psychosocial and sensory therapeutic interventions, (7) other healthcare interventions, and (8) therapeutic interventions strengthening the immune system.[25] Section (5) obstetrical and fetal interventions were not included as no interventions assigned in this section was identified in the cohort. For each intervention, experts were asked to rate whether the intervention should be conducted exclusively in the ED, or alternatively, if could be conducted in a sub-acute healthcare centre. If an expert indicated an intervention

suitable for a sub-acute centre, they were asked if it could be conducted in a: (1) urgent care centre, (2) walk-in medical centres, and (3) nurse practitioner led-clinics (multiple selections were permitted). These sub-acute centres were selected as they represented the most feasible centres patients could be redirected to when transported by paramedic services, their services target non-emergent events, are abundant in Ontario, and at present do not receive patients by ambulance. Standardized definitions of each destination were provided to minimize any heterogeneity in expert interpretation of a healthcare centres function. Additionally, descriptions of each healthcare centres staffing, imaging and non-clinical specialty service abilities were provided to increase inter-member consistency. We hosted a videoconference debrief with the Delphi expert committee to share the results of Round 1 (RPS, APC) , and facilitate a discussion on the interventions that did not reach consensus.[24] The videoconference was not recorded, but study investigators were permitted to take notes.[3]

Data Analysis

We determined consensus as any intervention receiving 70% or greater agreement amongst all experts for an individual health care centre (either ED or sub-acute centre). We collected all expert ratings from Round 1, extracted the data of individual reports (*CheckMarket* software, extracted by RPS) and composed a general feedback form that contained aggregate percent agreement of all interventions reaching consensus, and those that did not.

Round 2 of the modified Delphi included all ED interventions that did not receive consensus in Round 1. Expert ratings of Round 2 would serve as the final consensus level on the residual interventions.

Ethics

This study received a research ethics board exemption waiver from the Hamilton Integrated Research Ethics Board; review reference 2020-11451-GRA.

Results

A total of 25 physicians who met the selection criteria were invited to participate by email, 21 accepted and consented to participate. Collectively 20 experts completed Round 1 and constituted the Delphi expert committee for this study. Experts were recruited from October 13 to November 5, 2020, and the modified Delphi consensus rounds occurred between November 6 and December 19, 2020; videoconference held between rounds on December 9, 2020. Figure 1 shows the flow of recruitment and modified Delphi Rounds in the study.

The majority of experts were male (70%) and reported their primary medical practice as emergency medicine (80%), with the remaining as family medicine (15%) or both (5%). The characteristics of the Delphi expert committee are shown in Table 1.

In Round 1, 139 interventions achieved a 70% consensus agreement amongst all experts (92.7%) for use in at least a single sub-acute healthcare centre. All interventions included in Round 1 were considered and rated by all 20 participating experts; only one submission per expert was accepted. The remaining 11 interventions which did not achieve consensus were included in Round 2, of which all were CCI section 1 interventions (i.e., physical/physiological therapeutic interventions). In Round 2, seven additional interventions reached consensus from experts for use in at least a single sub-acute healthcare centre, with the remaining four not reaching consensus in this study. Two experts that completed Round 1 did not complete Round 2. Consensus results in

the RAND/UCLA modified Delphi exercise are shown in summary by round and healthcare centre in Table 2.

Of ED interventions that achieved overall consensus, 103 (68.7%) were rated from experts as suitability for a sub-acute healthcare centre. Of the 47 remaining, 43 interventions (28.7%) were rated as only appropriate for the ED, and four interventions did not reach consensus (2.6%). All 103 intervention were deemed suitable for an urgent care centre, of which 46 interventions were suitable for a walk-in medical centre, and 47 for a nurse practitioner-led clinic. Of interventions requiring diagnostic imaging (Section 3), all magnetic resonance imaging (MRI) or computed tomography (CT) imaging were identified as only suitable for the ED, while the remaining two imaging categories (x-ray, ultrasound) were all rated appropriate for urgent care centres. All interventions of CCI Sections 7 and 8 were determined to be appropriate for sub-acute healthcare centres, and nearly all inventions of Section 2 and 6. The four interventions that did not receive consensus ranged in rating of 50-66% amongst expert agreement. All interventions receiving consensus for any of the 3 subacute health care centres are shown in Appendix 1, available at www.cmajopen.ca/content/10/1/E1/suppl/DC1, and results of the RAND/UCLA modified Delphi agreement ratings for all interventions are shown in Appendix 2, available at www.cmajopen.ca/content/10/1/E1/suppl/DC1.

Interpretation

Our study showed consensus primary and emergency care physicians on what clinical interventions commonly performed in the ED for non-emergent paramedic transported patients are suitable for alternative sub-acute healthcare settings. Specifically, 68.7% of included ED interventions were rated as suitable for conduction in

urgent care centres, 30.7% in walk-in medical centres and 31.3% for nurse-practitioner led clinics, while 2.6% did not receive consensus.

Our results are consistent with previous literature that suggests urgent care centres and similar sub-acute centres can be reasonable avenues for treatment of non-emergent patient conditions who would otherwise be directed to the ED.[14,29] There is an absence of evidence that measures the appropriateness of which ED interventions could be conducted in sub-acute settings, as most articles analyze patient conditions, diagnostics and medication administration.[14,15,30] Previous literature describes 13.7% to 27.1% of all ED patients could be safely managed by urgent care, however do not report which interventions were conducted.[14] Ample literature describes the use of sub-acute centres to offset ED use, however focus heavily on outcomes of patient satisfaction and cost avoidances[14,29], when quality of care, care received and simulation modeling may be more important indicators for supporting paramedics redirection models.[31,32]

That most of the included interventions were found to be appropriate for sub-acute centres acknowledges the confidence that study experts have in a sub-acute centres ability to conduct emergency department interventions. Of interventions that were rated for ED only, many required sedation practices, intensive monitoring, or advanced emergency physician skills. The four interventions that did not receive consensus all shared the same intervention procedure of using a reduction technique to treat an injury. Of Section 3 interventions involving diagnostic imaging, equipment was determined as the limiting factor (not injury site or physician interpretation).

An overarching goal of our study was to determine if consensus on which ED interventions could be performed elsewhere, such that an epidemiological patient classification could be constructed to inform redirection by paramedics. We recognize that interventions alone are insufficient considerations for such redirection programs. However, in combination with other indicators (e.g., contextualized patient features) and supports (e.g., education), knowledge of interventions suitable for sub-acute healthcare centers has the potential to support the construction of a patient classification model for paramedic-initiated redirection from the ED. Future research is required to incorporate additional patient and administrative information into a classification in order to provide contextualization before evaluating its validity for clinical guidance. The results of this study contribute evidence towards informing the circumstances (in part) in which paramedic service-based programs intended to support redirecting ED bound patients may be feasible and appropriate.

Limitations

Our Delphi expert panel of emergency physicians was mostly male, a limitation of purposively sampling, although we do not believe this influenced the study's results. An inherent limitation of using secondary administrative datasets is the completeness of the procedural fields. Our dataset included 63.7% completeness of the main interventions field in NACRS (1 319 388 / 2 070 260), to which this is expected as patients admitted to hospital may have their ED interventions recorded in the Discharge Abstract Database as opposed to NACRS. In other instances, there was no intervention completed during the visit, or the intervention was not recorded. Our cohort size remained large and is trustworthy based on our study objectives.

Individual judgements may be subjective given an expert's own evaluation with safety in selecting healthcare centres. This limitation was minimized in the study design to include only physicians with adequate knowledge of emergency and primary care practices in Ontario, the Delphi committee contained a high number of experts, and a detailed description of each healthcare centre was provided.

Our findings may not be generalizable in settings where payment structures for healthcare, accessibility to sub-acute care or ambulance availability are different. In addition, our research was specific in terms of population (adult, non-emergent, ambulance) and only included ED interventions and did not take into consideration any additional clinical details.

Conclusion

With a continued increase in the proportion of patients with nonemergent or low-acuity conditions transported to emergency departments by paramedic services, it is important to explore features that support redirection programs so that their effect on outcomes for patients and use of emergency departments can be evaluated. Most interventions provided by physicians in the emergency department to patients with nonemergent conditions transported by paramedic services were identified as suitable for subacute health care centres (i.e., urgent care centres, walk-in medical centres and clinics led by nurse practitioners). Although focusing on interventions alone has limitations, our results suggest there may be a patient population suitable for redirection programs by paramedic services in Ontario as a way of countering the emergency department crisis.

Our findings may help to inform construction of a patient classification system for patients with nonemergent conditions for use by paramedic services that could be used to prevent visits to the emergency department and to align paramedic services with patient needs better. Future research is required to augment our findings with additional patient and hospital contextualization toward such a classification system.

Tables and Figures

Figure 1: Study course of recruitment and two rounds of the RAND/UCLA modified Delphi consensus survey.

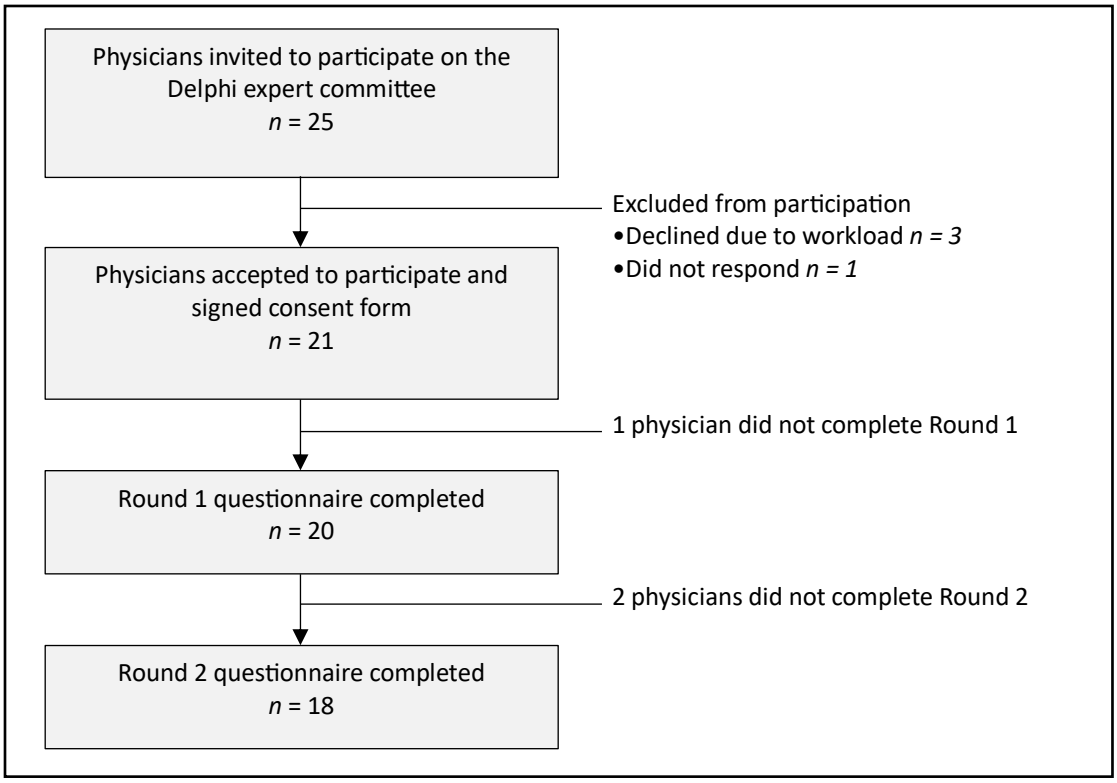

Table 1: Demographic characteristics of the Delphi expert committee in the RAND/UCLA modified Delphi consensus process.

Characteristic	Experts, *n*=20 (*n*, %)
Sex	
Male	14 (70%)
Female	6 (30%)
Province of primary practice	
Ontario	18 (90%)
Quebec	2 (10%)
Primary medical practice	
Emergency medicine	16 (80%)
Family medicine	3 (15%)
Both	1 (5%)
Length of practice, yrs	
0 to 4	2 (10%)
5 to 9	5 (25%)
10 to 14	2 (10%)
15 to 19	2 (10%)
20 to 24	2 (10%)
25 to 29	2 (10%)
30 or greater	5 (25%)
Medical director, Ontario paramedic practices	5 (25%)

Table 2: Emergency department interventions receiving consensus through each round of the RAND/UCLA modified Delphi survey.

Canadian Classification of Health Interventions section*	Round 1		Round 2		Cumulative result	
	No. of interventions	No. (%) with consensus	No. of interventions	No. (%) with consensus	No. (%) of interventions with consensus	No. of interventions with no consensus
1) Physical or physiologic therapeutic	56	45 (80.4)	11	7 (63.6)	52 (92.9)	4
2) Diagnostic	8	8 (100)	–	–	8 (100)	0
3) Diagnostic imaging	73	73 (100)	–	–	73 (100)	0
6) Cognitive, psychosocial and sensory therapeutic	11	11 (100)	–	–	11 (100)	0
7) Other health care	1	1 (100)	–	–	1 (100)	0
8) Therapeutic interventions strengthening the immune system	1	1 (100)	–	–	1 (100)	0

Note: consensus = 70% consensus reached, intervention = main emergency department intervention, no consensus = 70% consensus was not reached.
*Description and origin of sections are described in the Methods.

Table 3: Health care centre that could conduct emergency department interventions receiving consensus in the RAND/UCLA modified Delphi process.

		Acute centre	Subacute centre		
Canadian Classification of Health Interventions section*	No. of interventions	No. of interventions selected only for an ED	No. of interventions selected for an UCC	No. of interventions selected for a WM centre	No. of interventions selected for an NP clinic
1) Physical or physiologic therapeutic	52	10	42	27	29
2) Diagnostic	8	1	7	6	6
3) Diagnostic imaging	73	32	41	0	0
6) Cognitive, psychosocial and sensory therapeutic	11	0	11	11	10
7) Other health care	1	0	1	1	1
8) Therapeutic interventions strengthening the immune system	1	0	1	1	1

Note: intervention = main emergency department intervention, ED = emergency department, NP clinic = nurse practitioner–led clinic, UCC = urgent care centre, WM centre = walk-in medical centre.
*Description and origin of sections are described in the Methods.

Supplemental Data

Appendix 1: Emergency department interventions on non-emergent paramedic transported patients deemed suitable for sub-acute healthcare centres, shown by care centre.

CCI section/intervention*	CCI Coding	Subacute health care centre		
		Urgent care centre, *n = 103*	**Walk-in medical centre, *n = 46***	**Nurse practitioner-led clinic, *n = 47***
1) Physical/ physiological therapeutic interventions				
Control of bleeding, nose using per orifice approach and agent NEC [e.g. silver nitrate]	1ET13CAZ9	Yes	Yes	Yes
Control of bleeding, nose using per orifice approach and device NEC (e.g. electrocautery)	1ET13CAGX	Yes	-	-
Control of bleeding, nose using per orifice approach and packing	1ET13CANP	Yes	-	-
Drainage, bladder using per orifice approach and drainage catheter	1PM52CATS	Yes	Yes	-
Extraction, rectum using per orifice approach and manual technique	1NQ57CJ	Yes	Yes	Yes
Immobilization, knee joint using splinting device [e.g. supportive and corrective]	1VG03JASR	Yes	Yes	Yes
Immobilization, shoulder joint using sling	1TA03JASQ	Yes	Yes	Yes
Implantation of internal device, stomach of gastric tube [e.g. nasogastric feeding tube] using per orifice approach	1NF53CATS	Yes	-	-
Implantation of internal device, vein NEC of intravenous catheter using percutaneous approach	1KX53HAFT	Yes	Yes	Yes
Management of internal device, bladder of catheter using per orifice approach	1PM54CATS	Yes	-	Yes
Management of internal device, stomach of percutaneously inserted gastric tube [PEG]	1NF54HATS	Yes	-	-
Oxygenation, respiratory system NEC using bulk storage manifold system	1GZ32CAMY	Yes	-	-
Pharmacotherapy (local), circulatory system NEC percutaneous infusion approach of electrolyte balance agents	1LZ35HHC7	Yes	-	-
Pharmacotherapy (local), rectum using per orifice approach and agent NEC (e.g. oil retention, soap suds)	1NQ35CAZ9	Yes	-	-
Pharmacotherapy (local), respiratory system NEC using antiasthmatic agent	1GZ35CAR3	Yes	-	Yes
Pharmacotherapy, total body blood and blood forming organ agents percutaneous approach [intramuscular, intravenous, subcutaneous, intradermal] using antithrombotic agent	1ZZ35HAC1	Yes	-	-
Pharmacotherapy, total body general antiinfective agents percutaneous approach [intramuscular, intravenous, subcutaneous, intradermal] cephalosporin and related substance	1ZZ35HAK4	Yes	Yes	Yes

Pharmacotherapy, total body musculoskeletal system agents percutaneous approach [intramuscular, intravenous, subcutaneous, intradermal] antiinflammatory and antirheumatic agent	1ZZ35HAN1	Yes	Yes	Yes
Pharmacotherapy, total body nervous system agents percutaneous approach [intramuscular, intravenous, subcutaneous, intradermal] analgesic	1ZZ35HAP2	Yes	Yes	Yes
Reduction, small and large intestine using manual technique (for hernia reduction alone)	1NP73JH	Yes	-	-
Reduction, wrist joint using closed (external) approach	1UB73JA	Yes	-	-
Repair, lip using apposition technique [e.g. suture]	1YE80LA	Yes	-	-
Repair, scalp using apposition technique [e.g. suture, staple]	1YA80LA	Yes	Yes	Yes
Repair, scalp using closure device (e.g. clip, adhesive skin closure [Steri-Strips])	1YA80JAFF	Yes	Yes	Yes
Repair, scalp using glue for apposition (e.g. crazy glue, glustitch)	1YA80LAW4	Yes	Yes	Yes
Repair, skin of abdomen and trunk using open apposition technique [suture]	1YS80LA	Yes	Yes	Yes
Repair, skin of arm using apposition technique [suture]	1YT80LA	Yes	Yes	Yes
Repair, skin of arm using closure device (e.g. clip, adhesive skin closure [Steri-Strips])	1YT80JAFF	Yes	Yes	Yes
Repair, skin of ear using apposition technique [e.g. suture]	1YC80LA	Yes	-	-
Repair, skin of face using apposition technique [suture]	1YF80LA	Yes	Yes	Yes
Repair, skin of face using closure device (e.g. clip, adhesive skin closure [Steri-Strips])	1YF80JAFF	Yes	Yes	Yes
Repair, skin of face using glue for apposition (e.g. crazy glue or glustitch)	1YF80LAW4	Yes	Yes	Yes
Repair, skin of foot using apposition technique [suture]	1YW80LA	Yes	Yes	Yes
Repair, skin of forehead using apposition technique [e.g. suturing, stapling]	1YB80LA	Yes	Yes	Yes
Repair, skin of forehead using closure device (e.g.clip, adhesive skin closure [Steri-Strips])	1YB80JAFF	Yes	Yes	Yes
Repair, skin of forehead using glue (e.g. crazy glue, glustitch)	1YB80LAW4	Yes	Yes	Yes
Repair, skin of hand using apposition technique [suture]	1YU80LA	Yes	Yes	Yes
Repair, skin of hand using closure device (e.g. clip, adhesive skin closure [Steri-Strips])	1YU80JAFF	Yes	Yes	Yes
Repair, skin of hand using glue for apposition (e.g. crazy glue, glustitch)	1YU80LAW4	Yes	Yes	Yes
Repair, skin of leg using apposition technique [suture]	1YV80LA	Yes	Yes	Yes
Repair, skin of leg using closure device (e.g. clip, adhesive skin closure [Steri-Strips])	1YV80JAFF	Yes	Yes	Yes
Repair, skin of nose using apposition technique [e.g. suture]	1YD80LA	Yes	-	-
2) Diagnostic interventions				
Assessment (examination), total body general NEC (e.g. multiple reasons)	2ZZ02ZZ	Yes	Yes	Yes
Electrophysiological measurement, heart NEC external application using recording electrodes (or ECG NOS)	2HZ24JAXJ	Yes	Yes	Yes
Function study, bladder capacity determination	2PM58VE	Yes	-	-
Function study, bladder post- void residual volume measurement	2PM58VD	Yes	Yes	Yes

Function study, respiratory system at rest (steady state)	2GZ58TA	Yes	Yes	Yes
Inspection, rectum using per orifice manual (digital) technique	2NQ70CA	Yes	Yes	Yes
Specimen collection (for diagnostic testing), total body blood by venous puncture	2ZZ13RA	Yes	Yes	Yes
3) Diagnostic imaging interventions				
Ultrasound, abdominal cavity alone	3OT30DA	Yes	-	-
Ultrasound, abdominal cavity transvaginal probe	3OT30LA	Yes	-	-
Ultrasound, arteries of leg NEC with Doppler	3KG30DC	Yes	-	-
Ultrasound, bladder NOS alone	3PM30DA	Yes	-	-
Ultrasound, female genital tract NEC alone	3RZ30DA	Yes	-	-
Ultrasound, female genital tract NEC transvaginal approach	3RZ30LA	Yes	-	-
Ultrasound, kidney alone	3PC30DA	Yes	-	-
Ultrasound, leg NEC alone	3VZ30DA	Yes	-	-
Ultrasound, scrotum alone	3QG30DA	Yes	-	-
Ultrasound, thoracic cavity NEC alone	3GY30DA	Yes	-	-
Ultrasound, veins of arm NEC with Doppler	3JU30DC	Yes	-	-
Ultrasound, veins of leg NEC alone	3KR30DA	Yes	-	-
Ultrasound, veins of leg NEC with color flow and Doppler	3KR30DC	Yes	-	-
Ultrasound, veins of leg NEC with Doppler	3KR30DD	Yes	-	-
Xray, abdominal cavity without contrast (with or without fluoroscopy)	3OT10VA	Yes	-	-
Xray, ankle joint without contrast (e.g. plain film) (with or without fluoroscopy)	3WA10VA	Yes	-	-
Xray, clavicle without contrast (with or without fluoroscopy)	3SM10VA	Yes	-	-
Xray, elbow joint without contrast	3TM10VA	Yes	-	-
Xray, facial bone structure without contrast (e.g. plain film)	3EI10VA	Yes	-	-
Xray, femur without contrast (with or without fluoroscopy)	3VC10VA	Yes	-	-
Xray, foot without contrast (e.g. plain film) (with or without fluoroscopy)	3WG10VA	Yes	-	-
Xray, hand with wrist without contrast (e.g. plain film) (with or without fluoroscopy)	3UZ10VA	Yes	-	-
Xray, hip joint without contrast (with or without fluoroscopy)	3VA10VA	Yes	-	-
Xray, humerus without contrast (e.g. plain film) (with or without fluoroscopy)	3TK10VA	Yes	-	-
Xray, joints of fingers and hand NEC without contrast (e.g. plain film) (with or without fluoroscopy)	3UL10VA	Yes	-	-
Xray, kidney with ureter and bladder without contrast (e.g. plain film KUB)	3PS10VA	Yes	-	-
Xray, knee joint without contrast (with or without fluoroscopy)	3VG10VA	Yes	-	-
Xray, lung NEC without contrast (e.g. plain film) (with or without fluoroscopy)	3GT10VA	Yes	-	-
Xray, mandible without contrast (e.g. plain film) (with or without fluoroscopy)	3EE10VA	Yes	-	-
Xray, nose without contrast (e.g. plain film) (with or without fluoroscopy)	3ET10VA	Yes	-	-

Xray, pelvis without contrast	3SQ10VA	Yes	-	-
Xray, radius and ulna without contrast (e.g. plain film) (with or without fluoroscopy)	3TV10VA	Yes	-	-
Xray, ribs without contrast (with or without fluoroscopy)	3SL10VA	Yes	-	-
Xray, sacrum and coccyx without contrast	3SF10VA	Yes	-	-
Xray, shoulder joint without contrast (with or without fluoroscopy)	3TA10VA	Yes	-	-
Xray, soft tissue of head and neck without contrast (e.g. plain film) (with or without fluoroscopy)	3EQ10VA	Yes	-	-
Xray, spinal vertebrae without contrast	3SC10VA	Yes	-	-
Xray, sternum without contrast (with or without fluoroscopy)	3SK10VA	Yes	-	-
Xray, thoracic cavity NEC without contrast (with or without fluoroscopy)	3GY10VA	Yes	-	-
Xray, tibia and fibula without contrast (e.g. plain film) (with or without fluoroscopy)	3VQ10VA	Yes	-	-
Xray, wrist joint without contrast (e.g. plain film) (with or without fluoroscopy)	3UB10VA	Yes	-	-
6) Cognitive, psychosocial and sensory therapeutic interventions				
Assessment, mental health and addictions for capacity for harm (to self or others)	6AA02CP	Yes	Yes	Yes
Assessment, mental health and addictions for coping skills NEC	6AA02SK	Yes	Yes	Yes
Assessment, mental health and addictions for other reason NEC	6AA02ZZ	Yes	Yes	-
Counseling, mental health for substance addiction	6AA10AD	Yes	Yes	Yes
Counseling, mental health for behavior	6AA10BE	Yes	Yes	Yes
Counseling, mental health and addictions for concurrent disorders	6AA10CD	Yes	Yes	Yes
Counseling, mental health for trauma NEC	6AA10CT	Yes	Yes	Yes
Counseling, mental health for mood (e.g. anger, anxiety, relaxation, leisure)	6AA10MA	Yes	Yes	Yes
Counseling, mental health for other reasons	6AA10ZZ	Yes	Yes	Yes
Therapy, mental health crisis/trauma active listening	6AA30CTAA	Yes	Yes	Yes
Assessment, motor and living skills for activities of daily living [ADL]	6VA02ZZ	Yes	Yes	Yes
7) Other health care interventions				
Counseling, promoting health and preventing disease for other reason	7SP10ZZ	Yes	Yes	Yes
8) Therapeutic interventions strengthening the immune system				
Immunization (to prevent) diphtheria and tetanus by intramuscular [IM] injection of toxoid	8MK70HABK	Yes	Yes	Yes
Note: CCI = Canadian Classification for Health Interventions, ECG = electrocardiogram, NEC = not elsewhere classified, NOS = not otherwise specified. * Tabular List, 2018 Volume 3				

Appendix 2: Intervention consensus of the Delphi expert committee from the modified Delphi exercise, shown as percentages.

Intervention	CCI Coding	Acute	Sub-Acute		
		ED Only	UCC	WMC	NPC
Control of bleeding, nose using per orifice approach and agent NEC [e.g. silver nitrate]	1ET13CAZ9	5	95	75	70
Control of bleeding, nose using per orifice approach and device NEC (e.g. electrocautery)*	1ET13CAGX	11	89	28	28
Control of bleeding, nose using per orifice approach and packing	1ET13CANP	15	85	60	60
Drainage, abdominal cavity using percutaneous (needle) approach	1OT52HA	70	30	0	0
Drainage, bladder using per orifice approach and drainage catheter	1PM52CATS	5	95	70	65
Drainage, pleura using percutaneous (needle) approach	1GV52HA	85	15	5	5
Drainage, pleura using percutaneous catheter (intracostal) with underwater seal drainage system	1GV52HAHE	90	10	5	0
Drainage, stomach using per orifice approach and mechanical suction pump	1NF52CAQN	70	30	5	0
Extraction, rectum using per orifice approach and manual technique	1NQ57CJ	5	95	75	80
Immobilization, knee joint using splinting device [e.g. supportive and corrective]	1VG03JASR	0	100	85	75
Immobilization, shoulder joint using sling	1TA03JASQ	0	100	90	85
Implantation of internal device, stomach of (gastric) tube using percutaneous approach	1NF53HATS	70	30	10	10
Implantation of internal device, stomach of gastric tube [e.g. nasogastric feeding tube] using per orifice approach*	1NF53CATS	28	72	11	11
Implantation of internal device, vein NEC of intravenous catheter using percutaneous approach	1KX53HAFT	0	100	75	80
Implantation of internal device, vena cava (superior and inferior) non-tunnelled central venous catheter using percutaneous transluminal venous approach	1IS53GRLF	100	0	0	0
Management of internal device, bladder of catheter using per orifice approach	1PM54CATS	5	95	60	70
Management of internal device, stomach of percutaneously inserted gastric tube [PEG]	1NF54HATS	30	70	30	30
Oxygenation, respiratory system NEC using bulk storage manifold system	1GZ32CAMY	10	90	55	50
Pharmacotherapy (local), circulatory system NEC percutaneous infusion approach of electrolyte balance agents	1LZ35HHC7	10	90	50	55

Pharmacotherapy (local), rectum using per orifice approach and agent NEC (e.g. oil retention, soap suds)	1NQ35CAZ9	5	95	60	60
Pharmacotherapy (local), respiratory system NEC using antiasthmatic agent	1GZ35CAR3	5	95	65	75
Pharmacotherapy, total body blood and blood forming organ agents percutaneous approach [intramuscular, intravenous, subcutaneous, intradermal] using antithrombotic agent	1ZZ35HAC1	20	80	50	65
Pharmacotherapy, total body general antiinfective agents percutaneous approach [intramuscular, intravenous, subcutaneous, intradermal] cephalosporin and related substance	1ZZ35HAK4	0	100	80	90
Pharmacotherapy, total body musculoskeletal system agents percutaneous approach [intramuscular, intravenous, subcutaneous, intradermal] antiinflammatory and antirheumatic agent	1ZZ35HAN1	0	100	85	90
Pharmacotherapy, total body nervous system agents percutaneous approach [intramuscular, intravenous, subcutaneous, intradermal] analgesic	1ZZ35HAP2	0	100	80	95
Reduction, ankle joint using closed (external) approach[+]	1WA73JA	50	50	0	0
Reduction, elbow joint using closed (external) approach[+]	1TM73JA	50	50	0	0
Reduction, hip joint using closed (external) approach*	1VA73JA	72	28	0	0
Reduction, radius and ulna using closed (external) approach[+]	1TV73JA	67	33	0	0
Reduction, small and large intestine using manual technique (for hernia reduction alone)	1NP73JH	30	70	45	35
Reduction, tibia and fibula using closed (external) approach[+]	1VQ73JA	67	33	0	0
Reduction, wrist joint using closed (external) approach*	1UB73JA	28	72	0	0
Repair, lip using apposition technique [e.g. suture]	1YE80LA	5	95	50	50
Repair, scalp using apposition technique [e.g. suture, staple]	1YA80LA	0	100	90	95
Repair, scalp using closure device (e.g. clip, adhesive skin closure [Steri-Strips])	1YA80JAFF	0	100	90	95
Repair, scalp using glue for apposition (e.g. crazy glue, glustitch)	1YA80LAW4	0	100	90	95
Repair, skin of abdomen and trunk using open apposition technique [suture]	1YS80LA	5	95	80	80
Repair, skin of arm using apposition technique [suture]	1YT80LA	5	95	85	90
Repair, skin of arm using closure device (e.g. clip, adhesive skin closure [Steri-Strips])	1YT80JAFF	5	95	85	90

Repair, skin of ear using apposition technique [e.g. suture]	1YC80LA	15	85	35	25
Repair, skin of face using apposition technique [suture]	1YF80LA	15	85	70	70
Repair, skin of face using closure device (e.g. clip, adhesive skin closure [Steri-Strips])	1YF80JAFF	15	85	70	70
Repair, skin of face using glue for apposition (e.g. crazy glue or glustitch)	1YF80LAW4	15	85	70	70
Repair, skin of foot using apposition technique [suture]	1YW80LA	5	95	85	85
Repair, skin of forehead using apposition technique [e.g. suturing, stapling]	1YB80LA	10	90	70	75
Repair, skin of forehead using closure device (e.g.clip, adhesive skin closure [Steri-Strips])	1YB80JAFF	0	100	80	85
Repair, skin of forehead using glue (e.g. crazy glue, glustitch)	1YB80LAW4	0	100	80	85
Repair, skin of hand using apposition technique [suture]	1YU80LA	0	100	85	75
Repair, skin of hand using closure device (e.g. clip, adhesive skin closure [Steri-Strips])	1YU80JAFF	0	100	85	75
Repair, skin of hand using glue for apposition (e.g. crazy glue, glustitch)	1YU80LAW4	0	100	85	75
Repair, skin of leg using apposition technique [suture]	1YV80LA	0	100	85	85
Repair, skin of leg using closure device (e.g. clip, adhesive skin closure [Steri-Strips])	1YV80JAFF	0	100	85	85
Repair, skin of nose using apposition technique [e.g. suture]	1YD80LA	10	90	45	45
Stimulation, heart NEC external approach using electrode with synchronized DC shock*	1HZ09JAJF	89	11	6	0
Ventilation, respiratory system NEC invasive per orifice approach by (endotracheal) intubation and positive pressure (e.g. CPAP, BIPAP, IPPV)*	1GZ31CAND	89	11	0	0
Ventilation, respiratory system NEC non-invasive approach and positive pressure ventilation (e.g. CPAP, BIPAP, IPPV)*	1GZ31CBND	89	11	0	0
Assessment (examination), total body general NEC (e.g. multiple reasons)	2ZZ02ZZ	0	100	95	90
Electrophysiological measurement, heart NEC external application using recording electrodes (or ECG NOS)	2HZ24JAXJ	0	100	85	85
Function study, bladder capacity determination	2PM58VE	20	80	65	65
Function study, bladder post- void residual volume measurement	2PM58VD	10	90	75	75
Function study, respiratory system at rest (steady state)	2GZ58TA	5	95	85	85
Inspection, rectum using per orifice manual (digital) technique	2NQ70CA	0	100	100	100

Specimen collection (diagnostic), spinal canal and meninges using percutaneous (needle) approach	2AX13HA	80	20	5	5
Specimen collection (for diagnostic testing), total body blood by venous puncture	2ZZ13RA	0	100	90	90
Computerized tomography [CT], abdominal arteries NEC with contrast	3KE20WC	75	25	0	0
Computerized tomography [CT], abdominal cavity with contrast	3OT20WC	75	25	0	0
Computerized tomography [CT], abdominal cavity without contrast	3OT20VA	75	25	0	0
Computerized tomography [CT], abdominal cavity without enhancement (contrast)	3OT20WA	75	25	0	0
Computerized tomography [CT], arm NEC without contrast	3TZ20VA	75	25	0	0
Computerized tomography [CT], brain with and without enhancement (contrast)	3AN20WE	80	20	0	0
Computerized tomography [CT], brain with contrast	3AN20WC	80	20	0	0
Computerized tomography [CT], brain without contrast	3AN20VA	80	20	0	0
Computerized tomography [CT], brain without enhancement (contrast)	3AN20WA	80	20	0	0
Computerized tomography [CT], carotid artery with contrast	3JE20WC	75	25	0	0
Computerized tomography [CT], head NEC with contrast	3ER20WC	80	20	0	0
Computerized tomography [CT], head NEC without contrast	3ER20VA	80	20	0	0
Computerized tomography [CT], head NEC without enhancement (contrast)	3ER20WA	80	20	0	0
Computerized tomography [CT], kidney without contrast	3PC20VA	75	25	0	0
Computerized tomography [CT], kidney without enhancement (contrast)	3PC20WA	75	25	0	0
Computerized tomography [CT], leg NEC without contrast	3VZ20VA	75	25	0	0
Computerized Tomography [CT], leg NEC without enhancement (contrast)	3VZ20WA	75	25	0	0
Computerized tomography [CT], lung NEC with contrast	3GT20WC	80	20	0	0
Computerized tomography [CT], musculoskeletal system NEC without contrast	3WZ20VA	75	25	0	0
Computerized tomography [CT], other vessels of head, neck and spine NEC with contrast	3JX20WC	80	20	0	0
Computerized tomography [CT], soft tissue of neck with contrast	3FY20WC	75	25	0	0
Computerized tomography [CT], spinal vertebrae without contrast	3SC20VA	80	20	0	0
Computerized tomography [CT], spinal vertebrae without enhancement (contrast)	3SC20WA	80	20	0	0
Computerized tomography [CT], thoracic cavity NEC without contrast	3GY20VA	75	25	0	0

Computerized tomography [CT], total body without contrast	3ZZ20VA	75	25	0	0
Computerized tomography [CT], total body with contrast	3ZZ20WC	75	25	0	0
Computerized tomography [CT], urinary system NEC without contrast	3PZ20VA	85	15	0	0
Computerized tomography thoracic cavity NEC with contrast	3GY20WC	75	25	0	0
Computerized tomography thoracic cavity NEC without enhancement (contrast)	3GY20WA	75	25	0	0
Computerized tomography, thoracic vessels NEC with contrast	3JY20WC	75	25	0	0
Magnetic resonance imaging [MRI], spinal vertebrae without contrast	3SC40VA	90	10	0	0
Magnetic resonance imaging [MRI], spinal vertebrae without enhancement	3SC40WA	90	10	0	0
Ultrasound, abdominal cavity alone	3OT30DA	5	95	50	35
Ultrasound, abdominal cavity transvaginal probe	3OT30LA	20	80	45	30
Ultrasound, arteries of leg NEC with Doppler	3KG30DC	20	80	45	25
Ultrasound, bladder NOS alone	3PM30DA	10	90	50	35
Ultrasound, female genital tract NEC alone	3RZ30DA	15	85	45	35
Ultrasound, female genital tract NEC transvaginal approach	3RZ30LA	20	80	45	30
Ultrasound, kidney alone	3PC30DA	15	85	45	25
Ultrasound, leg NEC alone	3VZ30DA	20	80	45	30
Ultrasound, scrotum alone	3QG30DA	25	75	35	20
Ultrasound, thoracic cavity NEC alone	3GY30DA	15	85	35	25
Ultrasound, veins of arm NEC with Doppler	3JU30DC	20	80	45	30
Ultrasound, veins of leg NEC alone	3KR30DA	15	85	45	30
Ultrasound, veins of leg NEC with color flow and Doppler	3KR30DC	15	85	45	30
Ultrasound, veins of leg NEC with Doppler	3KR30DD	15	85	45	30
Xray, abdominal cavity without contrast (with or without fluoroscopy)	3OT10VA	0	100	0	0
Xray, ankle joint without contrast (e.g. plain film) (with or without fluoroscopy)	3WA10VA	0	100	0	0
Xray, clavicle without contrast (with or without fluoroscopy)	3SM10VA	0	100	0	0
Xray, elbow joint without contrast	3TM10VA	0	100	0	0
Xray, facial bone structure without contrast (e.g. plain film)	3EI10VA	10	90	0	0
Xray, femur without contrast (with or without fluoroscopy)	3VC10VA	0	100	0	0
Xray, foot without contrast (e.g. plain film) (with or without fluoroscopy)	3WG10VA	5	95	0	0
Xray, hand with wrist without contrast (e.g. plain film) (with or without fluoroscopy)	3UZ10VA	5	95	0	0
Xray, hip joint without contrast (with or without fluoroscopy)	3VA10VA	5	95	0	0
Xray, humerus without contrast (e.g. plain film) (with or without fluoroscopy)	3TK10VA	0	100	0	0

Xray, joints of fingers and hand NEC without contrast (e.g. plain film) (with or without fluoroscopy)	3UL10VA	5	95	0	0
Xray, kidney with ureter and bladder without contrast (e.g. plain film KUB)	3PS10VA	10	90	0	0
Xray, knee joint without contrast (with or without fluoroscopy)	3VG10VA	5	95	0	0
Xray, lung NEC without contrast (e.g. plain film) (with or without fluoroscopy)	3GT10VA	0	100	0	0
Xray, mandible without contrast (e.g. plain film) (with or without fluoroscopy)	3EE10VA	10	90	0	0
Xray, nose without contrast (e.g. plain film) (with or without fluoroscopy)	3ET10VA	5	95	0	0
Xray, pelvis without contrast	3SQ10VA	5	95	0	0
Xray, radius and ulna without contrast (e.g. plain film) (with or without fluoroscopy)	3TV10VA	5	95	0	0
Xray, ribs without contrast (with or without fluoroscopy)	3SL10VA	5	95	0	0
Xray, sacrum and coccyx without contrast	3SF10VA	5	95	0	0
Xray, shoulder joint without contrast (with or without fluoroscopy)	3TA10VA	5	95	0	0
Xray, soft tissue of head and neck without contrast (e.g. plain film) (with or without fluoroscopy)	3EQ10VA	5	95	0	0
Xray, spinal vertebrae without contrast	3SC10VA	5	95	0	0
Xray, sternum without contrast (with or without fluoroscopy)	3SK10VA	5	95	0	0
Xray, thoracic cavity NEC without contrast (with or without fluoroscopy)	3GY10VA	5	95	0	0
Xray, tibia and fibula without contrast (e.g. plain film) (with or without fluoroscopy)	3VQ10VA	5	95	0	0
Xray, wrist joint without contrast (e.g. plain film) (with or without fluoroscopy)	3UB10VA	5	95	0	0
Assessment, mental health and addictions for capacity for harm (to self or others)	6AA02CP	15	85	80	80
Assessment, mental health and addictions for coping skills NEC	6AA02SK	10	90	85	85
Assessment, mental health and addictions for other reason NEC	6AA02ZZ	15	85	80	60
Counseling, mental health for substance addiction	6AA10AD	5	95	90	90
Counseling, mental health for behavior	6AA10BE	5	95	90	70
Counseling, mental health and addictions for concurrent disorders	6AA10CD	5	95	90	85
Counseling, mental health for trauma NEC	6AA10CT	10	90	80	75
Counseling, mental health for mood (e.g. anger, anxiety, relaxation, leisure)	6AA10MA	10	90	90	80
Counseling, mental health for other reasons	6AA10ZZ	10	90	90	75
Therapy, mental health crisis/trauma active listening	6AA30CTAA	10	90	95	90
Assessment, motor and living skills for activities of daily living [ADL]	6VA02ZZ	5	95	95	90
Counseling, promoting health and preventing disease for other reason	7SP10ZZ	5	100	100	95

Immunization (to prevent) diphtheria and tetanus by intramuscular [IM] injection of toxoid	8MK70HABK	0	100	100	100
Note: CCI = Canadian Classification for Health Interventions, 2018 edition, NEC = not elsewhere classified, UCC = urgent care centre, WMC = walk-in medical centre, NPC = nurse practitioner-led clinic *Consensus received in Round 2 [+] Did not receive consensus following Round 2					

Appendix 3: Checklist of proposed key methodologic criteria to report in publications of Delphi studies.

Category	Recommendation	Page No.
Study Objective	Does the Delphi study aim to address consensus?	4
	Is the objective of the Delphi study to present results (eg, a list or statement) reflecting the consensus of the group, or does the study aim to merely quantify the level of agreement?	4
Participants	How will participants be selected or excluded?	5,6
Consensus Definition	How will the consensus be defined?	8
	(a) If applicable, what threshold value will be required for the Delphi to be stopped based on the achievement of consensus?	7
	(b) What criteria will be used to determine when to stop the Delphi in the absence of consensus?	7
Delphi Process	(a) Were items dropped?	10
	(b) What criteria will be used to determine which items to drop?	N/A
	What criteria will be used to determine to stop the Delphi process or will the Delphi be run for a specific number of rounds only?	7

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Inclusion of Patient-Level Emergency Department Characteristics to Classify Potentially Redirectable Visits to Subacute Care: a modified Delphi Consensus Study

Summary

In this chapter's second study, the focus was on the significance of patient characteristics when classifying ED visits that could have been handled outside the ED. The same panel of emergency and family medicine physicians participated in this consensus study, which required two rounds to achieve consensus. Consensus was pre-defined as 75% agreement among the committee members.

I found that four of nine characteristics were important to classify ED visits. These characteristics were further refined with constraints: patients who were young and middle-aged adults with a non-emergent triage acuity, did not receive a specialist physician consult in the ED and were discharged from the ED. Similar to the initial consensus study, this study is novel in its approach to construct a patient classification using consensus methodology. There were no deviations from the study protocol.

Citation:
Strum, R.P., Tavares, W.T., Worster, A., Griffith, L.E., Costa, A.P. Inclusion of patient-level emergency department characteristics to classify potentially redirectable visits to subacute care: a modified Delphi consensus study. *CMAJ Open.* 2023; 11 (1), E70-E76.

Abstract

Background: Most patients transported by Ontario paramedics to the emergency department have non-emergent conditions and may be more appropriately served by subacute community-based care centres. We sought to determine consensus on a set of patient characteristics that could be useful to classify retrospective emergency department visits that had a high probability of being primary care–like and potentially redirectable to a subacute care centre by paramedics.

Methods: We conducted a modified Delphi study to assess expert consensus on characteristics of patients transported by paramedics to the emergency department from August to October 2021. An expert Delphi committee was constructed of emergency and family physicians in Ontario using purposive sampling. Experts rated whether each characteristic was useful to be included in a classification to identify potentially redirectable visits retrospectively, as well as characteristic details (e.g., upper and lower bounds). Consensus was considered 75% agreement.

Results: Sixteen experts participated in the study; the experts were mostly male (75%) and evenly divided between emergency and family medicine. After 2 rounds, consensus was achieved on 8 of 9 characteristics (89%). Four characteristics were determined as useful to classify potentially redirectable emergency department visits: age (81%), triage acuity (100%), specialist consult in the emergency department (94%) and emergency department visit outcome (81%). Specifications of each characteristic were refined as follows: young and middle-aged adults with a non-emergent triage acuity, did not receive a specialist physician consult in the emergency department and discharged from the emergency department.

Interpretation: Strong consensus was achieved to specify a classification system for potentially redirectable emergency department visits. These results will be combined with knowledge of which subacute care centres could conduct the main physician interventions to retrospectively identify emergency department visits that could have been suitable for paramedic redirection for further research.

Background

Most patients transported by Ontario paramedics to the emergency department (ED) have non-emergent conditions.[1] Despite efforts to improve ED throughput (such as instituting ED ambulatory care divisions), challenges to provide timely and high quality care remain.[2,3] Sub-acute community-based care centres (i.e. urgent care or specialized community services that manage chronic illnesses) may be appropriate ED alternatives when patients do not require emergency healthcare, and have an association with increased continuity of care, shorter wait times, and fewer healthcare costs per visit.[4–6] Moreover, redirection of specific patient cohorts could be an important strategy to reduce ED overcrowding, whist providing equivalent patient-centred care.[7–9] Paramedic redirection has been difficult to implement; there is a lack of validated patient classifications to identify redirection suitability in the prehospital field reliably.[7,8,10] Various epidemiological classifications describe ED visits that could have been potentially preventable, but their translation to paramedic practices is problematic; paramedic redirection is not incorporated and large heterogeneity exits in objectives, inclusion criteria or clinician scope of practice.[1,11–13] Lastly, identification of patient cohorts potentially suitable for ED redirection is challenging to determine prior to the ED visit, when diagnostics, services rendered and outcome of the visit are unknown.[7,8,10]

To inform prospective paramedic redirection research, a retrospective epidemiological classification is needed first to identify and examine ED visits where redirection could have been appropriate. The specific parameters of which clinical and non-clinical features are useful to retrospectively identify potentially redirectable patient cohorts in ED data are not known.[14] Knowledge of useful patient characteristics to

classify potentially redirectable ED visits could be helpful to provide a concise depiction of patients for further investigation regarding care needs, services required and redirection feasibility. Particularly, ED visits determined to have been potentially suitable for redirection could permit study of their prehospital clinical presentations following linkage between paramedic and ED data resources.[15–17]

Our objective was to determine consensus on a set of ED visit patient characteristics that could be useful to retrospectively identify ED patient visits that had a high probability of being primary care-like and could have been potentially redirectable to sub-acute centres by paramedics.

Methods

Study Design and Setting

We used a modified Delphi study design to establish and examine consensus on which patient characteristics are useful to consider when determining primary care-like ED visits that are potentially redirectable by paramedics to sub-acute care. All patient characteristics included are routinely collected in each ED visit and stored in the National Ambulatory Care Reporting System (NACRS) ED database.[18] Ontario paramedics are legislatively mandated to transport all patients to the ED, independent of care needs or acuity.[19] However, Ontario's Ministry of Health has amended paramedic regulation to incorporate new models of care, including transport to subacute non-ED alternatives.[20] Combining useful ED patient characteristics identified in this study could identify a retrospective patient cohort of potentially redirectable ED visits with high internal validity and inform future research that support paramedic redirection

initiatives. This study occurred between August 2021 and October 2021 in Ontario, Canada.

Participants

Emergency and family care physicians were recruited to participate from differing regions across Ontario between August 1, 2021 to August 11, 2021. Selection of experts were based on their participation in a parallel modified Delphi study that determined appropriateness of an ED physician intervention to be conducted in specified sub-acute care centres instead of the ED.[14] These physicians were previously screened for their expertise and met the inclusion criteria of: currently practicing, practicing in Ontario, and exhibited at least one of (a) leadership role in paramedic practice oversight or paramedic medical director, (b) extensive medical experience (15 years or greater) or (c) holding an academic faculty appointment.[14] Ontario medical directors are physicians who authorize paramedics to perform controlled medical acts in the prehospital field and are responsible for each paramedic's quality of care.[21] Physicians were originally recruited using purposive sampling, and were balanced between emergency and primary care medicine.[14] Recruited physicians were sent a study package describing this study's objectives and methods when invited to participate. We determined *a priori* the Delphi expert committee should be composed of at least fourteen physicians, greater than the generally accepted minimum of twelve participants.[22,23] Consent was obtained in writing prior to any data collection. Physicians were provided an e-gift card at the completion of the study for their participation.

Characteristic Selection

We generated a list of all available patient characteristics in the NACRS ED database for inclusion consideration in the exercise. NACRS is a hospital and community-based ambulatory care administrative database that collects data of every patient's ED visit at the time of service in Ontario. [24] All Ontario ED's provide administrative reports to NACRS quarterly, constituting a population database with minimal incompleteness. [25] All potential characteristics were initially screened by authors RPS and AW, and excluded if they had greater than 50% missingness in the NACRS database, or did not have clinical relevancy to the study's objective. Overall, we selected nine characteristics for inclusion in the modified Delphi rounds based on scientific literature, inclusion as a variable in other ED patient classification systems, clinical judgement and availability of data in NACRS.[11–13,18,26] The included characteristics were: age, sex, triage acuity, main diagnostic category, comorbidities, specialist consult performed in the ED, outcome of ED visit, time from triage to ED outcome and return to ED within 30 days or less.

Patient age parameters were collapsed into five-year ordinal levels, after age twenty. Triage acuity is categorized by the Canadian Triage and Acuity Scale (CTAS), an ordinal scale that ranges from one (most emergent; resuscitation) to five (least emergent; non-urgent).[27] The main diagnostic category was assigned by the ED physician, and recorded using the International Statistical Classification of Diseases and Related Health Problems, 10th revision. [28] Comorbidities were defined as pre-existing diagnoses at time of ED visit, and included hypertension, diabetes, chronic obstructive pulmonary disease, asthma, rheumatoid arthritis, congestive heart failure, bowel

disease and cancer. Only these eight comorbidities could be included in the study, only these are readily collected in the administrative data of NACRS. [18]

Delphi Process

The modified Delphi method is a consensus strategy to systematically analyze the judgements of experts in a specified field.[29] Modified Delphi studies provide practical applications of questionnaires to engage experts individually while yielding results as aggregate consensus that is greater than any expert individually.[23] Iterations (or rounds) often involve inviting input, tabulating consensus and re-presenting items that reached consensus and remain discrepant for additional consideration. In each round, experts were posed questions related to the usefulness of patient characteristics to classify ED visits that are primary care-like and potentially redirectable to sub-acute care centres by paramedics. When experts rated a patient characteristic as useful, each were asked to rate which parameters of the characteristic would specify the ED with a high specificity to the study's objective. Standardized definitions of each patient characteristic were provided to minimize unintended or heterogeneous interpretations. Consensus was evaluated through two rounds of expert ratings as further rounds are unlikely to result in differing ratings when items of the subsequent rounds are minimal and could not be modified.[30]. The structure of the questions posed to experts is shown in *Box 1*, and the content of plausible questionnaire responses are shown in *Appendix 1*. Participants selected their parameters from a list, shown in Appendix 1; no free text was accepted.

The modified Delphi rounds occurred between August 11, 2021 and September 21, 2021. Round 1 was distributed to all experts for their individual ratings. After completing Round 1, data were extracted to analyze consensus of each characteristic

and parameter. A general feedback form was distributed to all experts reporting the aggregated results of Round 1 to aid their considerations for characteristic ratings in Round 2 (i.e., reported percent agreement).[29] Round 2 was constructed with only the characteristics that did not receive consensus in Round 1, and distributed for a second round of ratings. We determined *a priori* ratings of Round 2 would serve as the final consensus results, as further rounds are unlikely to change consensus and participation rates diminish when items on subsequent rounds are minimal. We used *CheckMarket*, an electronic survey software to collect all data. All data were stored with the investigators via *CheckMarket's* secure and encrypted program.

Data Analysis

We determined *a priori* a characteristic must receive 75% agreement or greater to achieve consensus.[31] Each patient characteristic was considered independent from one another during ratings. All parameter specifications used in this study were taken directly from NACRS, we did not categorize the parameters of each characteristic. Demographic statistics of the expert Delphi committee were reported using frequency and proportion.

Ethics Approval and Consent to Participate

This study received a research ethics board exemption waiver from the Hamilton Integrated Research Ethics Board; review reference 2020-11451-GRA. All participants provided written consent prior to study initiation.

Results

Sixteen physicians agreed to participate in this study. Three declined due to current workload, and one did not respond. The expert Delphi committee was mostly

male (75%) and acknowledged their primary practicing field as emergency medicine (81%). Medical training of the committee was split evenly between family and emergency medicine. The expert's length of practice was spread evenly throughout the Delphi committee with a range from less than five years to thirty-or-greater years, with the largest groups of five-to-nine years (25%) and thirty-or-greater years (25%). Approximately one-third of the expert committee are Medical Directors responsible for medical oversight of paramedic practices in Ontario. Characteristics of the committee are shown in Table 1.

Table 2 shows the results of the consensus modified Delphi exercise. Overall, four patient characteristics achieved consensus in the Delphi exercise. In Round 1 of the modified Delphi exercise, seven of nine patient characteristics achieved consensus. The two characteristics that did not receive consensus were reposed in Round 2, resulting in one characteristic reaching consensus and one characteristic not. All sixteen experts completed the Round 1 questionnaire, and fifteen completed Round 2. The patient characteristics identified as useful characteristics to consider in a classification were: age (81%), triage acuity (100%), specialist consult performed in the ED (94%) and outcome of the ED visit (81%). Patient characteristics determined not useful to classify ED visits were: sex (100%), comorbidities (75%), time parameter from triage to ED outcome (88%) and return to ED within 30 days or less (80%). The characteristic 'main diagnostic category' did not receive consensus following two rounds. Overall, the disagreement on characteristics were spread evenly amongst the physicians trained in emergency and family medicine.

Parameters of useful characteristics that achieved consensus were refined to: young and middle-aged adults with a non-emergent triage acuity, did not receive a specialist physician consult in the ED and discharged from the ED. When experts rated patient characteristics useful to classify ED visits that are primary care-like and potentially redirectable by paramedics, each supplied a parameter specification to constrain a characteristics range based on their expert judgement. Of the thirteen experts that rated age as a useful patient characteristic, all rated the lowest age provided (18 years) appropriate for the lower boundary, and the upper boundary ranged from 50 years to 'no upper limit'. The largest selection for the upper age was 70 years. Triage acuity was rated by all as useful, with all rating CTAS 5 as the lowest acuity for the lower boundary. All experts selected an upper acuity boundary as CTAS 4 (100%), with CTAS 3 rated as the upper boundary from a smaller proportion (37.5%). Nearly all found specialist consult in the ED a useful characteristic to include, with all rating that only ED visits which did not receive an ED specialist physician consult as useful to consider for the classification. Lastly, the majority of experts that rated the outcome of the ED visit as useful selected discharged from ED as useful for this classification, with the other options not suitable (admitted to hospital, transfer to another acute care facility directly from ED and left after triage no medical assessment).

Interpretation

Strong consensus was found by an emergency and primary care physician committee for a set of patient characteristics that may be useful to determine ED visits that were primary care-like and potentially redirectable by paramedics to sub-acute care centres. Patient age, triage acuity, specialty consult in the ED and outcome of the ED

visit are useful characteristics to specify inclusion criteria in an epidemiological classification system.

Our results were fairly consistent with alike published classifications that propose to identify preventable ED visits retrospectively. Our lowest triage acuity parameter was consistent with similar classifications, though triage acuity was not included as a parameter in many classifications.[12] Age was incorporated into only a small number of similar classifications, but when included had an upper boundary of 75 years or lower.[11,32] Classifications that incorporated the outcome of an ED visit included only patients to those that were discharged from the ED, and must not have been hospitalized, admitted or died in ED, a finding consistent with our study.[12] Some classifications included the main diagnostic or presenting complaint as an identifier, though our study results could not achieve consensus on whether this is an important determining factor.[11,13,33,34] Some classifications cited only ED visits arriving by self-referral or walk-in as eligible, a deviation from the objective of our study to construct a classification specifically to examine paramedic transported patients.[35] Given the abundant exclusion of paramedic transported patients from published classifications, our research contributes a focus on an under-integrated patient cohort of potentially preventable ED classifications.

The majority of useful patient characteristics had large agreement amongst the physician committee on parameter specification. The upper age limit differed amongst experts, showing their hesitancy to include the geriatric cohort in plausibly redirecting patients from the ED. High agreement was recognized in the lower age limit (18 years), indicating experts were content with redirecting patients that likely will not have as

numerous or complex conditions as older age groups. Specifying triage acuity was largely consistent by including the most non-emergent acuities (CTAS 4 and 5), with relatively a third of experts indicating urgent (CTAS 3) acuities could be appropriate. The low number of experts rating urgently triaged patients suitable may exemplify a conservative approach to withhold making clinical judgements on ED visits that potentially could require acute care, though the majority of urgently triaged ED visits do not.[36] High agreement was also observed in specifying discharge as the ED outcome, and not having received a specialist consult during the visit. These specifications acknowledge that patients should be stable to be discharged home/their place of residence, and should not exceed the scope of practice of an attending emergency physician. The main diagnostic category did not receive consensus, an important finding that implies some experts desired to understand the condition of the ED visit prior to making a judgement on redirection suitability. A plausible explanation for this result is the diagnostic categories of ICD-10 are too broad to make generalizations on appropriateness as determined by the physicians. Given broad diagnostic categories do not predict acuity or severity of illness, the indecision of its utility to incorporate into a classification remains in question. Though knowledge of diagnostic categories was important to some experts, comprehension of the main intervention received during the ED visit ought to contribute more beneficial evidence to make a judgement on redirection.

While this study contributes to evolving conceptual frameworks intended to comprehensively categorize patients potentially suitable for redirection, the absence of a validated patient classification remains. For instance, patient characteristics alone

may not be sufficient classifying features to make determinations on which patients could have been potentially redirected. Inclusion of the physician intervention is an important element missing from our study that is core to developing a redirection patient classification, though is minimally included in published classifications.[11,12,14,34] Further understanding and inclusion of a sub-acute centre's capacity to provide equivocal medical care to the ED may also be needed, and should be incorporated into any patient classification aiming to identify redirectable ED visits retrospectively.

The results of this study will support the construction of an epidemiological patient classification to retrospectively identify paramedic transported ED visits that may have been suitable for redirection in ED databases for further study. This patient classification will be constructed using the results of this study and knowledge of which sub-acute care centres could conduct a specified primary-care intervention.[1,14] Data linkage of paramedic medical reports to ED data resources for ED visits that meet this classifications inclusion criterion will identify which patients to examine prior to their hospital arrival, an important component to inform prospective redirection research and direct clinical guideline development.[1] Our results inform our epidemiological understanding of which patients could have been potentially suitable for paramedic redirection, and cannot be readily incorporated into clinical practice before thorough validation is undertaken. Future research is required to experimentally validate our results and determine the generalizability of our study in differing ED datasets.

Limitations

The expert Delphi committee was comprised mostly of emergency physicians, a limitation of purposive sampling. Recruitment was balanced between emergency and

family care physicians but enrollment rates left a slight imbalance with a higher proportion of physicians practicing in an emergency department. However, emergency physicians were well equipped to make determinations in this study, and we do not anticipate this impacting the results when the committee's medical training was split evenly between emergency and family medicine. Individual judgements may be subjective based on an expert's own clinical experiences, formal training or approach to patient care, though this limitation was minimized by providing detailed definitions of each patient characteristic and using a robust Delphi methodology to reduce effects subjective outliers. Only patient characteristics that were available in NACRS had the potential to be included in this study. Using ED visit characteristics retrospectively limits the translation of our results to direct paramedic practices, however translation of these findings into paramedic medic reports would make a useful application for prehospital translation.

Conclusion

Patient characteristics were identified to assist classifying ED visits that may have been primary care-like and potentially redirectable by paramedics to sub-acute care centres. Though patient features alone cannot make determinations on patient suitability for a redirection classification, these variables contribute to ongoing efforts to identifying eligibility criteria of patients encountered by paramedics for further epidemiological study. Combining the results of this research along with knowledge of where the main ED intervention could be conducted may be helpful to analyze who, when and where potentially redirectable patients could be transported for care other than the ED.

Tables and Figures

Box 1: Questions posed to expert physicians in the modified Delphi questionnaire consensus exercise to evaluate suitability of patient characteristics that indicate an ED visit was potentially redirectable to sub-acute centres by paramedics.

1. Determining Consensus on Patient Characteristics:

Do you think *(patient characteristic)* is a useful characteristic to consider when determining if an ED visit is both primary care-like and potentially redirectable to sub-acute care centres by paramedics?

2. Determining Specific Parameters of a Useful Patient Characteristic:*

If so, what specific parameters of *(patient characteristic)* suggest a visit is primary care-like and potentially redirectable to sub-acute care centres by paramedics?

Note: ED = emergency department
* Parameter specification posed only to experts that answered 'Yes' to the consensus question.

Table 1: Demographic characteristics of the expert committee in the modified Delphi consensus exercise.

Characteristic	Modified Delphi Committee, N=16; *n*, (%)
Sex	
Male	12 (75%)
Female	4 (25%)
Primary medical practice	
Emergency medicine	13 (81%)
Family medicine	2 (13%)
Both	1 (6%)
Physician College Certification	
Certification in the College of Family Physicians (CCFP)	2 (13)
Certification in the College of Family Physicians, with Competence in Emergency Medicine (CCFP EM)	6 (37)
Fellow of The Royal College of Physicians of Canada (FRCPC)	8 (50%)
Length of practice, years	
Less than 5	2 (13%)
5 to 9	4 (25%)
10 to 14	1 (6%)
15 to 19	2 (13%)
20 to 24	1 (6%)
25 to 29	2 (13%)
30 or greater	4 (25%)
Medical director, Ontario paramedic practices	5 (31%)

Table 2: Results of a two-round modified Delphi exercise to establish which patient characteristics are important to consider when classifying if an ED visit was primary care-like and potentially redirectable to sub-acute care centres by paramedics.

Characteristic	Round 1, *n (%)*[a]		Round 2, *n (%)*[a,b]		Consensus	Specification of parameters from Expert Committee, *(n)*[c]
	Yes	No	Yes	No		
Age, years	13 (81)	3 (19)	-	-	Useful	Lowest age -18 (13)[+]. Highest age – 50 (1), 55(1), 65(1), 70(5)[++], 75(3), no upper limit (2).
Sex	0 (0)	16 (100)	-	-	Not Useful	Not useful to include and/or specify.
Triage Acuity, CTAS	16 (100)	0 (0)	-	-	Useful	Lowest acuity – CTAS 5 (16)[+]. Highest acuity – CTAS 4 (12)[++], CTAS 3 (6).
Main Diagnostic Category, ICD-10[d]	9 (56)	7 (44)	10 (67)	5 (33)	No Consensus	Consensus was not reached amongst the Delphi committee.
Comorbidities	4 (25)	12 (75)	-	-	Not Useful	Not useful to include and/or specify.
Specialist Consult Performed in ED	15 (94)	1 (6)	-	-	Useful	Include only visits that did not receive a specialist consult in the ED (15).
Outcome of ED Visit	13 (81)	3 (19)	-	-	Useful	Discharged from ED (13). Admitted to Hospital (1). Transfer to another acute care facility directly from ED (1). Left after triage, no medical assessment (6).
Time from Triage to ED Outcome	2 (12)	14 (88)	-	-	Not Useful	Not useful to include and/or specify.
Return to ED within 30 Days or Less	7 (44)	9 (56)	3 (20)	12 (80)	Not Useful	Not useful to include and/or specify.

[a] Consensus set at 75% agreement of all experts.
[b] 15 of the 16 experts participated in Round 2.
[c] Only experts that answered 'Yes' to the consensus question were included to specify parameters.
[d] Category did not receive consensus following Round 2.
[+] Indicates the lower bound of a characteristic parameter.
[++] Indicates the upper bound of a characteristic parameter.

Supplemental Data

Appendix 1: List of patient characteristics included in a modified Delphi consensus exercise and their plausible answers.

Patient Characteristic	Parameter Specification
Age, years	18, 20, 25, 30, 35, 40, 45, 50, 55, 60, 65, 70, 75, 80, 85, 90, 95, 100, 105 Other
Sex	Only male Only female
Triage Acuity, CTAS [27]	1 – Resuscitation 2 – Emergent 3 – Urgent 4 – Less Urgent 5 – Non-Urgent
Main Diagnostic Category, ICD-10[a,b]	Endocrine, nutrition and metabolic disorders Mental and behavioural disorders Diseases of the nervous system Diseases of the circulatory system Diseases of the respiratory system Diseases of the digestive system Diseases of the skin and subcutaneous tissue Diseases of the musculoskeletal system and connective tissue Diseases of the genitourinary system Diseases of the blood involving immune system Diseases of the eye, adnexa, ear and mastoid process Traumatic injuries (consequences of external causes) Symptoms, signs and abnormal clinical and laboratory findings Factors influencing health status and contact with health services Pregnancy, childbirth and the puerperium Conditions originated in the perinatal period Congenital malformations, deformations and chromosomal abnormalities Infectious diseases Morbidity and mortality Neoplasms and cancer
Comorbidities[c]	Hypertension Diabetes Asthma

	Chronic obstructive pulmonary disease Rheumatoid arthritis Bowel disease Cancer
Specialist Consult Performed in ED	Include only visits that received a specialist consult in the ED Include only visits that did not receive a specialist consult in the ED
Outcome of ED Visit	Discharged Admitted to hospital Transfer to another acute care facility directly from ED Left after triage, no medical assessment
Time from Triage to ED Outcome	Less than 30 minutes Less than 1 hour Less than 1.5 hours Less than 2 hours Less than 2.5 hours Less than 3 hours
Return to ED within 30 Days or Less, days	5, 10, 15, 20, 25, 30 Should not have returned within 30 days of initial ED visit

Note: CTAS = Canadian Acuity and Triage Scale, ED = emergency department
[a] International Statistical Classification of Diseases and Related Health Problems 10th Revision, categorized by diagnostic chapter.
[b] Represents primary diagnosis category of emergency department visit.
[c] Diagnosed diseases prior to ED visit.

Appendix 3: Checklist of proposed key methodologic criteria to report in publications of Delphi studies.

Category	Recommendation	Page No.
Study Objective	Does the Delphi study aim to address consensus?	4
	Is the objective of the Delphi study to present results (eg, a list or statement) reflecting the consensus of the group, or does the study aim to merely quantify the level of agreement?	4, 6-8
Participants	How will participants be selected or excluded?	5
Consensus Definition	How will the consensus be defined?	8
	(a) If applicable, what threshold value will be required for the Delphi to be stopped based on the achievement of consensus?	7,8
	(b) What criteria will be used to determine when to stop the Delphi in the absence of consensus?	7,8
Delphi Process	(a) Were items dropped?	10
	(b) What criteria will be used to determine which items to drop?	N/A
	What criteria will be used to determine to stop the Delphi process or will the Delphi be run for a specific number of rounds only?	7,8

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CHAPTER THREE

Identifying Patient Characteristics Associated with Potentially Redirectable Paramedic Transported Emergency Department Visits in Ontario, Canada: a Population-Based Cohort Study

Summary

This chapter investigates the association between selected ED physician interventions, identified in chapter one as suitable for non-ED care, and patient characteristics available in administrative data. The analysis used a population-based cohort study of Ontario, encompassing all patients transported by paramedics with recorded physician interventions during their ED visits.

I found the majority of ED visits had a physician intervention that could be appropriately conducted in an urgent care centre, with a small portion for a general practice office. Notably, the patient characteristics associated with these ED interventions closely align with those identified in the second consensus study of chapter two. This alignment between the characteristics identified in this study and those recognized by physicians in chapter two suggests the face validity of the ED interventions in representing the intended patient cohort. These results serve as the basis for constructing a patient classification system to be tested for external validity.

Citation:
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Abstract

Objective: Paramedic redirection from emergency department (ED) to sub-acute centres may be more beneficial for some patients, though little is known about which patients are potentially appropriate. We examined whether patient characteristics were associated with ED visits when the main intervention was suitable to be performed in a sub-acute centre.

Methods: We conducted a retrospective observational study using the National Ambulatory Care Reporting System from 2014 to 2018 in Ontario, Canada. We included all adult patients transported by paramedics and had a main physician intervention recorded. We used results of a RAND/UCLA modified Delphi study to categorize patients into either ED or a sub-acute care (urgent care and/or general practice centre) based on their main intervention. An independent logistic regression model was analyzed for each sub-acute centre.

Results: A total of 2,394,072 ED visits were included; 59% of ED interventions were categorized as ‘urgent care’, 27% ‘ED-only’, 9% either ‘urgent care’ or ‘general practice’, and 5% had an intervention not previously classified. ED visits suitable for ‘general practice’ had the highest percentage of patients discharged, while ‘ED-only’ had the lowest. Lower medical acuity, younger age, time of triage in evening and overnight, and discharged from ED were independently associated with both sub-acute centres. ‘Urgent care’ visits/interventions were associated with an ED main diagnosis of the respiratory system (OR 3.49), while ‘general practice’ visits were associated with mental health disorders (OR 9.85) and injury/poison/consequences of external causes (OR 3.38).

Conclusions: The majority of ED visits had a main intervention that could have potentially been conducted in a sub-acute centre. We identified characteristics and diagnostic patterns associated with ED visits when the main intervention was categorized as a sub-acute centre intervention. This study contributes knowledge to inform which patients are potentially appropriate for paramedic redirection.

Background

Patients with non-emergent medical conditions constitute the majority of paramedic emergency department (ED) transports in Ontario, Canada.[1] Contrary to traditional paramedic service delivery models, 60% of transported patients have non-emergent medical acuities and half (51%) are categorized as 'urgent' (Canadian Triage and Acuity Scale).[1,2] Usage of paramedic services have broadened and increased to provide access and transport to healthcare by patients that do not necessarily require acute management, thereby overcrowding ED's and increasing workloads.[3,4] The most appropriate setting may not be the ED when visits are non-emergent, and have complex primary care needs or require greater assessment times.[1,5] Sub-acute care centres could offer similar or more efficient care alternatives for non-emergent patients and at a higher cost effectiveness, though paramedics are restricted from ED transport deviation.[1,2,6,7]

The evidence for safe paramedic redirection from ED to sub-acute centres is established in North America and internationally, though the literature for relative effectiveness is inconclusive.[8–12] A major limitation has been the lack of consistent targeting of which patients could be appropriately redirected to alternative care, and which cannot. No patient classification system has been developed or implemented to evaluate patient suitability for redirection.[13–15] To that end, we conducted a RAND/UCLA modified Delphi study to evaluate ED main intervention applicability for their suitability to be conducted in three sub-acute centres.[1,16] However, the characteristics of the ED visits determined appropriate for sub-acute has not been reported. Incorporating patient characteristics (i.e., age, acuity, diagnosis, ED visit outcome) associated with ED visits

suitable for sub-acute centres dependent on the main visit intervention will be important to further contextualize an epidemiological classification of which patients are potentially redirectable. ED visit main interventions performed by physicians could be a core component to classifying patient suitability for redirection that has been overlooked in previous categorization of which patients are potentially appropriate.[13–15] Inclusion of ED main interventions has the potential to scaffold with additional characteristic variables to construct a robust epidemiological patient classification for potentially identifying redirectable visits for paramedics.

Our objective was to examine which patient characteristics were associated with ED visits that had a recorded main intervention suitable to be conducted in a sub-acute care centre in a population-based cohort from Ontario, Canada. We hypothesized that younger patient age, lower medical acuity and being discharged from ED as the visit outcome would be associated with ED visits with a main intervention suitable to be conducted in sub-acute care centres.

Methods

Design

We used a retrospective observational design to analyze secondary administrative ED patient records from the National Ambulatory Care Reporting System (NACRS) database. The STROBE statement was followed for reporting this study.[17]

Population

All Ontario adult patients (≥18 years) transported to the ED by paramedics following a 911 request and had a recorded triage acuity score were eligible. Visits were excluded if they did not have a recorded main physician intervention in NACRS, as visit

could not be classified into a care centre. We excluded any individual who was not triaged by hospital staff (registered but left prior to triage) or was not assigned a Canadian Triage and Acuity Score (CTAS). Sampling methods were not incorporated as all ED visits satisfying eligibility criteria were included as to minimize potential bias.

Data Sources

This study used ED NACRS data from January 1, 2014 to March 31, 2018, representing the most recently available records at time of study initiation. NACRS is a hospital and community-based ambulatory care administrative database that collects patient visit data at the time of service.[18,19] All hospitals in Ontario are mandated to submit electronic patient abstracts from the ED to comply with standard reporting or quality control measures. NACRS was accessed through the Institute for Clinical Evaluative Sciences (IC/ES) Data & Analytical Virtual Environment (IDAVE) portal. Briefly, IC/ES is a non-profit, independent corporation that supports the study of health service and population-wide outcomes in Ontario using administrative databases. IDAVE acts as a secure virtual server for researchers to access approved cohort created data for scientific research and manuscript-ready output.

Variables and Codification

We used a RAND/UCLA modified Delphi design to assess the 150 most frequently recorded main physician intervention codes for conduction in the ED exclusively, or in any of three sub-acute care centres (urgent care centre, walk-in medical centre and/or nurse practitioner-led clinic).[16] Modified Delphi studies use an iterative process to systematically examine the collective consensus of an expert group through repeated rounds of individual ratings.[20] This methodology constituted a reliable

strategy to determine consensus on defined clinical problems where there is little or no effective evidence with high internal validity.[21,22] Consensus was achieved on 146 interventions; 43 were rated for 'ED only', 103 for 'urgent care', 46 for 'walk-in medical centres' and 47 for 'nurse practitioner-led clinics'.[16]Walk-in medical centres and nurse practitioner-led clinics had high similarity in results with 44 interventions in common. Due to high agreement, these centres were collapsed into a category called 'general practice' and included all interventions from either centre. ED visits were sorted into three categories for study, based on the consensus of this previous classification of patient main interventions: 'ED only', 'urgent care' and 'general practice'. ED visits categorized as 'general practice' were also categorized for 'urgent care', thus 'general practice' represents a specific subset of the 'urgent care' cohort.

Patient characteristics selection was based on clinical judgement, scientific literature and access availability to variables. Age was grouped into twenty ordinal levels by IC/ES due to privacy restrictions, and further collapsed into three categories for grouping of similar patients in similar life-stage progressions (18-39, 40-64, 65-105 years). Access to primary care is assigned as the physician class that provides the patients usual source of care prior to ED visit. Triage acuity was assigned to patients by the ED triage nurse upon entry to ED using CTAS. CTAS is an ordinal scale that ranges from one to five, with a score of one to act as the most emergent (resuscitation) and five as least urgent (non-urgent).[23] Triage acuity was collapsed into three categories (emergent, urgent, non-urgent) to ensure model stability as relatively few patients receive a CTAS score of one (4.4%) or five (3.2%). ED main diagnosis was assigned by the attending ED physician and recorded using the International Statistical Classification

of Diseases and Related Health Problems, 10th revision (ICD-10). ICD-10 is recognized as the international standard for reporting diagnostic conditions, and managed by the World Health Organization internationally, and Canadian Institute of Health Information in Canada.[24] ICD-10 diagnostic codes were collapsed into eight categories to ensure model stability; diagnostic categories comprising less than 5% of the study cohort were grouped together.

Ethics Approval

IC/ES's collection of ambulatory care ED administrative data were authorized under Section 45 of the Personal Health Information Protection Act, which does not require review by a Research Ethics Board; all data were absent of personal health identifying information.

Statistical Analysis

Analyses of patients visit characteristics were described using general measures of frequency. Association of characteristics to each sub-acute care centre was examined using two separate binary logistic regression analyses to make distinctions between visits/interventions suitable for 'urgent care' and 'general practice'. Only ED visits with main interventions classified in the RAND/UCLA modified Delphi study were included in the modelling analyses; visits with interventions not classified were excluded. Results were reported using unadjusted and adjusted odds ratios for each model with corresponding 95% confidence intervals (CI). Data were managed and analyzed in R software, version 3.4. All variables used in the models were reported with a significantly high completion rate (>99%). For this reason, as required, data were directly stated as unreported or missing where applicable; imputation was not required.

Patient and Public Involvement

Frontline paramedics in Canada were consulted to gauge their satisfaction with the reporting and potential implications of this study. The reporting of results received input from paramedic services in several provinces across Canada. All input helped to modify the study design, analysis plan, and preparation of the manuscript.

Results

Descriptive Statistics

This study included 2,394,072 adult patients transported by paramedics to an Ontario ED and had a main physician intervention recorded in NACRS. The study cohort represents 68.5% of all ED visits transported by paramedics in the study period (2,394,072 / 3,493,059). All ED visits absent of a recorded main intervention were excluded. In this cohort, 59% of ED visits were categorized as having a main intervention suitable to be conducted in ‘urgent care’, 27% were ‘ED only’, 9% either ‘urgent care’ or ‘general practice’, and 5% did not have an intervention classified in the RAND/UCLA modified Delphi study. The proportion of patients sorted into care settings based on categorized main intervention consensus is shown in Figure 1.

To facilitate the comparison of characteristics amongst the three care categories, the 5% of ED visits with recorded main physician interventions but not classified in the RAND/UCLA modified Delphi study were excluded from the following descriptive statistics and modeling analyses. A total of 2,267,585 ED visits (94.7% of the original cohort) were included in the following analyses.

Of ED visit interventions classified in the RAND/UCLA modified Delphi study, most were suitable for ‘urgent care’ (68.7%), of which some were also fitting for ‘general

practice' (10.3%); interventions classified as 'ED only' comprising the rest (31.3%). All ED visits with interventions classified suitable for 'general practice' centres were also suitable for 'urgent care' centres. Visit interventions suitable for 'general practice' had the highest proportion of visits in the youngest age category (29.7%), while visits classified as 'ED only' had the highest proportion in the oldest age category (63.6%). Across the three centres classified, triage acuities two and three were the largest CTAS proportions. Of main diagnosis categorizations, visits classified for 'ED only' had the largest patient proportion with diseases in the nervous, circulatory and digestive systems. 'Urgent care' classified ED visits had the largest proportion in infectious diseases, endocrine/nutrition/metabolic disorders, respiratory system and diseases of the musculoskeletal system. ED visits classified for 'general practice' had the largest in mental/behavioural disorders and injury/poisoning/certain other consequences of external causes. Missing data were not found for most included characteristics, however minimally in access to primary care (5.0%). The characteristics of the study cohort are shown in Table 1.

All three classified centres showed increases in proportion of ED visits discharged as CTAS scoring increased from one to four (i.e., medical acuity decreased), with CTAS four to five holding generally consistent. ED visits classified as 'urgent care' were similar in discharge percentages with 'ED only' visits for CTAS scores one and two (17.4% vs. 13.5%; 50.0 vs. 46.5%), but similar in discharge percentages with classified visits for 'general practice' in higher CTAS scores four and five (81.5% vs. 89.0%, 79.6% vs. 86.3%). There was no overlap amongst the three care centre categories in

percentage of ED visits discharged across all CTAS levels. A visual representation of ED visits by care centre and acuity is shown in Figure 2.

Main Results

In an adjusted model, ED visits/interventions classified suitable for 'urgent care' were significantly associated with urgent and non-urgent triage acuities (OR 1.38, 95% CI: 1.37-1.39; OR 3.10, 95% CI: 3.05-3.15), evening and overnight triage times (OR 1.10, 95% CI: 1.09-1.11; OR 1.16, 95% CI: 1.15-1.17) and main diagnoses of the respiratory system (OR 3.49, 95% CI: 3.44-3.54) and mental health disorders (OR 1.06, 95% CI: 1.04-1.08). Visits classified for 'urgent care' had a 26% odds reduction in hospital admission compared with 'ED only' classified visits (OR 0.74, 95% CI: 0.73-0.74). Additionally, older age groups (40 to 64, 65 to 105) had reduced odds of association with 'urgent care'. The area under the receiver operating characteristic curve (AUC) was 0.625, inferring this adjusted model is a less than fair classifier to identify patient visit associations with 'urgent care'.

In a second adjusted model, ED visits/interventions classified suitable for 'general practice' also had significant associations with urgent and non-urgent triage acuities (OR 1.49, 95% CI: 1.47-1.51; OR 4.40, 95% CI: 4.30-4.50). ED main diagnoses of the digestive system (OR 1.10, 95% CI: 1.05-1.14), genitourinary system (OR 1.15, 95% CI: 1.11-1.20), mental health disorders (OR 9.85, 95% CI: 9.56-10.14), symptoms and signs of abnormal clinical labs (OR 1.38, 95% CI: 1.34-1.42), and injury consequences of external causes (OR 3.38, 95% CI: 3.29-3.48) were all significantly associated with visits/interventions suitable for 'general practice' centres. ED visits classified for 'general practice' had a 49% odds reduction in hospital admission

compared with ‘ED only’ (OR 0.51, 95% CI: 0.50-0.52). Older age groups of 40-64 years and 65-105 years had reducing odds of association (OR 0.50, 95% CI: 0.49-0.50; OR 0.32, 95% CI: 0.32-0.33). This adjusted model was a fair classifier to identify patient visit associations with an AUC of 0.772 for ‘general practice’. Table 2 shows the unadjusted and adjusted models for patient characteristic associations with sub-acute care settings in comparison with interventions classified as ‘ED only’.

Interpretation

The majority of ED visits with a recorded main intervention were suitable to have the intervention conducted in an urgent care centre. Similar characteristics were found in both sub-acute centres in the younger age groups, lower triage acuity’s, triage times not during day hours, and discharged from ED as the visit outcome. The sub-acute care groups differed in associated characteristics of gender and main diagnoses. ‘Urgent care’ was positively associated with the female gender, and diagnoses of the respiratory system and mental health disorders. Visits classified for ‘general practice’ were positively associated with the male gender, and main diagnoses of the digestive system, genitourinary system, mental health disorders, abnormal clinical labs, injuries of external causes and the remaining diagnostic categories collapsed together. Our hypothesis of patient characteristics associations was accurate and supported in both models.

Our study that examines the associated characteristics of ED visits that may be suitable for sub-acute centres is novel, given there is no previous literature directly comparable. The most analogous literature resides in articles that studied characteristic associations of patients with low acuity ED visits. Our study yielded similar results to the literature, finding patients triaged in the evening and overnight hours, and having a

primary complaint categorization of psychiatric or toxicology/poisoning were correlated with non-emergent ambulance usage for ED transportation.[25] While some literature suggests that older age is associated with non-emergent paramedic transported visits, our study contrasts this finding with both sub-acute centres being associated with the youngest group (18-39 years).[25–27] The percentage of ED visits appropriate for general practice settings was 10.3% of the study cohort, a consistent result with studies that have estimated this range to be 10-12%.[14] Visits discharged from the ED classified as 'urgent care' or 'general practice' is consistent with previous analyses of paramedic transported ED visits that have low priority conditions.[2]

In this study, patient visit characteristics were identified for their independent association with two sub-acute care centre classifications compared with 'ED only' visits based on suitability of their main intervention. Several associated characteristics were consistent between the two sub-acute classifications, but some differences were recognized in diagnostic categories. These differences may be due to the much larger number and variation of ED interventions identified by experts as potentially appropriate for urgent care (103) than for general practice (47), and corresponding larger visit incidence of each centre (1,557,245 urgent care, 233,896 general practice). Mental health as a main diagnostic category was associated significantly with classification of 'general practice' compared to 'ED only' (OR 9.85, 95% CI: 9.56-10.14). All included mental health interventions were suitable for sub-acute care, and none exclusively for the ED, which may explain this finding. Although not represented in the RAND/UCLA modified Delphi study, some mental health patients may benefit from transport to facilities that can provide specific mental healthcare that is not a general practice centre.

No crossover in percentage of patients discharged was observed amongst the centre classifications at each ordinal CTAS level, inferring a plausible hierarchical relationship may exist in ability to manage acuity.

Identification of characteristics associated with paramedic transported patients that could have potentially received their main intervention in sub-acute care will help to inform further study of out-of-hospital redirection classifications. Two thirds of patients that visited the ED could have potentially received their intervention in an urgent care centre, though paramedics are restricted from urgent care transport and are relatively rare compared with other sub-acute alternatives. This study serves as a first-step to constructing and describing an epidemiological patient classification, however these results cannot be translated into clinical guidance without prospective validation. Future research is required to provide additional contextualization of patients, especially patients admitted from ED that were determined as appropriate for sub-acute centres. The patient characteristics identified in this study will aid in classifying which characteristics should be included in a high specific patient classification system to examine retrospectively which patients may have been suitable for paramedic. Development of paramedic redirection protocols can be supported by this research to inform potential patient eligibility criteria, though further evidence must be incorporated prior to integrating these results into paramedic clinical practices, such as non-clinical features, operational features, patient values/preferences and external validation research. The results of this study will contribute novel evidence to paramedic-based programs that intend to support ED redirection protocols or research, independent of healthcare insurance structures.[1,28]

Limitations

Given the inherent limitations of ED administrative databases in a retrospective observational design, we could only determine the characteristics of ED visits based on the completeness of the main physician intervention field. Our dataset of NACRS contained 68.5% of all recorded ED visits in Ontario, of which this study's analyses examined 94.7% of these visits as they were previously classified in a RAND/UCLA modified Delphi study (2,267,585). A proportion of missing data in recorded ED interventions is expected in administrative datasets; some admitted patients may have had their ED interventions recorded in the Discharge Abstract Database as opposed to NACRS, or in some instances there is no intervention or has not been recorded. This study utilized the results of a modified Delphi consensus exercise to categorize patients, a methodology that has its own inherent limitations, though were minimized. Lastly, this study was pursued for epidemiological purposes using a specific population (adult, paramedic transported), and cannot inform clinical decision management without further patient contextualization or prospective testing.

Conclusion

Paramedic redirection of some non-emergent patients to alternative sub-acute care could be a pragmatic strategy to improve patient-centered care (i.e., by better aligning paramedic services with patient needs) and ED utilization in North America. Categorization of patients into the most appropriate care centre based on RAND/UCLA modified Delphi panel consensus allowed for study of patient characteristics associated with 'urgent care' and 'general practice' centres. This epidemiological study will provide evidence and knowledge to inform construction of a patient classification to potentially

redirectable paramedic transported patients, and augment further research in paramedic alternative destination protocols.

Tables and Figures

Figure 1: Breakdown of ED visits where the main physician intervention could potentially be conducted based on care setting. The cohort represents all Ontario paramedic transported ED visits when the main intervention was recorded in the National Ambulatory Care Reporting System database.

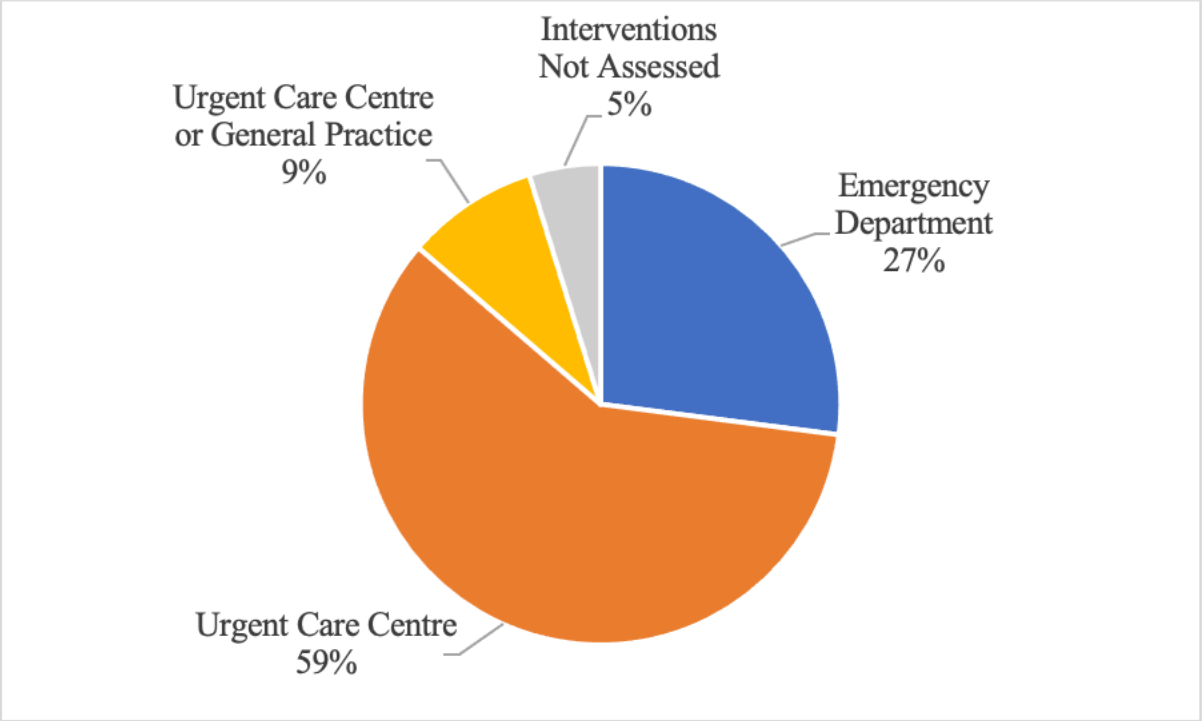

Table 1: Characteristics of the study cohort assessed in the ED, grouped by healthcare setting that could conduct the main ED intervention.

Characteristic	Emergency Department Only, no. (%)	Urgent Care Centre, no. (%)	General Practice, no. (%)*
Overall, 2,267,585	710,340 (31.3) [+]	1,557,245 (68.7) [+]	233,896 (10.3) [+]
Gender			
Male	335,526 (47.2)	701,921 (45.1)	118,624 (50.7)
Female	374,814 (52.8)	855,324 (54.9)	115,272 (49.3)
Age, years			
18 – 39	68,456 (9.6)	222,126 (14.3)	69,550 (29.7)
40 – 64	187,776 (26.4)	407,518 (26.2)	70,409 (30.1)
65 – 105	452,013 (63.6)	927,601 (59.6)	93,937 (40.2)
Access to Primary Health Care			
Family Physician	628,410 (88.5)	1,380,558 (88.7)	190,855 (81.6)
Other	3,070 (0.4)	10,446 (0.7)	2,875 (1.2)
None	45,255 (6.4)	102,792 (6.6)	24,804 (10.6)
Unreported	33,605 (4.7)	63,449 (4.1)	15,362 (6.6)
Year of Visit			
2014	142,988 (20.1)	360,483 (23.1)	60,677 (25.9)
2015	157,724 (22.2)	361,686 (23.2)	54,942 (23.5)
2016	172,327 (24.3)	365,899 (23.5)	53,767 (23.0)
2017	187,015 (26.3)	368,925 (23.7)	52,401 (22.4)
2018	50,286 (7.1)	100,252 (6.4)	12,109 (5.2)
CTAS[a], acuity			
1 – Resuscitation	55,787 (7.9)	37,559 (2.4)	6,067 (2.6)
2 – Emergent	310,363 (43.7)	611,786 (39.3)	85,448 (36.5)
3 – Urgent	323,284 (45.5)	789,010 (50.7)	116,014 (49.6)
4 – Less Urgent	20,108 (2.8)	113,891 (7.3)	25,020 (10.7)
5 – Non-Urgent	798 (0.1)	4,999 (0.3)	1,347 (0.6)
Time of Triage, hour			
Day (0700 – 1459)	319,312 (45.0)	652,013 (41.9)	81,448 (34.8)
Evening (1500 – 2259)	264,375 (37.2)	593,972 (38.1)	95,383 (40.8)
Overnight (2300 – 0659)	126,653 (17.8)	311,260 (20.0)	57,065 (24.4)
Diagnostic Category, ICD-10[b, c]			
A,B – Certain Infectious Diseases	17,995 (2.5)	50,360 (3.2)	2,904 (1.2)
C – Neoplasms	8,429 (1.2)	10,781 (0.7)	653 (0.3)
D – Disorders of Blood involving Immune System	4,250 (0.6)	11,692 (0.8)	927 (0.4)
E – Endocrine, Nutrition, and Metabolic Disorders	13,805 (1.9)	34,167 (2.2)	3,249 (1.4)
F – Mental and Behavioural Disorders	35,363 (5.0)	86,911 (5.6)	57,728 (24.7)
G – Diseases of Nervous System	43,001 (6.1)	9,912 (0.6)	2,658 (1.1)
H – Diseases of the Eye, Adnexa, Ear and Mastoid Process	9,132 (1.3)	2,329 (0.1)	698 (0.3)
I – Diseases of the Circulatory System	80,452 (11.3)	130,083 (8.4)	7,585 (3.2)
J – Diseases of the Respiratory System	34,828 (4.9)	214,284 (13.8)	13,735 (5.9)
K – Diseases of the Digestive System	44,821 (6.3)	76,472 (4.9)	5,074 (2.2)
L – Diseases of the Skin and Subcutaneous Tissue	2,188 (0.3)	14,220 (0.9)	998 (0.4)
M – Diseases of the Musculoskeletal	16,385 (2.3)	75,194 (4.8)	2,515 (1.1)

System and Connective Tissue			
N – Diseases of the Genitourinary System	36,992 (5.2)	69,707 (4.5)	5,558 (2.4)
O – Pregnancy, Childbirth, and the Puerperium	195 (0.0)	2,171 (0.1)	202 (0.1)
P – Certain conditions origination in the Perinatal Period	2 (0.0)	1 (0.0)	0 (0.0)
Q – Congenital Malformations, Deformations and Chromosomal Abnormalities	119 (0.0)	115 (0.0)	19 (0.0)
R – Symptoms, Signs and Abnormal Clinical and Laboratory Findings	198,556 (28.0)	376,542 (24.2)	39,005 (16.7)
S,T – Injury, Poisoning and Certain Other Consequences of External Causes	152,591 (21.5)	370,165 (23.8)	87,161 (37.3)
U – External Coucals of Morbidity and Mortality	0 (0.0)	2 (0.0)	0 (0.0)
Z – Factors Influencing Health Status and Contact with Health Services	11,236 (1.6)	22,137 (1.4)	3,227 (1.4)
Visit Outcome			
Admitted to Reporting Facility, to Special Care Unit or Operating Room	44,651 (6.3)	49,851 (3.2)	3,950 (1.7)
Admitted to Reporting Facility, to another Unit	283,378 (39.9)	541,719 (34.8)	51,593 (22.1)
Discharged Home	291,956 (41.1)	773,555 (49.7)	142,624 (61.0)
Discharged to Place of Residence (Institution)	62,062 (8.7)	143,350 (9.2)	24,128 (10.3)
Dead on or After Arrival in ED	540 (0.1)	441 (0.0)	32 (0.0)
Other	27,753 (3.9)	36,669 (2.4)	11,569 (4.9)
Days to Left ED			
0	416,687 (58.7)	1,012,242 (65.0)	162,894 (69.6)
1	261,869 (36.9)	487,555 (31.3)	66,194 (28.3)
2	25,725 (3.6)	46,228 (3.0)	3,743 (1.6)
3	4,833 (0.7)	9,013 (0.6)	799 (0.3)
4	820 (0.1)	1,628 (0.1)	175 (0.1)
>4	231 (0.0)	286 (0.0)	91 (0.0)

* General Practice is a subset of Urgent Care; visits categorized as General Practice were also categorized as Urgent Care.

+ Percentage of the total patients in cohort.

[a] Canadian Triage and Acuity Scale.

[b] International Statistical Classification of Diseases and Related Health Problems 10th Revision.

[c] Represents primary diagnosis of emergency department visit.

Figure 2: Percentage of ED visits discharged from unit, broken down triage acuity and healthcare centre classified by the main physician intervention.

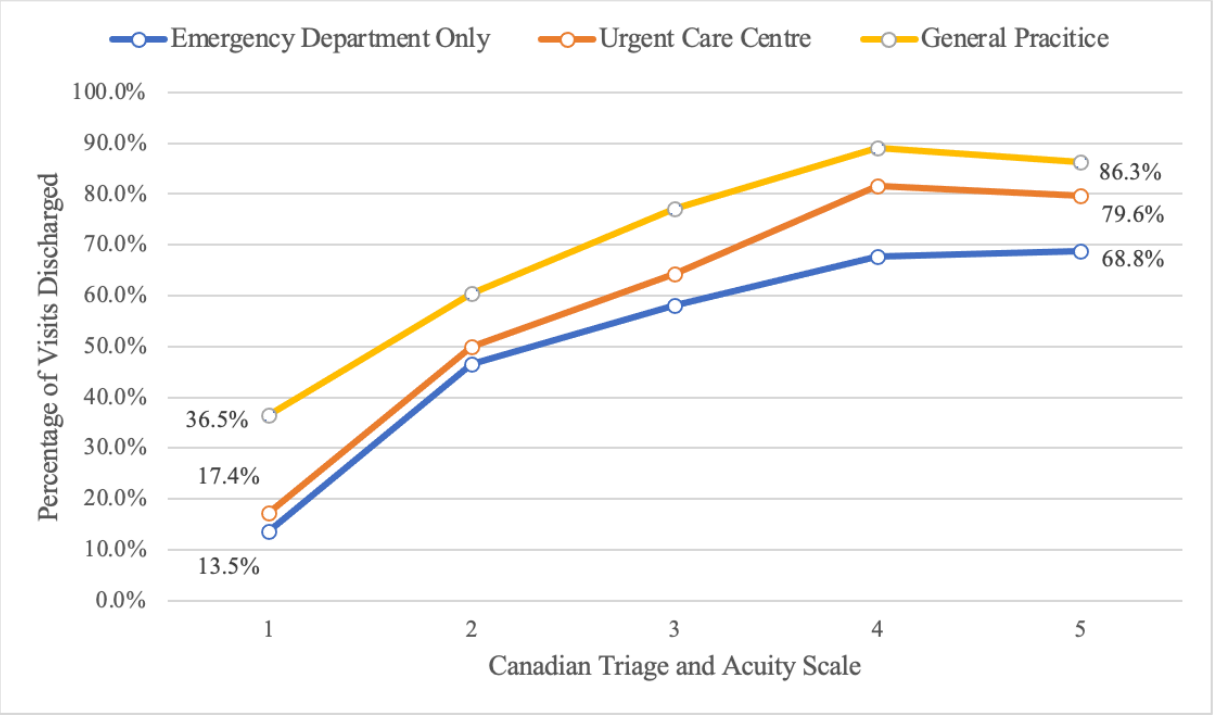

Table 2: Unadjusted and adjusted patient visit characteristics associated with urgent care and general practice setting interventions, compared against ED only intervention.

	Urgent Care Centre versus Emergency Department		General Practice versus Emergency Department	
Characteristic	**Unadjusted OR (95% CI)**	**Adjusted OR (95% CI)**	**Unadjusted OR (95% CI)**	**Adjusted OR (95% CI)**
Intercept	-	2.72 (2.68 – 2.76)	-	0.25 (0.24 – 0.26)
Sex, male	0.92 (0.91 – 0.92)	0.92 (0.91 – 0.92)	1.15 (1.14 – 1.16)	1.02 (1.00 – 1.03)
Age, years				
18 – 39	-	-	-	-
40 – 64	0.67 (0.66 – 0.68)	0.69 (0.69 – 0.70)	0.37 (0.36 – 0.37)	0.50 (0.49 – 0.50)
65 – 105	0.63 (0.62 –0.64)	0.64 (0.63 – 0.65)	0.20 (0.20 – 0.21)	0.32 (0.32 – 0.33)
Acuity				
Emergent	-	-	-	-
Urgent	1.38 (1.37 – 1.38)	1.38 (1.37 – 1.39)	1.44 (1.42 – 1.45)	1.49 (1.47 – 1.51)
Non-urgent	3.21 (3.16 – 3.26)	3.10 (3.05 – 3.15)	5.05 (4.95 – 5.15)	4.40 (4.30 – 4.50)
Time of Triage				
Day	-	-	-	-
Evening	1.11 (1.10 – 1.12)	1.10 (1.09 – 1.11)	1.45 (1.43 – 1.46)	1.21 (1.19 – 1.22)
Overnight	1.20 (1.19 – 1.21)	1.16 (1.15 – 1.17)	1.75 (1.73 – 1.77)	1.31 (1.29 – 1.33)
Diagnosis				
Diseases of Circulatory System	-	-	-	-
Diseases of Respiratory System	3.81 (3.75 – 3.86)	3.49 (3.44 – 3.54)	4.18 (4.06 – 4.31)	0.81 (0.78 – 0.85)
Diseases of Digestive System	1.06 (1.04 – 1.07)	0.88 (0.87 – 0.89)	1.20 (1.16 – 1.25)	1.10 (1.05 – 1.14)
Diseases of Genitourinary System	1.17 (1.15 – 1.18)	0.95 (0.94 – 0.97)	1.59 (1.54 – 1.66)	1.15 (1.11 – 1.20)
Mental and Behavioural Disorders	1.52 (1.50 – 1.54)	1.06 (1.04 – 1.08)	17.31 (16.85 – 17.79)	9.85 (9.56 – 10.14)
Symptoms, Signs & Ab. Clin. Labs[a]	1.17 (1.16 – 1.19)	0.92 (0.91 – 0.93)	2.08 (2.03 – 2.13)	1.38 (1.34 – 1.42)
Injury, Poison., Conseq. of Ext Causes[b]	1.50 (1.48 – 1.52)	1.00 (0.99 – 1.01)	6.06 (5.91 – 6.21)	3.38 (3.29 – 3.48)
Other	1.14 (1.12 – 1.15)	0.88 (0.87 – 0.89)	1.51 (1.47 – 1.55)	1.04 (1.01 – 1.07)
Visit Outcome				
Discharged	-	-	-	-
Admitted	0.70 (0.69 – 0.70)	0.74 (0.73 – 0.74)	0.36 (0.36 – 0.36)	0.51 (0.50 – 0.52)
Other	0.67 (0.66 – 0.68)	0.74 (0.73 – 0.75)	0.87 (0.85 – 0.89)	1.00 (0.98 – 1.03)
Concordance statistic[c]	-	0.625	-	0.772

OR = Odds Ratio, CI = Confidence Interval.
[a] Symptoms, Signs and Abnormal Clinical and Laboratory Findings.
[b] Injury, Poisoning and Certain Other Consequences of External Causes.
[c] Reported as Area Under the Receiver Operating Characteristic Curve (95% CI).

Supplemental Data

Table 1: STROBE Statement – Checklist of items for reporting results of observational cohort studies.

	Item No	Recommendation	Page No
Title and abstract	1	(*a*) Indicate the study's design with a commonly used term in the title or the abstract (*b*) Provide in the abstract an informative and balanced summary of what was done and what was found	 2
Introduction			
Background/rationale	2	Explain the scientific background and rationale for the investigation being reported	4
Objectives	3	State specific objectives, including any prespecified hypotheses	4
Methods			
Study design	4	Present key elements of study design early in the paper	5
Setting	5	Describe the setting, locations, and relevant dates, including periods of recruitment, exposure, follow-up, and data collection	5
Participants	6	(*a*) Give the eligibility criteria, and the sources and methods of selection of participants. Describe methods of follow-up (*b*) For matched studies, give matching criteria and number of exposed and unexposed	5 -
Variables	7	Clearly define all outcomes, exposures, predictors, potential confounders, and effect modifiers. Give diagnostic criteria, if applicable	5,6
Data sources/ measurement	8*	For each variable of interest, give sources of data and details of methods of assessment (measurement). Describe comparability of assessment methods if there is more than one group	5,6
Bias	9	Describe any efforts to address potential sources of bias	5
Study size	10	Explain how the study size was arrived at	5,6
Quantitative variables	11	Explain how quantitative variables were handled in the analyses. If applicable, describe which groupings were chosen and why	5,6
Statistical methods	12	(*a*) Describe all statistical methods, including those used to control for confounding (*b*) Describe any methods used to examine subgroups and interactions (*c*) Explain how missing data were addressed (*d*) If applicable, explain how loss to follow-up was addressed (*e*) Describe any sensitivity analyses	6 6 6 - -
Results			
Participants	13*	(a) Report numbers of individuals at each stage of study—eg numbers potentially eligible, examined for eligibility, confirmed eligible, included in the study, completing follow-up, and analysed (b) Give reasons for non-participation at each stage (c) Consider use of a flow diagram	6,7 6 7
Descriptive data	14*	(a) Give characteristics of study participants (eg demographic, clinical, social) and information on exposures and potential confounders (b) Indicate number of participants with missing data for each variable of interest (c) Summarise follow-up time (eg, average and total amount)	7-9 8,9 8,9

Outcome data	15*	Report numbers of outcome events or summary measures over time	9,10
Main results	16	(a) Give unadjusted estimates and, if applicable, confounder-adjusted estimates and their precision (eg, 95% confidence interval). Make clear which confounders were adjusted for and why they were included	10,11
		(b) Report category boundaries when continuous variables were categorized	8,9,11
		(c) If relevant, consider translating estimates of relative risk into absolute risk for a meaningful time period	-
Other analyses	17	Report other analyses done—eg analyses of subgroups and interactions, and sensitivity analyses	-
Discussion			
Key results	18	Summarise key results with reference to study objectives	11,12
Limitations	19	Discuss limitations of the study, taking into account sources of potential bias or imprecision. Discuss both direction and magnitude of any potential bias	13
Interpretation	20	Give a cautious overall interpretation of results considering objectives, limitations, multiplicity of analyses, results from similar studies, and other relevant evidence	12
Generalisability	21	Discuss the generalisability (external validity) of the study results	12,13
Other information			
Funding	22	Give the source of funding and the role of the funders for the present study and, if applicable, for the original study on which the present article is based	14

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CHAPTER FOUR

Validating the Emergency Department Avoidability Classification (EDAC): A Cluster Randomized Single-Blinded Agreement Study

Summary

This chapter presents the first of two studies investigating the validity of the developed classification, the Emergency Department Avoidability Classification (EDAC), and similar classifications against a standard. Building upon previous chapters, this study evaluates the EDAC against a criterion standard of ED physicians. These physicians independently assessed randomly selected ED visits from 2019 to determine if they could have been managed outside the ED. Each visit was assessed by two physicians independently. The EDAC classified each visit as avoidable, potentially avoidable or not avoidable.

This study found ED physicians exhibited substantial agreement and reliability when judging the avoidability of ED visits, establishing them as a criterion standard. The EDAC was highly correlated with ED physician judgements, demonstrating strong accuracy to identify retrospective avoidable ED visits. This study used an innovative approach to establish a criterion standard in absence of a gold standard. The strength of this study lies in its robust methodology and design, suggesting that the EDAC is likely applicable and generalizable to other ED settings.

Study Protocol:
Strum, R.P., Mondoux, S., Mowbray, F.I., Worster, A., Griffith, L.E., Tavares, W.T., Miller, P., Hanel, E., Aryal, K., Sivakumaran, R., Costa, A.P. Validation of a classification to identify emergency department visits suitable for subacute and virtual care models: a randomised single-blinded agreement study protocol. *BMJ Open.* 2022; 12, e068488.

Abstract

Introduction: The Emergency Department Avoidability Classification (EDAC) retrospectively classifies emergency department (ED) visits that could have been safely managed in subacute primary care settings, but has not been validated against a criterion standard. A validated EDAC could enable accurate and reliable quantification of avoidable ED visits. We compared agreement between the EDAC and ED physician judgements to specify avoidable ED visits.

Materials and Methods: We conducted a cluster randomized, single-blinded agreement study in an academic hospital in Hamilton, Canada. ED visits between January 1, 2019, and December 31, 2019 were clustered based on EDAC classes and randomly sampled evenly. A total of 160 ED visit charts were randomly assigned to ten participating ED physicians at the academic hospital for evaluation. Physicians judged if the ED visit could have been managed appropriately in subacute primary care (an avoidable visit); each ED visit was evaluated by two physicians independently. We measured interrater agreement between physicians with a Cohen's kappa and 95% confidence intervals (CI). We evaluated the correlation between the EDAC and physician judgements using a Spearman rank correlation and ordinal logistic regression with odds ratios (ORs) and 95% CIs. We examined the EDAC's precision to identify avoidable ED visits using accuracy, sensitivity and specificity.

Results: ED physicians agreed on 139 visits (86.9%) with a kappa of 0.69 (95% CI 0.59 – 0.79), indicating substantial agreement. Physicians judged 96.2% of ED visits classified as avoidable by the EDAC as suitable for management in subacute primary care. We found a high correlation between the EDAC and physician judgements (0.64),

as well as a very strong association to classify avoidable ED visits (OR 80.0, 95% CI 17.1 – 374.9). The EDACs avoidable and potentially avoidable classes demonstrated strong accuracy to identify ED visits suitable for management in subacute care (82.8%, 95% CI 78.2 – 86.8).

Discussion: The EDAC demonstrated strong evidence of criterion validity to classify avoidable ED visits. This classification has important potential for accurately monitoring trends in avoidable ED utilization, measuring proportions of ED volume attributed to avoidable visits and informing interventions intended at reducing ED use by patients who do not require emergency or life-saving healthcare.

Introduction

Emergency departments (EDs) internationally have experienced significant increases in attendance over the past two decades from 2003 to 2023, with indications this trend will continue to escalate.[1–4] EDs are overcrowded, posing a significant challenge for the healthcare system[5,6]. The consequences of overcrowding are wide-reaching, affecting both clinicians and patients (increased mortality[7–10], reduced quality of care[11], reduced treatment performance[11], increased medical errors[12], decreased compliance with treatment guidelines[13,14]), ED staff (higher burnout and stress[15], lower job satisfaction[15]), and the broader healthcare system (increased per-visit costs due to extended lengths of stay[15,16]). While patient boarding is the primary driver of overcrowding, it is a multifactorial issue influenced by poor patient flow, staffing shortages and rising patient volumes, particularly patients seeking ED care for non-emergent and minor health concerns.[6,17–19]

One strategy that may address this challenge is redirecting patients with specific non-emergent complaints and conditions to non-ED subacute care instead of the ED. Redirection interventions have yielded mixed results (i.e., electronic ED screening applications, secondary ED triage).[20,21] However, redirection has recently gained renewed focus as research continues to highlight managing non-emergent patients in the ED is associated with negative patient experiences, increased risk of hospital-acquired infections, staff burnout/emotional exhaustion and potentially higher healthcare costs.[22–24] A critical barrier to developing successful redirection interventions is the absence of an objective and consistent method for identifying patient cohorts suitable for these care models.[20,21,25] Previously published classifications for avoidable ED visits

have shown to be unreliable and inconsistent classifiers due to a lack of validity evidence and consensus of classification criteria, yielding wide prevalence estimates that range from 5 to 90%.[26,27] Their inaccuracies highlight the immediate need for an innovative epidemiological classification that is established with experimental validity to inform accurate intervention development.

The Emergency Department Avoidability Classification (EDAC) is an novel retrospective patient classifier that identifies ED visits that could have been appropriately managed and effectively treated in a subacute healthcare setting (an avoidable visit).[28] The EDAC was developed through a collaborative effort involving expert emergency and primary physicians in Ontario, Canada, using a rigorous multi-stage and multicentered consensus process.[29,30] The EDAC has demonstrated construct validity (i.e., the EDAC components represent the concept of avoidable ED visits) but has not been examined for evidence of criterion validity.[31] Successful validation would enable the EDAC to function as a trustworthy benchmark for policy stakeholders, epidemiologists and researchers to identify opportunities for modifying health policy, designing interventions to reduce avoidable ED visits, monitoring trends, and understanding gaps in community care that contribute to avoidable visits.

Our purpose was to examine the criterion validity of the EDAC to retrospectively classify ED visits that could have been managed in a subacute primary care against ED physician judgements. Our preliminary objective was to evaluate ED physician judgements as a criterion standard. Our main objective was to examine the correlation and association between the EDAC and ED physician judgments to specify avoidable

ED visits. Our secondary objective aimed to assess the comparability of the mid-level class (potentially avoidable) with the avoidable and not avoidable EDAC classes.

Materials and Methods

Study Design

We conducted a cluster randomized, single-blinded agreement study. ED physicians were recruited from an academic hospital in Hamilton, Canada. Retrospective ED visits were categorized based on the EDAC into a three-cluster design (avoidable, potentially avoidable and not avoidable) and randomly sampled using a predetermined randomization protocol.[32] Physicians were randomly assigned ED charts from each study cluster evenly and judged whether the ED visit could have been safely managed in a subacute primary care setting. Physicians were blinded to the ED visits study cluster. We adhered to the study steps detailed in the study protocol.[32]

Selection of Participants

ED physicians were eligible to participate in the study if they were (1) currently practicing, and (2) held a staff emergency physician position at the academic hospital. All physicians meeting the eligibility criteria were invited to participate in the study. An information letter and consent form were provided and all physicians were given the opportunity to review and ask questions prior to participating. Upon acceptance of participation, each physician signed and returned the study consent form. ED physicians provided demographic information about themselves, their length of clinical experience and medical training. Recruitment started September 7, 2022 and ended on October 18, 2022. We obtained informed consent from all twelve ED physicians invited to participate in the study.

The Emergency Department Avoidability Classification

The EDAC is a patient classification that identifies retrospective ED visits that could have been appropriately and safely managed in a subacute primary care clinical setting.[32] The EDAC's inclusion criteria were constructed in a multi-stage, multicentred consensus process involving emergency and primary care physicians.[30,33] The consensus process assembled clinical and non-clinical characteristics readily available in administrative databases to retrospectively identify avoidable visits with a high specificity .[30,33] The EDAC classifies ED visits as avoidable, potentially avoidable, and not avoidable. *Table 1* shows the EDAC classification logic: avoidable ED visits could have been safely managed in a subacute primary care centre, potentially avoidable ED visits could potentially have been managed in subacute primary care, and not avoidable ED visits could not be managed outside of the ED in subacute primary care.

Selection of ED Visits

Electronic ED visits at the academic hospital were eligible for study inclusion if the visit occurred between January 1, 2019, and December 31, 2019, all variables required to classify the visit using the EDAC were recorded in the chart (patient age, triage acuity, specialist consult completed, main physician intervention, ED visit outcome), and the patient did not leave against medical advice or without being assessed by an ED physician. We grouped included ED visits into three study clusters based on the EDAC classes: avoidable, potentially avoidable, and not avoidable. We randomly selected an equal quantity of ED visits from each study cluster to be included in the study, totaling 160 ED visits.

Measurements

We randomly assigned a reasonably equal quantity of ED visits from each study cluster to each participating ED physician that totaled 20 ED visits (configuration of: seven, seven and six of the three study clusters). Overall, ten of the twelve ED physicians completed 20 ED visit ratings; two did not contribute. All participating physicians were offered a second round of ED visits for review, of which six agreed and completed. Overall, six physicians judged 40 ED visits each, and four physicians judged 20 ED visits each. ED physicians were provided the ED visits unique medical reporting number (MRN), which they used to retrieve the chart from the hospital's electronic database. The physicians were blinded to the knowledge of the EDAC criteria and EDAC class to which an ED visit belonged. Following the chart review, the ED physicians answered two study questions (described below). The ED charts format, information and presentation were not altered in any way for the study. Each ED visit was rated by two ED physicians independently. We calculated a priori that 126 ED visits were needed to sufficiently power the study at an optimal 80% to detect statistical significance using a two tailed 0.05 alpha.[32]

Outcome Measurement

Physicians answered two study questions based on their analysis of the ED visit. First, physicians were requested to judge whether an ED visit could have been appropriately and safely managed in a subacute primary care model. Second, we asked physicians to rate their confidence in this judgement using a 5-point Likert scale, ranging from not confident (1) to very confident (5).[34] We provided the physicians with descriptions, definitions, staffing, diagnostic imaging and care services (i.e. laboratory,

pharmaceutical) for various subacute centres to align understanding of subacute centre capabilities prior to providing ratings. Physicians received instruction and training on how to complete the questionnaire before the study commenced. All questionnaires were completed and submitted electronically using *CheckMarket* survey software.

Statistical Analysis

We reported demographic characteristics of the participating ED physicians and patient ED visits as frequencies and proportions. To determine if ED physicians could be established as a criterion standard, we calculated interrater reliability of physician agreement overall and for each EDAC class using a Cohen's kappa coefficient with 95% confidence intervals (CIs). We predetermined a kappa coefficient equal to or greater than 0.6 would establish physician judgements as a criterion standard to identify avoidable ED visits.[32] This threshold was chosen as a 0.6 kappa indicated substantial agreement greater than chance.[35] Physician confidence scores were reported as means and standard deviations. We used a Spearman rank correlation to assess the correlation between the EDAC and ED physician judgements. Ordinal rankings of the EDAC were structured into three-levels of the classification (avoidable, potentially avoidable, not avoidable). Ordinal rankings of physician judgements were structured as: both physicians agreed the ED visit was only appropriate for the ED, the physicians disagreed (one judged the visit as only appropriate for the ED and the second judged as appropriate for subacute care), and both physicians agreed the ED visit was appropriate for subacute primary care. To understand the magnitude of association between the EDAC and ED physicians to classify avoidable ED visits, we computed a three-level ordinal logistic regression using odds ratios (ORs) and 95% CIs, along with the model's

area under the receiver operating characteristic curve (AUC). EDAC classes were modeled as a set of dummy variables with the not avoidable class set as the referent group. Finally, to determine the directionality of the potentially avoidable class towards either avoidable or not avoidable ED visits, we calculated the accuracy, sensitivity and specificity of the EDAC and ED physician judgements in three sequestered analyses. Initially, we computed baseline precision statistics using only avoidable and not avoidable ED visits. We repeated precision analyses when all potentially avoidable ED visits were classified as avoidable ED visits, then as not avoidable ED visits. We compared changes in precision measures relative to the initial analysis. Data were managed and analyzed using the '*dplyr'* package in R software(v. 3.6).[36]

Ethics Approval

Our study was approved by the Hamilton Integrated Research Ethics Board (HiREB), review reference number 2022-14625-GRA. Informed and written consent was obtained from all study participants.

Results

Characteristics of Participating ED Physicians

The participating physicians were mostly male (8), currently practicing in both the ED and an urgent care centre (8), and holding an academic appointment at a Canadian University (9). Physicians were nearly equal in medical training for the disciplines of emergency medicine (Fellow of The Royal College of Physicians of Canada; 6) and family medicine with emergency medicine certification (Certification in the College of Family Medicine, with Special Competence in Emergency Medicine; 4).

Main Results

Overall, there were 160 ED visits judged twice by different ED physicians, amassing 320 ratings. All ED visits were judged by two physicians; no visit was excluded, and no visit was reviewed only once. *Table 2* shows descriptive statistics of all ED visits used in the study and by EDAC class. The ED visits were fairly evenly distributed by sex (48% male, 52% female). ED visits were predominantly aged 18 to 40 years (48%), with 41 to 60 (31%) and 61 to 105 (21%) constituting the remainder. Visits were mostly assigned an urgent triage score (48%). Most visits had an ED physician recorded as the most responsible provider (81%) and were discharged from the ED (79%). The quantity of ED visits in each EDAC class were largely consistent (54, 53, and 53, respectively).

Table 3 shows agreement between ED physicians after evaluating the ED visits. Physicians agreed on 139 (86.9%) of 160 ED visits, yielding a kappa coefficient of 0.69 (95% CI 0.59 – 0.79). Avoidable ED visits showed near-perfect agreement with 53 of 54 visits (98.1%). Potentially avoidable ED visits had the lowest agreement, 40 of 53 visits (75.5%), and the lowest kappa of 0.25 (95% CI 0.01 – 0.48). Not avoidable ED visits resulted in the highest kappa (0.70, 95% CI 0.53 – 0.87). Physician confidence scores mirrored the kappa gradient observed, giving the highest confidence in not avoidable ED visits and the lowest in potentially avoidable ED visits. ED visits identified as either avoidable or not avoidable were chosen to analyze ED visits strictly avoidable or not, yielding an almost agreement amongst physicians with a kappa of 0.84 (95% CI 0.73 – 0.95).

Figure 1 shows the proportion of physician agreement within each class of the EDAC. Of ED visits classified by the EDAC as avoidable, physicians agreed 52 (96.2%) were appropriate for management in subacute primary care. Of ED visits identified as potentially avoidable, physicians agreed 37 (69.8%) were suitable for subacute primary care, 13 (24.5%) were not suitable, and 3 (5.7%) had disagreement between physicians. Of ED visits classified as not avoidable from ED care, physicians agreed the ED was the appropriate centre on 33 visits (62.3%), 13 visits physicians agreed were appropriate for subacute care (24.5%), and 7 had physician disagreement (13.2%).

Table 4 shows the results of the correlation and regression validity analyses. A Spearman rank correlation coefficient analysis found a significant association between the EDAC and ED physician judgement with a high and positive correlation coefficient (0.64; $p<0.01$). In an ordinal logistic regression analysis, the odds ED physicians agreed an ED visit was avoidable increased by 80 times when the EDAC identified an ED visit was avoidable (OR 80, 95% CI 17.1 – 374.9). The AUC of the regression model was 0.84, inferring this model is an excellent classifier to identify avoidable ED visits in comparison to physician agreement.[37]

We conducted a sequestered analysis that examined whether the potentially avoidable class was more comparable to either the avoidable or not avoidable EDAC class. *Table 5* shows the results and *Appendix 2* shows the raw data of the analysis. When including only avoidable and not avoidable visits, the EDAC showed strong accuracy (83.2%, 95% CI 77.5 – 88.0%) to delineate ED visits suitable for subacute care with high specificity (97.2%, 95% CI 92.1 – 99.4), and moderate sensitivity of (68.9%, 95% CI 59.1 – 77.3). When potentially avoidable ED visits were grouped with

avoidable ED visits, accuracy and sensitivity remained relative consistent while specificity lowered 7.5%. When potentially avoidable ED visits were grouped with not avoidable ED visits, accuracy and sensitivity lowered substantially (21.6%, 25.5% respectively) while specificity remained constant.

Discussion

We successfully established ED physician judgment as a criterion standard for identifying ED visits that were suitable for subacute primary care. The EDAC demonstrated its validity as an accurate classifier of avoidable ED visits with a strong correlation and association to ED physician judgements. The EDAC exhibited high specificity, high accuracy and modest sensitivity, evidence of validity that substantiates its capacity to identify avoidable ED visits with precision in routinely collected ED data.

Our study further supports the EDAC as a valid classification tool. While previously published classifications such as ambulatory care sensitive conditions, family practice sensitive conditions, sentinel nonurgent conditions, and CTAS may offer more simplistic inclusion criteria compared to the EDAC, they may yield less accurate estimates of avoidable ED visits due to their limited reliance on one or two criteria variables.[26] For example, ambulatory care-sensitive conditions and family practice-sensitive conditions rely solely on diagnostic criteria to define their cohorts, a characteristic our previous consensus study found to be isolated from identifying avoidable ED visits.[26,33] Most published classifications lack validity testing to a criterion standard, a critical phase needed to determine a classifications generalizability. We speculate that researchers have relied on these classifications due to convenience and

insufficient information regarding their validation, a gap in the literature this study aimed to address with the EDAC.

Practically, the EDAC could serve as a valuable measure for policymakers seeking to address ED overcrowding, optimize healthcare resource utilization, and improve care continuity in primary care. The EDAC has the potential to augment or enhance existing quality indicators of ED use, providing a clearer understanding of patient cohorts using the ED improperly when non-ED care is capable of managing their primary condition. The EDAC could plausibly be leveraged as an indirect indicator of access to primary care and the healthcare system's capacity to manage patients with primary care conditions, thus aiding in understanding patient trends in ED use for primary care treatable conditions. Epidemiologically, the EDAC could support the investigation of neighbourhood characteristics that influence avoidable ED visits. Understanding these characteristics could inform intervention development to address geospatial care gaps. Lastly, the EDAC could guide interventions promoting integration with primary care, virtual care, or new care models (i.e., paramedic transport to non-ED care centres).

The EDAC was constructed with a conservative approach towards identifying avoidable ED visits, as evidenced with its high specificity. The low proportion of avoidable and potentially avoidable ED visits judged by ED physicians as requiring ED care further supports it as a highly specific classifier for visits that could have been managed outside of the ED. We attribute our results to the inclusion of the main ED physician intervention as a criterion, a variable not commonly incorporated in previous epidemiological classifications. Based on our study’s experimental methodology and

results, we assert the EDAC's performance can be replicated in other EDs seeking to identify and understand avoidable ED visits.

An important finding of our study was gaining insights into the potentially avoidable class in the EDAC. When grouped with avoidable ED visits, specificity decreased marginally while accuracy remained consistent. When grouped with not avoidable visits, specificity remained constant, but accuracy decreased substantially. These results, combined with approximately 70% of ED physicians agreeing that potentially avoidable visits were suitable for subacute care, suggest that potentially avoidable visits align more closely with avoidable visits than not avoidable visits.

A critical feature of our study was establishing ED physician judgement as a reliable criterion in the absence of a gold standard. Overall, substantial agreement was observed among ED physicians, with near perfect agreement when evaluating only avoidable and not avoidable ED visits. These results, combined with their confidence scores, support our a priori hypothesis that ED physicians possess a strong and similar clinical understanding of which ED visits require ED medicine, ED services or general hospital care, and which visits do not. Potentially avoidable visits showed slight agreement among ED physicians, a result consistent with the theoretical nature of a middle-level category within a classification.

Although the EDAC demonstrated criterion validity, the EDAC is not a pragmatic tool for clinical decision-making at the time of care, since it is based on post-ED visit information (i.e., ED discharge). However, the EDAC can be used for epidemiological comparisons, benchmarking, and program evaluations, where the desired outcome of the model is to classify avoidable ED visits.

Limitations

Physicians could not be blinded to patient identity, potentially introducing implicit bias if they were familiar with the ED visit. However, this is unlikely given the very low probability that a participating physician encountered the ED visit and could recount the visit several years previously. We contend this bias was minimal due to the incorporation of randomization in selection of ED visits and random assignment to each physician. Though we established physician judgment as a criterion standard in our analyses, we acknowledge that the same interrater agreement may vary in different EDs. While ten ED physicians were deemed sufficient for conducting this study, recruiting additional physicians could have enhanced the robustness of the results. Future research could reproduce this study with more study centres (academic hospitals), ED physicians and ED visits to further validate the EDAC. Physician agreement supplied a benchmark for comparison with the EDAC, although this is not a gold standard. Lastly, the EDAC provides a broad classification of ED visits that could have been managed in non-ED settings but cannot discern the necessity of a visit for different population groups, such as marginalized patients, patients of lower socioeconomic status, or patients facing disproportionate barriers to primary care.

Conclusion

The Emergency Department Avoidability Classification demonstrated evidence of validity against ED physician judgements as a trustworthy retrospective classifier of avoidable ED visits. This classification has potential to inform epidemiological examinations of avoidable ED visits, support the development of ED avoidable models, triaging tools and as an outcome indicator for experimentation and benchmarking.

Pragmatically, the EDAC could permit cohort and geospatial analyses to improve our understanding of community care gaps that may contribute to avoidable ED visits, and subsequently ED overcrowding.

Tables and Figures

Table 1: The Emergency Department Avoidability Classification (EDAC) criteria to identify avoidable, potentially avoidable and not avoidable ED visits.

EDAC Classes	Avoidable	Potentially Avoidable	Not Avoidable
Definition	ED visits that could have been managed by subacute primary care	ED visits that could potentially have been managed by subacute primary care	ED visits that could not have been managed by subacute primary care
Age, years	18 – 70		Not be classified as either Avoidable or Potentially Avoidable
Triage Acuity, CTAS	4 (Less Urgent) or 5 (Non-Urgent)	3 (Urgent)	
Specialist Consultation in ED	No		
Main Physician Intervention, CCI	Listed in Appendix 1		
ED Visit Outcome	Discharged		

Note: CTAS = Canadian Triage and Acuity Scale, CCI = Canadian Classification of Health Interventions

Table 2: Clinical and non-clinical characteristics of ED visits used in the study, categorized by EDAC class.

Characteristics	All ED Visits, n (%)	Avoidable ED Visits, n (%)	Potentially Avoidable ED Visits, n (%)	Not Avoidable ED Visits, n (%)
Total ED Visits	160	54	53	53
Sex				
Male	77 (48)	26 (48)	25 (47)	26 (49)
Female	83 (52)	28 (52)	28 (53)	27 (51)
Age, years				
18-40	77 (48)	31 (57)	31 (58)	15 (28)
41-60	49 (31)	18 (33)	22 (42)	5 (9)
61-105	34 (21)	5 (9)	0 (0)	33 (62)
Mode of Arrival				
Walk-In	109 (68)	47 (87)	36 (68)	26 (49)
Ambulance	51 (32)	7 (13)	17 (32)	27 (51)
Triage Acuity, CTAS				
1 – Resuscitation	2 (1)	0 (0)	0 (0)	2 (4)
2 – Emergent	23 (14)	0 (0)	0 (0)	23 (43)
3 – Urgent	77 (48)	0 (0)	53 (100)	24 (45)
4 – Less Urgent	41 (26)	38 (70)	0 (0)	3 (6)
5 – Non-Urgent	17 (11)	16 (30)	0 (0)	1 (2)
Day of Week				
Monday	25 (16)	7 (13)	7 (13)	11 (21)
Tuesday	23 (14)	6 (11)	9 (17)	8 (15)
Wednesday	28 (18)	11 (20)	6 (11)	11 (21)
Thursday	20 (13)	8 (15)	6 (11)	6 (11)
Friday	18 (11)	5 (9)	7 (13)	6 (11)
Saturday	20 (13)	9 (17)	6 (11)	5 (9)
Sunday	26 (16)	8 (15)	12 (23)	6 (11)
Time in ED[a], minutes				
Average (SD)	429 (547)	213 (139)	238 (131)	839 (788)
Under 30	1 (1)	0 (0)	1 (2)	0 (0)
31 – 60	5 (3)	2 (4)	3 (6)	0 (0)
61 – 120	18 (11)	8 (15)	8 (15)	2 (4)
121 – 180	29 (18)	16 (30)	10 (19)	3 (6)
181 – 240	18 (11)	11 (20)	6 (11)	1 (2)
Over 241	89 (54)	15 (28)	24 (45)	47 (89)
Most Responsible Provider				
Emergency Medicine	129 (81)	54 (100)	53 (100)	22 (42)
Psychiatry	10 (6)	0 (0)	0 (0)	10 (19)
Internal Medicine	9 (6)	0 (0)	0 (0)	9 (17)
Nephrology	2 (1)	0 (0)	0 (0)	2 (4)
Cardiology	2 (1)	0 (0)	0 (0)	2 (4)
General Surgery	3 (2)	0 (0)	0 (0)	3 (6)
Other	5 (3)	0 (0)	0 (0)	5 (8)
ED Visit Outcome				
Discharged	127 (79)	54 (100)	53 (100)	20 (38)
Admission	27 (17)	0 (0)	0 (0)	27 (51)
Other	6 (4)	0 (0)	0 (0)	6 (11)

Note: CTAS = Canadian Triage and Acuity Scale, SD = Standard Deviation.
[a] Difference of triage time to left ED time; mean.

Table 3: Agreement between independent emergency physician's judgments on the suitability of ED visits that could have been managed in subacute primary care.

	All ED Visits, n (%)	Avoidable and Not Avoidable ED Visits, n (%)	Avoidable ED visit, n (%)	Potentially Avoidable ED Visits, n (%)	Not Avoidable ED visits, n (%)
Overall Agreement	139 (86.9)	99 (92.5)	53 (98.1)	40 (75.5)	46 (86.8)
Kappa	0.69 (0.59-0.79)	0.84 (0.73-0.95)	0.66 (0.14-1.00)	0.25 (0.01-0.48)	0.70 (0.53-0.87)
Kappa Interpretation	Substantial agreement	Almost perfect agreement	Substantial agreement	Slight agreement	Substantial agreement
Physician confidence, mean (SD)	4.1 (0.9)	4.3 (0.9)	4.2 (0.9)	3.9 (0.9)	4.4 (0.8)

Figure 1: EDAC classes displaying the proportion of physician agreement of 160 ED visits.

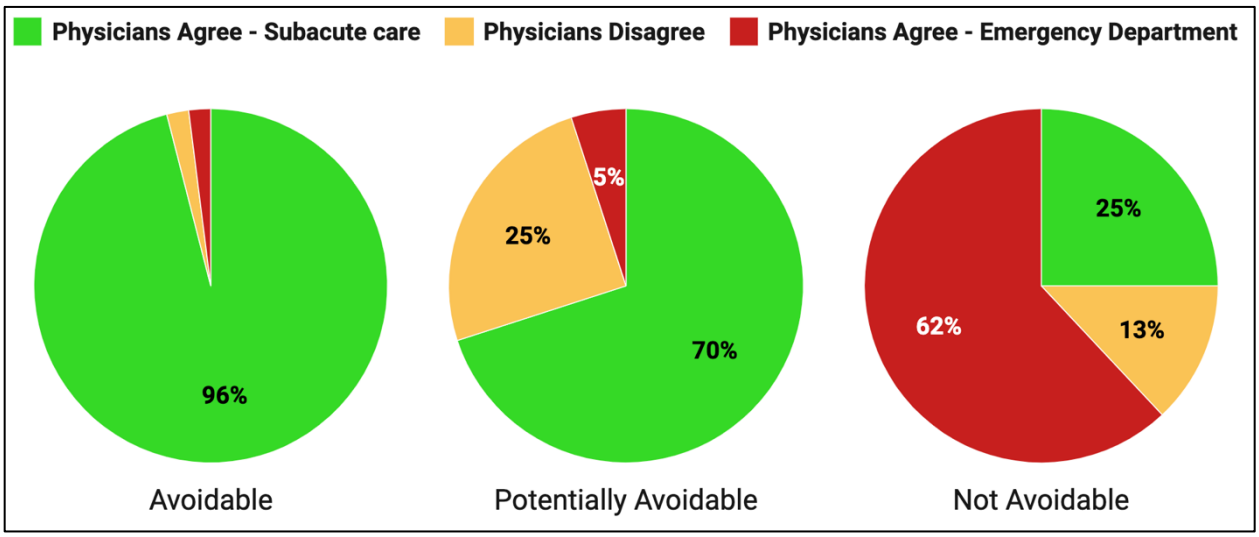

Table 4: Correlation and odds of ED physician agreement across EDAC classes using 160 ED visits from an academic hospital between January 1, 2019 to December 31, 2019.

Statistical Test	Result	p-value
Spearman Rank Correlation, coefficient	0.64	<0.05
Ordinal Logistic Regression, odds ratio (95% CI)		
Avoidable ED visits	80.0 (17.1 – 374.9)	<0.05
Potentially Avoidable ED visits	7.1 (3.0 – 16.8)	<0.05
Not Avoidable ED visits	-	-
Model AUC	0.84 (0.82 – 0.86)	
Note: CI = confidence interval, AUC = area under the receiver operator characteristic curve.		

Table 5: Accuracy, sensitivity and specificity of the EDAC's capacity to identify ED visits avoidable, potentially avoidable and not avoidable against 320 ED physician judgements of 160 ED visits.

Classification of Potentially Avoidable Visits	Accuracy, % (95% CI)	Sensitivity, % (95% CI)	Specificity, % (95% CI)
Potentially Avoidable ED Visits Excluded	83.2 (77.5 – 88.0)	68.9 (59.1 – 77.3)	97.2 (92.1 – 99.4)
Potentially Avoidable ED Visits Classified as Avoidable	82.8 (78.2 – 86.8)	68.9 (59.1 – 77.5)	89.7 (84.9 – 93.4)
Potentially Avoidable ED Visits Classified as Not Avoidable	61.6 (56.0 – 66.9)	43.4 (36.6 – 50.4)	97.2 (92.1 – 99.4)

Supplemental Data

Appendix 1: List of Canadian Classification of Health Interventions included in the EDAC.

Canadian Classification of Health Interventions Section	Physician Intervention	Codification
(1) Physical/ Physiological Therapeutic Interventions	Control of bleeding, nose using per orifice approach and agent NEC [e.g. silver nitrate]	1ET13CAZ9
	Control of bleeding, nose using per orifice approach and device NEC (e.g. electrocautery)	1ET13CAGX
	Control of bleeding, nose using per orifice approach and packing	1ET13CANP
	Drainage, bladder using per orifice approach and drainage catheter	1PM52CATS
	Extraction, rectum using per orifice approach and manual technique	1NQ57CJ
	Immobilization, knee joint using splinting device [e.g. supportive and corrective]	1VG03JASR
	Immobilization, shoulder joint using sling	1TA03JASQ
	Implantation of internal device, stomach of gastric tube [e.g. nasogastric feeding tube] using per orifice approach	1NF53CATS
	Implantation of internal device, vein NEC of intravenous catheter using percutaneous approach	1KX53HAFT
	Management of internal device, bladder of catheter using per orifice approach	1PM54CATS
	Management of internal device, stomach of percutaneously inserted gastric tube [PEG]	1NF54HATS
	Oxygenation, respiratory system NEC using bulk storage manifold system	1GZ32CAMY
	Pharmacotherapy (local), circulatory system NEC percutaneous infusion approach of electrolyte balance agents	1LZ35HHC7
	Pharmacotherapy (local), rectum using per orifice approach and agent NEC (e.g. oil retention, soap suds)	1NQ35CAZ9
	Pharmacotherapy (local), respiratory system NEC using antiasthmatic agent	1GZ35CAR3
	Pharmacotherapy, total body blood and blood forming organ agents percutaneous approach [intramuscular, intravenous, subcutaneous, intradermal] using antithrombotic agent	1ZZ35HAC1
	Pharmacotherapy, total body general antiinfective agents percutaneous approach [intramuscular, intravenous, subcutaneous, intradermal] cephalosporin and related substance	1ZZ35HAK4
	Pharmacotherapy, total body musculoskeletal system agents percutaneous approach [intramuscular, intravenous, subcutaneous, intradermal] antiinflammatory and antirheumatic agent	1ZZ35HAN1
	Pharmacotherapy, total body nervous system agents percutaneous approach [intramuscular, intravenous, subcutaneous, intradermal] analgesic	1ZZ35HAP2
	Reduction, small and large intestine using manual technique (for hernia reduction alone)	1NP73JH

	Reduction, wrist joint using closed (external) approach	1UB73JA
	Repair, lip using apposition technique [e.g. suture]	1YE80LA
	Repair, scalp using apposition technique [e.g. suture, staple]	1YA80LA
	Repair, scalp using closure device (e.g. clip, adhesive skin closure [Steri-Strips])	1YA80JAFF
	Repair, scalp using glue for apposition (e.g. crazy glue, glustitch)	1YA80LAW4
	Repair, skin of abdomen and trunk using open apposition technique [suture]	1YS80LA
	Repair, skin of arm using apposition technique [suture]	1YT80LA
	Repair, skin of arm using closure device (e.g. clip, adhesive skin closure [Steri-Strips])	1YT80JAFF
	Repair, skin of ear using apposition technique [e.g. suture]	1YC80LA
	Repair, skin of face using apposition technique [suture]	1YF80LA
	Repair, skin of face using closure device (e.g. clip, adhesive skin closure [Steri-Strips])	1YF80JAFF
	Repair, skin of face using glue for apposition (e.g. crazy glue or glustitch)	1YF80LAW4
	Repair, skin of foot using apposition technique [suture]	1YW80LA
	Repair, skin of forehead using apposition technique [e.g. suturing, stapling]	1YB80LA
	Repair, skin of forehead using closure device (e.g.clip, adhesive skin closure [Steri-Strips])	1YB80JAFF
	Repair, skin of forehead using glue (e.g. crazy glue, glustitch)	1YB80LAW4
	Repair, skin of hand using apposition technique [suture]	1YU80LA
	Repair, skin of hand using closure device (e.g. clip, adhesive skin closure [Steri-Strips])	1YU80JAFF
	Repair, skin of hand using glue for apposition (e.g. crazy glue, glustitch)	1YU80LAW4
	Repair, skin of leg using apposition technique [suture]	1YV80LA
	Repair, skin of leg using closure device (e.g. clip, adhesive skin closure [Steri-Strips])	1YV80JAFF
	Repair, skin of nose using apposition technique [e.g. suture]	1YD80LA
(2) Diagnostic Interventions	Assessment (examination), total body general NEC (e.g. multiple reasons)	2ZZ02ZZ
	Electrophysiological measurement, heart NEC external application using recording electrodes (or ECG NOS)	2HZ24JAXJ
	Function study, bladder capacity determination	2PM58VE
	Function study, bladder post- void residual volume measurement	2PM58VD
	Function study, respiratory system at rest (steady state)	2GZ58TA
	Inspection, rectum using per orifice manual (digital) technique	2NQ70CA
	Specimen collection (for diagnostic testing), total body blood by venous puncture	2ZZ13RA
(3) Diagnostic Imaging Interventions	Ultrasound, abdominal cavity alone	3OT30DA
	Ultrasound, abdominal cavity transvaginal probe	3OT30LA
	Ultrasound, arteries of leg NEC with Doppler	3KG30DC
	Ultrasound, bladder NOS alone	3PM30DA
	Ultrasound, female genital tract NEC alone	3RZ30DA
	Ultrasound, female genital tract NEC transvaginal approach	3RZ30LA
	Ultrasound, kidney alone	3PC30DA
	Ultrasound, leg NEC alone	3VZ30DA
	Ultrasound, scrotum alone	3QG30DA
	Ultrasound, thoracic cavity NEC alone	3GY30DA
	Ultrasound, veins of arm NEC with Doppler	3JU30DC
	Ultrasound, veins of leg NEC alone	3KR30DA

	Ultrasound, veins of leg NEC with color flow and Doppler	3KR30DC
	Ultrasound, veins of leg NEC with Doppler	3KR30DD
	Xray, abdominal cavity without contrast (with or without fluoroscopy)	3OT10VA
	Xray, ankle joint without contrast (e.g. plain film) (with or without fluoroscopy)	3WA10VA
	Xray, clavicle without contrast (with or without fluoroscopy)	3SM10VA
	Xray, elbow joint without contrast	3TM10VA
	Xray, facial bone structure without contrast (e.g. plain film)	3EI10VA
	Xray, femur without contrast (with or without fluoroscopy)	3VC10VA
	Xray, foot without contrast (e.g. plain film) (with or without fluoroscopy)	3WG10VA
	Xray, hand with wrist without contrast (e.g. plain film) (with or without fluoroscopy)	3UZ10VA
	Xray, hip joint without contrast (with or without fluoroscopy)	3VA10VA
	Xray, humerus without contrast (e.g. plain film) (with or without fluoroscopy)	3TK10VA
	Xray, joints of fingers and hand NEC without contrast (e.g. plain film) (with or without fluoroscopy)	3UL10VA
	Xray, kidney with ureter and bladder without contrast (e.g. plain film KUB)	3PS10VA
	Xray, knee joint without contrast (with or without fluoroscopy)	3VG10VA
	Xray, lung NEC without contrast (e.g. plain film) (with or without fluoroscopy)	3GT10VA
	Xray, mandible without contrast (e.g. plain film) (with or without fluoroscopy)	3EE10VA
	Xray, nose without contrast (e.g. plain film) (with or without fluoroscopy)	3ET10VA
	Xray, pelvis without contrast	3SQ10VA
	Xray, radius and ulna without contrast (e.g. plain film) (with or without fluoroscopy)	3TV10VA
	Xray, ribs without contrast (with or without fluoroscopy)	3SL10VA
	Xray, sacrum and coccyx without contrast	3SF10VA
	Xray, shoulder joint without contrast (with or without fluoroscopy)	3TA10VA
	Xray, soft tissue of head and neck without contrast (e.g. plain film) (with or without fluoroscopy)	3EQ10VA
	Xray, spinal vertebrae without contrast	3SC10VA
	Xray, sternum without contrast (with or without fluoroscopy)	3SK10VA
	Xray, thoracic cavity NEC without contrast (with or without fluoroscopy)	3GY10VA
	Xray, tibia and fibula without contrast (e.g. plain film) (with or without fluoroscopy)	3VQ10VA
	Xray, wrist joint without contrast (e.g. plain film) (with or without fluoroscopy)	3UB10VA
(6) Cognitive, Psychosocial and Sensory Therapeutic Interventions	Assessment, mental health and addictions for capacity for harm (to self or others)	6AA02CP
	Assessment, mental health and addictions for coping skills NEC	6AA02SK
	Assessment, mental health and addictions for other reason NEC	6AA02ZZ
	Counseling, mental health for substance addiction	6AA10AD
	Counseling, mental health for behavior	6AA10BE
	Counseling, mental health and addictions for concurrent disorders	6AA10CD
	Counseling, mental health for trauma NEC	6AA10CT

	Counseling, mental health for mood (e.g. anger, anxiety, relaxation, leisure)	6AA10MA
	Counseling, mental health for other reasons	6AA10ZZ
	Therapy, mental health crisis/trauma active listening	6AA30CTAA
	Assessment, motor and living skills for activities of daily living [ADL]	6VA02ZZ
(7) Other Healthcare Interventions	Counseling, promoting health and preventing disease for other reason	7SP10ZZ
(8) Therapeutic Interventions Strengthening the Immune System	Immunization (to prevent) diphtheria and tetanus by intramuscular [IM] injection of toxoid	8MK70HABK

Appendix 2: Contingency tables of EDAC classes and ED physician judgments with different groupings of the Potentially Avoidable class.

Potentially Avoidable ED Visits Excluded			
		EDAC	
		Appropriate for ED Only	Appropriate for Subacute Primary Care
ED Physicians	Appropriate for ED Only	73	3
	Appropriate for Subacute Primary Care	33	105

Potentially Avoidable ED Visits Classified as Avoidable			
		EDAC	
		Appropriate for ED Only	Appropriate for Subacute Primary Care
ED Physicians	Appropriate for ED Only	73	22
	Appropriate for Subacute Primary Care	33	192

Potentially Avoidable ED Visits Classified as Not Avoidable			
		EDAC	
		Appropriate for ED Only	Appropriate for Subacute Primary Care
ED Physicians	Appropriate for ED Only	92	3
	Appropriate for Subacute Primary Care	120	105

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CHAPTER FIVE

Comparing Epidemiological Classifications Designed to Identify Avoidable Emergency Department Visits

Summary

This chapter assesses the performance of the EDAC and seven other published classifiers in identifying avoidable ED visits against ED physician judgments. This study utilized primary data from chapter four and secondary administrative ED data from an academic hospital. Prevalence estimates for avoidable ED visits are calculated for each classification in a one-year period. Correlation, association, and precision analyses were conducted to compare the classifications with ED physician judgments. The classifications were ranked based on their accuracy in predicting avoidable ED visits.

I found prevalence of avoidable ED visits varied considerably amongst classifications between 0% and 25%. The EDAC demonstrates the highest correlation with ED physician judgments and exhibited the highest odds of correctly identifying avoidable ED visits. Conversely, traditionally used classifications performed poorly, showing low correlation and accuracy when compared to the standard.

More valid classifications consistently identified similar patients with a similar set of conditions as avoidable, including traumatic injuries, musculoskeletal disorders, mental and behavioral disorders, and respiratory diseases. This chapter's findings suggest the EDAC is preferred when assessing avoidable ED visits.

Abstract

Introduction: Available epidemiological classification systems provide varying estimates of avoidable emergency department (ED) visits. How these classifications relate to one-another and correlate with a reference standard has not been studied. We compared each classification's criteria for avoidable visits, prevalence estimation and correlation to independent ED physician judgement.

Methods: We conducted a retrospective cohort study using all administrative ED data from an academic hospital in Hamilton, Canada, between April 1, 2019, and March 31, 2020. Seven classifications were included that identified avoidable ED visits. We report the prevalence of patient characteristics for all avoidable ED visits. A total of 320 ED visits were randomly selected and randomly assigned to ED physicians who judged if the visit was avoidable or not. We used tetrachoric correlation and logistic regression analyses with 95% confidence intervals (CIs) to determine the magnitude of association, accuracy, sensitivity and specificity of each classification with ED physician judgement.

Results: The prevalence of avoidable ED visits ranged from 25.1% (Emergency Department Avoidability Scale; EDAC) to 0.3% (Sentinel Nonurgent Conditions; SNC) of 36,289 included ED visits. The EDAC had the highest correlation to the ED physician judgements (r = 0.6, 95% CI 0.53-0.67) and accuracy (82.8%), including high odds of identifying avoidable ED visits (OR=19.3; 95% CI10.6 – 35.3). Ambulatory Care Sensitive Conditions (ACSC) had the lowest correlation (r = -0.07) and accuracy (29.7%), followed by SNC and Family Practice Sensitive Conditions (FPSC). Classifiers with the highest accuracy did not include diagnostic fields as a criterion to classify avoidable ED visits. However, the most accurate classifiers identified similar clusters of

diagnostic groups as avoidable, including traumatic injuries, symptoms/signs/abnormal findings, diseases of the musculoskeletal system, mental and behavioural disorders, and diseases of the respiratory system.

Discussion: The EDAC was the most accurate classifier of avoidable ED visits in our study, with all other classifications showing moderate to no correlation with independent ED physician judgement. Caution should be used when interpreting prevalence estimates of avoidable ED visits from low performing classifications. Preference should be directed toward higher performing classifications.

Introduction

Emergency departments (EDs) play a crucial role in the health system by providing immediate medical attention to critically ill patients.[1] However, in practice, EDs have increasingly been providing care for patients with low acuity or non-emergent conditions over the past decade, instead of life-threatening emergencies.[1,2] As a result, patients seek ED treatment for conditions that could be managed by non-emergency clinicians in non-emergency settings, leading to what is known as avoidable ED visits.[3] These visits often involve patients seeking immediate consultation, diagnostic testing and medication administration to alleviate non-urgent symptoms, instead of seeking primary care.[4] Avoidable ED visits place a substantial burden on the health system (reducing limited ED resources, costing five times more than primary care for similar management), contribute to ED overcrowding, increase ED staff burnout and result in worse patient outcomes.[5–8]

Despite several initiatives aimed at reducing avoidable ED attendance, such as general practitioners performing home visits during out-of-office hours and increasing primary care clinics in close proximity to EDs, low acuity and avoidable ED visits continue to rise.[2,9] One of the challenges in addressing this issue is the lack of a reliable and valid classification algorithm that can identify and describe avoidable ED visits in administrative data.[10,11] Previously published classifications vary widely in their criteria and algorithms for classifying avoidable ED visits, leading to imprecise prevalence estimates that range from 5% to 90%.[10]

Although published ED classifications have been applied independently in research to identify avoidable ED visits, there have been few studies that evaluate the

differences between classification systems or compare them to a reference standard. Evaluating correlations between classifications and a reference standard would provide an objective assessment of the utility of each classification in accurately categorizing ED visits in administrative data. Presently, there is a severe lack of evidence to support the validity of previously published classifications that aim to identify avoidable ED visits. An examination is required to understand the validity of these classifications to support health policy stakeholders and epidemiologists in developing interventions to reduce avoidable ED visits.

Our objectives were to compare characteristics of patients identified as having avoidable ED visits using published epidemiological classification systems and to examine their measurement properties compared to independent ED physician judgement.

Methods

Study Design and Setting

We conducted a retrospective cohort study using administrative ED records from an academic hospital in Hamilton, Canada. We incorporated data from a study where ED physicians judged, independently, whether 320 randomly selected ED visits were avoidable or not avoidable. We adhered to the Reporting of Studies Conducted Using Observational Routinely-Collected Health Data (RECORD) statement for the reporting of results.[12]

Population

All patients triaged in the ED of the academic hospital between April 1, 2019, and March 31, 2020, were eligible for inclusion. All ED visits were included unless data were

missing to calculate a classification output. We selected the most recent 12-month period prior to the COVID-19 pandemic to eliminate the influence of change in care or practice for ED services and outcomes data.

Avoidable Emergency Department Classifications

We systematically searched the literature for published epidemiological classifications that identify avoidable or inappropriate ED visits. Classifications had to be able to identify avoidable ED visits using only administrative ED records, and be operationalized for general ED cohorts (i.e., not for a specific cohort, such as ED visits for only patients with cancer). Overall, we included seven epidemiological classifications for comparison and evaluation in this study: (1) the Emergency Department Avoidability Classification (EDAC)[11], (2) Ambulatory Care Sensitive Conditions (ACSC)[13], (3) the Canadian Triage and Acuity Scale (CTAS)[10], (4) Family Practice Sensitive Conditions (FPSC)[14], (5) Sentinel Nonurgent Conditions (SNC)[10], (6) the Australian Institute of Health and Welfare method (AIHW)[15] and (7) a method used by Hsia et al, 2017.[16] The EDAC is a classification with three classes: avoidable, potentially avoidable and not avoidable. To facilitate consistent analyses of avoidable ED visits across all classification, we included two divisions of the EDAC, first where only avoidable visits were considered avoidable ED visits, and second where avoidable and potentially avoidable visits were both considered avoidable ED visits.

Physician Ratings of Avoidable Emergency Department Visits

We used a cluster, randomized, single-blinded study design to examine the agreement between the EDAC and ED physician judgements to identify avoidable ED visits. These study data were used to (1) test whether ED physicians could act as a

reference standard for avoidable ED visits and (2) test the criterion validity of the EDAC. In the study, we grouped all ED visits at the academic hospital in 2019 into three clusters based on EDAC classes, and randomly selected 160 ED visits evenly between the clusters (54, 53, 53 respectively). Each ED visit was randomly assigned to ten participating staff ED physicians who judged whether the specified ED visit could have been safely managed in a non-ED setting. Each ED visit was judged independently and in duplicate by ED physicians, amassing 320 ED physician judgements overall. ED physicians were blinded to the cluster that the ED visit belonged to (avoidable, potentially avoidable, not avoidable), and had no knowledge of the EDAC's logic to classify avoidable ED visits. ED physician judgements were established as a reference standard prior to validity analyses of the EDAC.

Variables and Measurement

Patient characteristics of ED visits were measured and recorded at the time of visit. We selected patient characteristics to report prevalence for each classification based on prior literature and data availability. Age was collapsed into four groupings to represent clinically relevant age groups (0 to 17, 18 to 39, 40 to 64, 65 or greater). Triage acuity was assigned by the ED triage nurse following ED registration using the Canadian Triage and Acuity Scale (CTAS). CTAS is an ordinal scale that ranges from one to five; one indicating the most severe (resuscitation) and five the least severe (non-urgent).[17] Diagnostic categories were recorded using the Canadian Emergency Department Diagnostic Shortlist (CED-DxS).[18]

Statistical Analysis

We presented classification algorithm used for each classifier of avoidable ED visits. We tabulated the patient characteristics of patients with ED visits designated as avoidable using each classification system using frequency and precents (%). We compared the tetrachoric correlation (r) between the results of each classification and to independent ED physician judgements. We used logistic regression to estimate the odds ratio (OR) and 95% confidence interval (CI) for physician-judged avoidable ED visit for each classification system. We further estimated the overall accuracy, specificity and sensitivity for each classification system compared to the physician reference.

Ethics

This study was approved by the Hamilton Integrated Research Ethics Board (HiREB), review reference number 2022-14625-GRA.

Results

Table 1 shows each retrospective classifications' definition, variables used, algorithm, and classes of categorization. Most classifications contained more than one variable to classify ED visits as avoidable, with the EDAC contained the most variables (5). The most frequent variable was ED visit outcome (6), and the least were used variables were sex (1), physician consultation (1) and physician intervention (2). All classifications used a binary hierarchy to categorize avoidable ED visits except the EDAC which used a ternary hierarchy.

We included 36,289 ED records from the academic hospital, representing 56.7% of all ED visits in the study period. Most excluded ED visits had a missing physician intervention (n=27,286) and a small proportion had a missing triage score (n=476); all

other variables required to identify avoidable ED visits for each classification were complete. *Table 2* shows the frequency and proportion of all avoidable ED visits identified by the included classifications. The EDAC (avoidable and potentially avoidable) classified the highest quantity and proportion of avoidable ED visits (9,106, 25.1%); the SNC identified the least (105, 0.3%). Sex was evenly distributed amongst all classifications. ACSC and CTAS classified the highest proportion ED visits in the older age demographic, while Hsia and the EDAC (avoidable and potentially avoidable) had the highest proportion in the young adult age demographic. Nearly half of avoidable ED visits classified by ACSC were admitted to hospital (44.1%), the highest frequency and proportion of all classifications. ACSC and Hsia had the lowest proportion of ED visits that had an ED physician responsible for the patient's overall care in the ED. In contrast, the EDAC (avoidable), EDAC (avoidable and potentially avoidable) FPSC, SNC and AIHW had nearly all avoidable visits managed by an ED physician.

Figure 1 shows the proportion of triage acuity assignments for each epidemiological classification of avoidable ED visits. ACSC and Hsia both identified avoidable ED visits triaged as resuscitation (CTAS 1). ACSC, Hsia and FPSC included visits triaged as emergent (CTAS 2). AIHW, SNC, CTAS and EDAC (avoidable) contained only less urgent (CTAS 4) and non-urgent (CTAS 5) acuities; no classification had only one level of triage acuity.

Figure 2 shows the frequency of avoidable ED visits determined by the ED physicians and each classification in the random subsample of 320 ED visits. ED physicians identified the largest proportion of ED visits as avoidable (225). The EDAC (avoidable and potentially avoidable) identified a similar amount of avoidable ED visits

of (214). Classifications ACSC, FPSC and SNC identified minimal avoidable ED visits in the study sample (<3%).

Table 3 shows the correlation of each classification compared to independent ED physician judgement. Overall, the EDAC (avoidable and potentially avoidable) demonstrated the highest correlation (r = 0.60) and accuracy to identify avoidable ED visits (82.8%), with a wide margin to the next most accurate classifiers EDAC (avoidable) (61.6%), AIHW (59.7%) and CTAS (43.1%). ACSC, FPSC and SNC identified minimal avoidable ED visits (8, 8, 4 respectively), while the EDAC (avoidable and potentially avoidable) and CTAS identified the most (214, 108). Most classifications showed strong specificity (range from 50.0% to 100.0%) but wide variation in sensitivity (range from 14.2% to 89.7%) due to a high false negative rate for some classifications (i.e., an ED visit was determined not avoidable by the classification when ED physicians judged the visit was avoidable). AIHW had the highest odds of identifying avoidable ED visits to ED physicians (OR 71.2, 95% CI 9.8-520.1), with the EDAC (avoidable) (OR 26.8, 95% CI 8.3-87.3) and EDAC (avoidable and potentially avoidable) following (OR 19.3, 10.6-35.3). The lowest odds were reported in ACSC (OR 0.4, 95% CI 0.1-1.7) and Hsia (OR 1.7, 95% CI 0.9-3.2); FPSC and SNC did not identify enough ED visits to compute an OR.

Table 4 displays the top five diagnostic categories of all avoidable ED visits at the academic hospital in 2019, arranged in descending order of accuracy. The most accurate classifications identified the top five diagnostic categories. Categories of diseases of the respiratory system, traumatic injury and symptoms, signs and abnormal findings were the top three most common, followed by diseases of the musculoskeletal

system and connective tissue, and mental and behavioural disorders. A distention was observed between the higher ranked and lower classifications, there is very little similarity in diagnostic categories. The two most inaccurate classifications (SNC, ACSC) did not identify a fifth diagnostic category.

Discussion

The EDAC most accurately classified avoidable ED visits based on independent ED physician judgement. All other epidemiological classifications showed moderate-to-no correlation with independent ED physician judgement. Classification had widely discrepant prevalence estimates of avoidable ED visits, demonstrating the critical need to understand each classification's measurement properties prior to use.

We showed the EDAC (analyzed as two binary classifications) were the most correlated to ED physician judgements when determining ED visits that could have been managed by non-ED care. The correlation coefficients were consistent with the research examining the criterion validity of the EDAC, which reported a higher correlation when the EDAC was used as a ternary classifier. ACSC exhibited the worst performance in our study, consistent with literature that has questioned its utility for identing avoidable ED visits.[10,19] It is important to note that though ACSC has been commonly used to infer avoidable ED visits, its intended purpose was to identify ED visits that could have been prevented with robust primary preventive care not the avoidability upon presentation to the ED.[20] ACSCs high utilization in research to study avoidable ED visits may be due a lack of alterative published classifications and to remain consistent with previous literature. The prevalence of avoidable ED visits in an academic hospital is consistent with previous literature that examined population-based

data for FPSC and CTAS, but was higher for Hsia's method and lower for ACSC.[16,19,21,22] We found sizable heterogeneity in classification criteria algorithm used to identify avoidable ED visits, consistent with previous literature.[10]

The EDAC was the most accurate classifier in our study to identify avoidable ED visits. Classifications with poor accuracy were due to low sensitivity to identify ED visits judged by physicians as avoidable. Many classifications showed high specificity. However, this result is likely an overestimate of the classification's true specificity as some classifications (ACSC, FPSC, SNC) identified a negligible number of ED visits as avoidable and had very poor sensitivity. The classifications that identified small quantities of avoidable ED visits and showed the lowest accuracy. These classifications incorporated diagnoses into their classification algorithm, indicating the limitations of relaying on diagnostics to determine ED visit avoidability. Classifying ED visits based on low triage acuity alone outperformed some previously established classifications that primarily relied on diagnostics, potentially distorted our understanding of which ED visits were avoidable and explain the wide range of prevalence estimates. Additionally, the most inaccurate classifications face validity is a subject for scrutiny, identifying ED visits with high triage acuities (indicating need for emergency care and medicine), having a non-ED physician be responsible for the visit in the ED, and/or visits that were admitted to the receiving hospital for further care. These patient characteristics, in addition to our study's results, do not support the application of these classifications to detect ED visits that were avoidable or manageable by non-ED care.

We observed a clear distinction between classifications with higher accuracy compared to classifications with low accuracy in diagnostic categories of avoidable ED

visits. The most accurate classifiers identified the same diagnostic categories despite using different criteria algorithms, which were generally dissimilar from diagnostic categories of the least accurate classifiers. These results illustrate the least accurate classifications are identifying different patient populations compared to accurate classifications, which may explain why interventions informed by these classifications are ineffective. Classifications that analyze specific patient cohorts (i.e., ACSC, FPSC) may be targeting patient groups that are highly specific, which is inappropriate to generalize as a broad classifier for all avoidable ED visits. We postulate that poor performing classifications have been used in research of avoidable ED visit due to a misunderstanding of their intended purpose. For example, research has called into question the application of ACSC in ED epidemiology, suggesting a more specific and refined definition is warranted required, a gap potentially addressed by the EDAC.[20,23] Given the low performance and highly specific nature classifications for a small cohort of patient, these classifications should be avoided as broad identifiers of avoidable ED visits.

While ED utilization continues to grow without equitable increases in ED resources or centres, health policy should identify opportunities to implement interventions that decrease avoidable ED visits. The top performing classification of this study, the EDAC, could be integrated into population-based analyses to understand gaps in community care that could reduce avoidable ED visits. Given the EDAC requires only administrative data to identify retrospective avoidable ED visits, this EDAC can be integrated into ED datasets with relative simplicity. Health policy stakeholders should be cautious when classifications with low, accuracy and precision are used to

identify and describe avoidable ED visits, as each has a different definition and may lead to differing conclusions about prevalence of ED avoidability.

Ultimately, a single classification may not be adequate to identify all avoidable ED visits, highlighting the complexity and multidimensionality of categorizing avoidable ED visits in administrative data. Additional research should further our understanding of avoidable ED visits by incorporating additional variables into classifications that are not captured in previous research to improve correlation and precision with ED physicians. Further investigation is warranted to explore associations of avoidable visits with patient-level and population-level characteristics to inform changes that could better optimize ED's care, such as neighborhoods, socioeconomic status, marginalized groups, access to primary care and urbanism.

Limitations

Due to the inherent nature of secondary data, we were only able to assess patient characteristics collected in ED administrative data. We excluded a portion of ED visits due to their missingness of the main ED intervention from the ED chart record. However, we contend our results are reflective of the entire ED as the main intervention was missing randomly from ED visits, and not for any specific patient cohort, and our study size was sufficiently large. We analyzed precision of the classifications in a substantial sample of ED visits judged by ED physicians. We acknowledge the ED physician results were studied for validity research and not necessarily for testing research. The classifications of this study serve as proxies to understand patients that are cared for in the ED when alternative sub-acute primary care was suitable, but does not appraise whether the ED visit was necessary. We included commonly used

classifications in this study, though other classifications may exist that are not generally known in the scientific community, supporting the need for a systematic review of the literature. Lastly, one academic hospitals' ED data was used in this study, potentially limiting the generalizability of our results to other EDs where ED physicians may have differing interpretations of an avoidable ED visit.

Conclusion

The EDAC showed the highest measures of precision to identify avoidable ED visits, outperforming other commonly used classifications. Large heterogeneity was found between epidemiological classifications in definitions, classifying algorithms, discriminative accuracy and prevalence estimation. Interventions aimed at reducing avoidable ED visits could be strengthened by use of information provided by the most accurate classifiers of this study. Health policy stakeholders should understand the limitations and potential inaccuracies when relying on older classifications to delineate avoidable ED visits.

Tables and Figures

Table 1: Definition, criteria algorithm and classes of epidemiological classifications that retrospectively identify avoidable ED visits.

Classification	Definition	Variables to Classify Avoidable ED Visits	Classification Algorithm	Exclusion Criteria	Classes
Ambulatory Care Sensitive Conditions (ASCS)[14]	Health conditions for which effective and timely outpatient care could have prevented the risk of hospitalization by minimizing or delaying the onset of the illness, controlling an acute illness episode, or addressing a chronic condition or disease	1. Age 2. Sex 3. Diagnosis 4. ED visit outcome	Under 75 years, diagnoses for conditions: grand mal status or other epileptic convulsions, chronic lower respiratory diseases, asthma, diabetes, heart failure, pulmonary edema, hypertension, angina*, sex is recorded as male or female	Death in ED, newborn, stillborn or cadaveric donor records	Binary (Avoidable, Not Avoidable)
Australian Institute of Health and Welfare (AIHW)[16]	Health conditions that may have potentially been prevented through the delivery of suitable non-hospital services within the community	1. Triage acuity 2. ED visit outcome	Australasian Triage Scale 4 or 5 (attuned to CTAS as 4 or 5)	Not arrived by ambulance, police or correctional vehicle. Not admitted, referred to another hospital and did not die	Binary (Avoidable, Not Avoidable)
Canadian Triage and Acuity Scale (CTAS)[10]	ED visits that had a less urgent or non-urgent triage acuity	1. Triage acuity	CTAS 4 or 5	None	Binary (Avoidable, Not Avoidable)
Emergency Department Avoidability Classification (EDAC)[12]	ED visits that could or potentially could have been managed by subacute primary care	1. Age 2. Triage acuity 3. Physician intervention 4. Physician consultation 5. ED visit outcome	Age ≥18 to 70 years, CTAS 3-5, list of physician interventions*, discharged from ED	Consultation with physician specialist (non-ED physician)	Ternary (Avoidable, Potentially Avoidable, Not Avoidable)
Family Practice Sensitive Conditions (FPSC)[15]	ED visits for health conditions that could have been appropriately managed at a family physician office, as addressing these conditions would enable proper follow-up and result for improved patient outcomes	1. Diagnosis 2. ED visit outcome	List of diagnoses*, discharged from ED	Scheduled ED visit, death in ED	Binary (Avoidable, Not Avoidable)
Hsia, 2017[17]	Discharged ED visits that did not require any	1. Physician intervention	No diagnostic tests, procedures or	Hospital admission from	Binary (Avoidable,

	diagnostic tests, procedures or medication	2. ED visit outcome	medication, discharged from ED	ED, transferred to another hospital, died in ED, dead on arrival to ED.	Not Avoidable)
Sentinel Nonurgent Conditions (SNC)[10]	ED visits for conditions that could be addressed by nonhospital, alternative primary health care settings	1. Age 2. Triage acuity 3. Diagnosis 4. ED visit outcome	Age > 1 and <75 years, list of diagnoses*, CTAS 4 or 5	Scheduled ED visit, hospital admission from ED, out of province patients	Binary (Avoidable, Not Avoidable)
Notes: CTAS = Canadian Triage and Acuity Scale, ATS = Australasian Triage Scale, ED = Emergency Department. *List of intervention and diagnostic codification shown in *Appendix 2*.					

Table 2: Frequency and proportions of avoidable ED visits by classification, April, 2019 to March 31, 2020

Characteristic	All Visits	EDAC (avoidable)	EDAC (avoidable & potentially avoidable)	ACSC	CTAS	FPSC	SNC	AIHW	Hsia, 2017
Emergency Department Visits, Total	36,289	1,979	9,106	1,359	3,699	1,193	105	2,788	5,031
Proportion of All ED Visits, %	-	5.5	25.1	3.7	10.2	3.3	0.3	7.7	13.9
Sex									
Male	16,858 (46.5)	1,007 (50.9)	4,453 (48.9)	627 (46.1)	1,796 (48.6)	529 (44.3)	54 (51.4)	1,379 (49.5)	2,452 (48.7)
Female	19,390 (53.4)	967 (48.9)	4,640 (51.0)	732 (53.9)	1,898 (51.3)	664 (55.7)	51 (48.6)	1,405 (50.4)	2,554 (50.8)
Unknown/Other	41 (0.1)	5 (0.3)	13 (0.1)	0 (0.0)	5 (0.1)	0 (0.0)	0 (0.0)	4 (0.1)	25 (0.5)
Age, years									
0-17	501 (1.4)	0 (0.0)	0 (0.0)	8 (0.6)	83 (2.2)	33 (2.8)	1 (1.0)	83 (3.0)	2 (0.0)
18-39	12,848 (35.4)	1,048 (53.0)	4,622 (50.8)	198 (14.6)	1,518 (41.0)	493 (41.3)	50 (47.6)	1,318 (47.3)	3,314 (65.9)
40-64	12,480 (34.4)	803 (40.6)	3,831 (42.1)	674 (49.6)	1,240 (33.5)	452 (37.9)	45 (42.9)	940 (33.7)	1,481 (29.4)
65-108	10,460 (28.8)	128 (6.5)	653 (7.2)	479 (35.2)	858 (23.2)	215 (18.0)	9 (8.6)	447 (16.0)	234 (4.7)
Triage, CTAS									
1	453 (1.2)	0 (0.0)	0 (0.0)	51 (3.8)	0 (0.0)	2 (0.2)	0 (0.0)	0 (0.0)	44 (0.9)
2	12,436 (34.3)	0 (0.0)	0 (0.0)	556 (40.9)	0 (0.0)	262 (22.0)	0 (0.0)	0 (0.0)	2,582 (52.4)
3	19,701 (54.3)	0 (0.0)	7,127 (78.3)	675 (49.7)	0 (0.0)	670 (56.2)	0 (0.0)	0 (0.0)	2,071 (42.0)
4	2,614 (7.2)	1,348 (68.1)	1,348 (14.8)	60 (4.4)	2,614 (70.7)	151 (12.7)	59 (56.2)	1,854 (66.5)	161 (3.3)
5	1,058 (2.9)	631 (31.9)	631 (6.9)	17 (1.3)	1,085 (29.3)	108 (9.1)	46 (43.8)	934 (33.5)	73 (1.5)
Mode of Arrival									
Paramedic/Ambulance	11,308 (31.2)	274 (13.8)	1,779 (19.5)	675 (49.7)	755 (20.4)	116 (9.7)	13 (12.4)	0 (0.0)	1,382 (27.5)
Walk-In	24,981 (68.8)	1,705 (86.2)	7,327 (80.5)	684 (50.3)	2,944 (79.6)	1,077 (90.3)	92 (87.6)	2,788 (100.0)	3,649 (72.5)
Visit Outcome									
Discharged	26,838 (74.0)	1,979 (100.0)	9,106 (100.0)	734 (54.0)	3,327 (89.9)	1,193 (100.0)	100 (95.2)	2,741 (98.3)	5,031 (100.0)
Admitted	8,101 (22.3)	0 (0.0)	0 (0.0)	599 (44.1)	272 (7.4)	0 (0.0)	2 (1.9)	0 (0.0)	0 (0.0)
Died in ED	48 (0.1)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)
Other	1,302 (3.6)	0 (0.0)	0 (0.0)	26 (1.9)	100 (2.7)	0 (0.0)	3 (2.9)	47 (1.7)	0 (0.0)
Most Reasonable Provider[a,b]									
Emergency Medicine	25,256 (69.9)	1,978 (99.9)	9,104 (100.0)	756 (55.6)	3,280 (88.7)	1,182 (99.1)	103 (98.1)	2,689 (96.4)	2,818 (56.0)
Cardiology	143 (0.4)	0 (0.0)	0 (0.0)	19 (1.4)	1 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)
General Surgery	992 (2.7)	0 (0.0)	0 (0.0)	0 (0.0)	33 (0.9)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)
Internal Medicine	3,782 (10.4)	0 (0.0)	0 (0.0)	401 (29.5)	121 (3.3)	0 (0.0)	2 (1.9)	0 (0.0)	0 (0.0)
Nephrology	706 (1.9)	0 (0.0)	0 (0.0)	72 (5.3)	16 (0.4)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)
Orthopedic Surgery	384 (1.1)	0 (0.0)	0 (0.0)	6 (0.4)	24 (0.6)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)
Psychiatry	3,703 (10.2)	1 (0.1)	1 (0.0)	4 (0.3)	177 (4.8)	11 (0.9)	0 (0.0)	93 (3.3)	2,212 (44.0)
Respirology	198 (0.5)	0 (0.0)	0 (0.0)	75 (5.5)	1 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)
Other	1,125 (3.1)	0 (0.0)	1 (0.0)	26 (1.9)	46 (1.2)	0 (0.0)	0 (0.0)	6 (0.3)	1 (0.0)

Notes: CTAS = Canadian Triage and Acuity Scale, CED-DxS = Canadian Emergency Department Diagnostic Shortlist

[a] The provider who has primary responsibility for the patient at the time of ED visit.
[b] Other includes: Critical Care Medicine, Gastroenterology, Obstetrics & Gynecology, Ophthalmology, Plastic Surgery, RN Nursing, Thoracic Surgery, Urology, Vascular Surgery.

Figure 1: Triage acuity for ED visits classified as avoidable, by Classification.

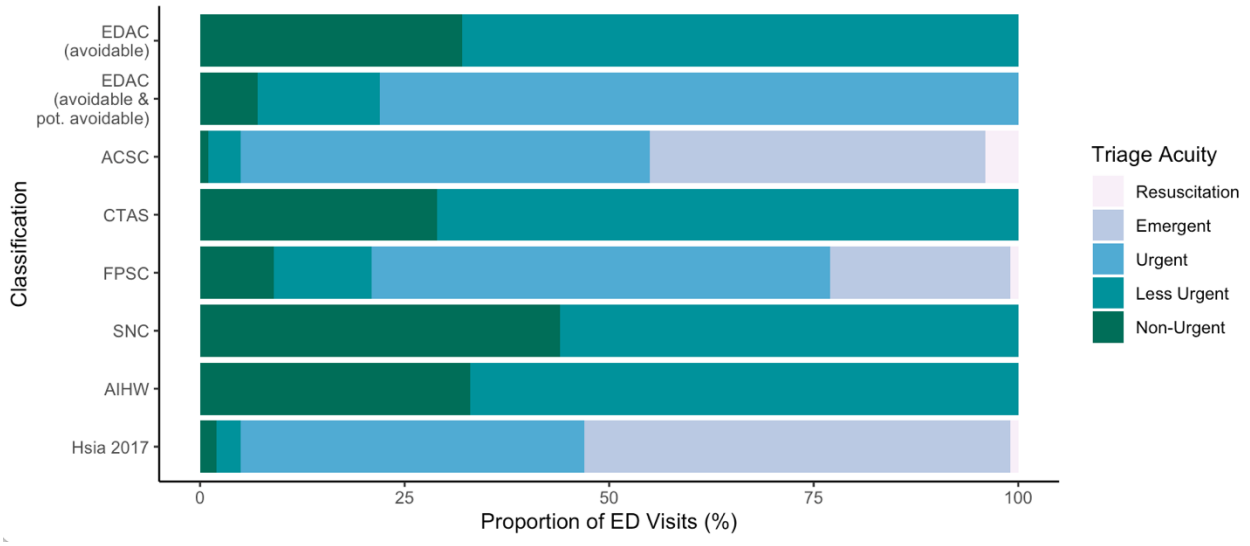

Figure 2: Avoidable ED visits determined by ED physicians and epidemiological classifications, (N= 320).

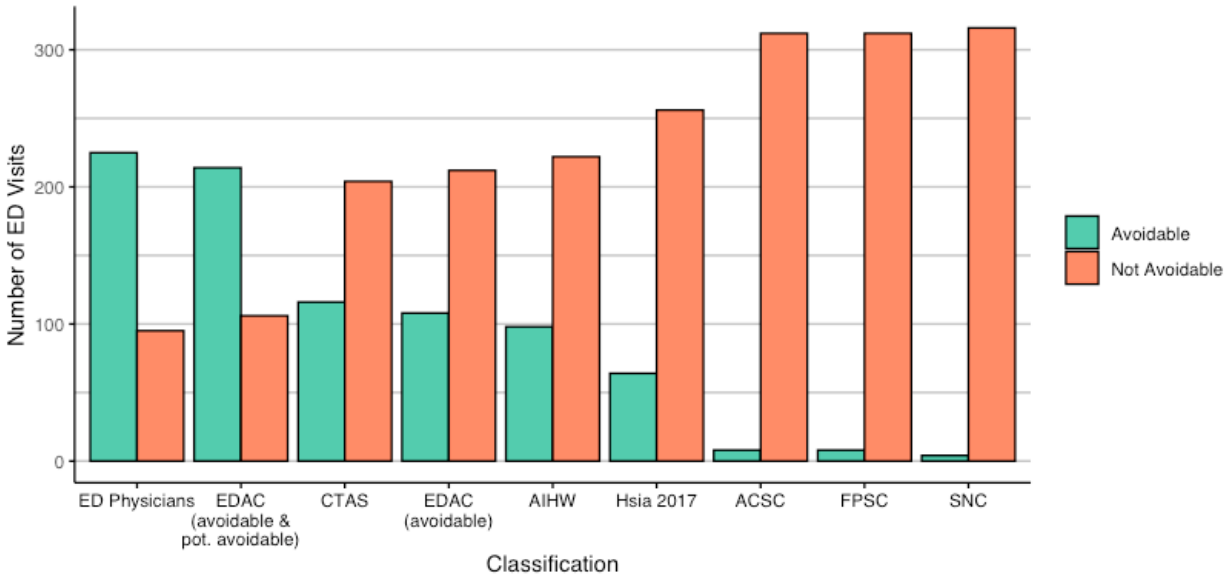

Table 3: Tetrachoric correlation and precision of ED classifications identifying avoidable ED visits compared to ED physician judgement

Classification	Correlation (95% CI)	Odds Ratio (95% CI)	Accuracy (%)	Sensitivity (%)	Specificity (%)
EDAC (avoidable)	0.42 (0.33 – 0.51)	26.8 (8.3-87.3)	61.6	43.4	97.2
EDAC (avoidable and potentially avoidable)	0.60 (0.53 – 0.67)	19.3 (10.6-35.3)	82.8	89.7	68.9
ACSC	-0.07 (-0.18 – 0.04)	0.4 (0.1-1.7)	29.7	29.2	50.0
CTAS	0.45 (0.36 – 0.53)	2.6 (1.1-6.1)	43.1	14.2	94.0
FPSC[a]	0.10 (-0.01 – 0.21)	-	32.2	30.4	100.0
SNC[a]	0.07 (-0.04 – 0.18)	-	30.9	30.1	100.0
AIHW	0.42 (0.32 – 0.50)	71.2 (9.8 – 520.1)	59.7	42.3	99.0
Hsia, 2017	0.28 (0.18 – 0.28)	1.7 (0.9 – 3.2)	40.9	31.6	78.1
[a] Insufficient cell sizes to compute an odds ratio					

Table 4: Most common diagnostic categories of classified avoidable ED visits.

Accuracy Rank	Classification	Top 5 Diagnostic Categories[a]				
		1	2	3	4	5
1	EDAC (avoidable and potentially avoidable)	Traumatic Injury	Symptoms, Signs, and Abnormal Findings	Diseases of the MSK System and Connective Tissue	Mental and Behavioural Disorders	Diseases of the Respiratory System
2	EDAC (avoidable)	Traumatic Injury	Symptoms, Signs, and Abnormal Findings	Mental and Behavioural Disorders	Diseases of the Respiratory System	Diseases of the MSK System and Connective Tissue
3	AIHW	Traumatic Injury	Symptoms, Signs, and Abnormal Findings	Mental and Behavioural Disorders	Diseases of the MSK System and Connective Tissue	Diseases of the Respiratory System
4	CTAS	Traumatic Injury	Symptoms, Signs, and Abnormal Findings	Diseases of the MSK System and Connective Tissue	Mental and Behavioural Disorders	Diseases of the Respiratory System
5	Hsia, 2017	Mental and Behavioural Disorders	Symptoms, Signs, and Abnormal Findings	Injury, Poisoning and Other	Contact with Health Services	Traumatic Injury
6	FPSC	Diseases of the Respiratory System	Diseases of the MSK System and Connective Tissue	Symptoms, Signs, and Abnormal Findings	Contact with Health Services	Diseases of the Nervous System
7	SNC	Diseases of the Respiratory System	Diseases of the Genitourinary System	Diseases of the Eye, Adnexa, Ear and Mastoid	Infectious and Parasitic Diseases	-
8	ASCS	Diseases of the Respiratory System	Diseases of the Circulatory System	Endocrine, Nutritional and Metabolic Diseases	Diseases of the Nervous System	-

[a] Categories organized by the Canadian Emergency Department Diagnostic Shortlist (CED-DxSIS)

Supplement Data

Appendix 1: Diagnoses and Interventions Codes used in Classifications.

Classification	List of Diagnoses (ICD-10)	List of Physician Interventions (CCI)
EDAC	-	1ET13CAZ9, 1ET13CAGX, 1ET13CANP, 1PM52CATS, 1NQ57CJ, 1VG03JASR, 1TA03JASQ ,1NF53CATS, 1KX53HAFT, 1PM54CATS, 1NF54HATS, 1GZ32CAMY, 1LZ35HHC7, 1NQ35CAZ9, 1GZ35CAR3, 1ZZ35HAC1, 1ZZ35HAK4, 1ZZ35HAN1, 1ZZ35HAP2, 1NP73JH, 1UB73JA, 1YE80LA, 1YA80LA, 1YA80JAFF, 1YA80LAW4, 1YS80LA, 1YT80LA, 1YT80JAFF, 1YC80LA, 1YF80LA, 1YF80JAFF, 1YF80LAW4, 1YW80LA, 1YB80LA, 1YB80JAFF, 1YB80LAW4, 1YU80LA, 1YU80JAFF, 1YU80LAW4, 1YV80LA, 1YV80JAFF, 1YD80LA, 2ZZ02ZZ, 2HZ24JAXJ, 2PM58VE, 2PM58VD, 2GZ58TA, 2NQ70CA, 2ZZ13RA, 3OT30DA, 3OT30LA, 3KG30DC, 3PM30DA, 3RZ30DA, 3RZ30LA, 3PC30DA, 3VZ30DA, 3QG30DA, 3GY30DA, 3JU30DC, 3KR30DA, 3KR30DC, 3KR30DD, 3OT10VA, 3WA10VA, 3SM10VA, 3TM10VA, 3EI10VA, 3VC10VA, 3WG10VA, 3UZ10VA, 3VA10VA, 3TK10VA, 3UL10VA, 3PS10VA, 3VG10VA, 3GT10VA, 3EE10VA, 3ET10VA, 3SQ10VA, 3TV10VA, 3SL10VA, 3SF10VA, 3TA10VA, 3EQ10VA, 3SC10VA, 3SK10VA, 3GY10VA, 3VQ10VA, 3UB10VA, 6AA02CP, 6AA02SK, 6AA02ZZ, 6AA10AD, 6AA10BE, 6AA10CD, 6AA10CT, 6AA10MA, 6AA10ZZ, 6AA30CTAA, 6VA02ZZ, 7SP10ZZ, 8MK70HABK
ACSC	G40, G41, J41, J42, J43, J44, J47, J45, E10.0^^, E10.1^^, E10.63, E10.9^^, E11.0^^, E11.1^^, E11.63, E11.9^^, E13.0^^, E13.1^^, E13.63, E13.9^^, E14.0^^, E14.1^^, E14.63, E14.9^^ When J44 is recorded as secondary diagnosis: J10.0, J11.0, J12-J16, J18, J20, J21, J22 When cardiac procedures are not reported* I50, J81, I10.0, I10.1, I11, I20, I23.82, I24.0, I24.8, I24.9 *List of cardiac procedure codes2 for exclusion (CCI): 1HA58, 1HA80, 1HA87, 1HB53, 1HB54, 1HB55, 1HB87, 1HD53, 1HD54, 1HD55, 1HH59, 1HH71, 1HJ76, 1HJ82, 1HM57, 1HM78, 1HM80, 1HN71, 1HN80, 1HN87, 1HP76, 1HP78, 1HP80, 1HP82, 1HP83, 1HP87, 1HR71, 1HR80, 1HR84, 1HR87, 1HS80, 1HS90, 1HT80, 1HT89, 1HT90, 1HU80, 1HU90, 1HV80, 1HV90, 1HW78, 1HW79, 1HX71, 1HX78, 1HX79, 1HX80, 1HX83, 1HX86, 1HX87, 1HY85, 1HZ53 rubric (except 1HZ53LAKP), 1HZ54, 1HZ55 rubric (except 1HZ55LAKP), 1HZ56, 1HZ57, 1HZ59, 1HZ80, 1HZ85, 1HZ87, 1IF83, 1IJ50, 1IJ54GQAZ, 1IJ55, 1IJ57, 1IJ76, 1IJ80	-
FPSC	A07, A56, A59, A63, A64, A74, B06, B07, B08, B09, B30, B35, B36, B37, B65, B80, B82, B83, B85, B86, C44, D04, D16, D17, D22, D23, D24, D29, D36, E07, E29, E53, E61, E78, F40, G43, G56, H00, H01, H04, H10, H11, H15, H18, H43, H57, H60, H61, H65, H66, H68, H69, H72, H73, H74, H91, H92, H93, I78, J00, J01, J02, J06, J30, J31, J32, J34, K00, K01, K02, K04, K05, K07, K08, K13, L01, L20, L21, L22, L23,	-

	L24, L25, L28, L29, L30, L42, L43, L50, L55, L57, L60, L63, L65, L70, L71, L72, L73, L74, L81, L82, L84, L85, L90, L91, L92, M18, M20, M22, M53, M67, M70, M75, M76, M77, M85, M92, M94, N34, N60, N62, N63, N64, N72, N89, N91, N94, N97, O92, P37, P78, Q10, Q66, R05, R21, R30, R36, R71, Z00, Z02, Z09, Z11, Z12, Z13, Z20, Z23, Z24, Z25, Z26, Z27, Z29, Z30, Z31, Z32, Z41, Z45, Z46, Z47, Z48, Z51, Z53, Z56, Z64, Z70, Z76	
SNC	A740, B309, H100, H101, H102, H103, H104, H105, H108, H109, H130, H131, H132, H133, N300, N301, N302, N303, N304, N308, N309, N330, N390, H650, H651, H652, H653, H654, H659, H660, H661, H662, H663, H664, H669, H670, H671, H678, J00, J010, J011, J012, J013, J014, J018, J019, J028, J029, J038, J039, J040, J041, J060, J068, J069, J310, J311, J312, J320, J321, J322, J323, J324, J328, J329, J350, J351, J352, J353, J358, J359, J399	-
Notes: ICD-10 = International Classification of Diseases, 10th Edition, CCI = Canadian Classification of Health Interventions		

Table 2: The RECORD statement – checklist of items, extended from the STROBE statement, that should be reported in observational studies using routinely collected health data.

	Item No.	STROBE items	Location in manuscript where items are reported	RECORD items	Location in manuscript where items are reported
Title and abstract					
	1	(a) Indicate the study's design with a commonly used term in the title or the abstract (b) Provide in the abstract an informative and balanced summary of what was done and what was found	(a) Pg 1 (b) Pg 1	RECORD 1.1: The type of data used should be specified in the title or abstract. When possible, the name of the databases used should be included. RECORD 1.2: If applicable, the geographic region and timeframe within which the study took place should be reported in the title or abstract. RECORD 1.3: If linkage between databases was conducted for the study, this should be clearly stated in the title or abstract.	(1.1) Pg 1 (1.2) Pg 1 (1.3) N/A
Introduction					
Background rationale	2	Explain the scientific background and rationale for the investigation being reported	Pg 1,2		
Objectives	3	State specific objectives, including any prespecified hypotheses	Pg 3		

Methods					
Study Design	4	Present key elements of study design early in the paper	Pg 3		
Setting	5	Describe the setting, locations, and relevant dates, including periods of recruitment, exposure, follow-up, and data collection	Pg 3		
Participants	6	*(a) Cohort study*- Give the eligibility criteria, and the sources and methods of selection of participants. Describe methods of follow-up *Case-control study*- Give the eligibility criteria, and the sources and methods of case ascertainment and control selection. Give the rationale for the choice of cases and controls *Cross-sectional study*- Give the eligibility criteria, and the sources and methods of selection of participants *(b) Cohort study*- For matched studies, give matching criteria and number of exposed and unexposed *Case-control study*- For matched studies, give matching criteria and the number of controls per case	(a) Pg 3,4 (b) N/A	RECORD 6.1: The methods of study population selection (such as codes or algorithms used to identify subjects) should be listed in detail. If this is not possible, an explanation should be provided. RECORD 6.2: Any validation studies of the codes or algorithms used to select the population should be referenced. If validation was conducted for this study and not published elsewhere, detailed methods and results should be provided. RECORD 6.3: If the study involved linkage of databases, consider use of a flow diagram or other graphical display to demonstrate the data linkage process, including the number of individuals with linked data at each stage.	(6.1) Pg 4,8,9, Appendix 1 (6.2) 4,5 (6.3) N/A
Variables	7	Clearly define all outcomes, exposures, predictors potential confounders, and effect modifiers. Give diagnostic criteria, if applicable.	Pg 5	RECORD 7.1: A complete list of codes and algorithms used to classify exposures, outcomes, confounders, and effect modifiers should be provided. If these cannot be reported, an	Pg 5,8,9, Appendix 1

				explanation should be provided.	
Data sources/ measurement	8	For each variable of interest, give sources of data and details of methods of assessment (measurement). Describe comparability of assessment methods if there is more than one group	Pg 5		
Bias	9	Describe any efforts to address potential sources of bias	Pg 3,4		
Study size	10	Explain how the study size was arrived at	Pg 3-5		
Quantitative variables	11	Explain how quantitative variables were handled in the analyses. If applicable, describe which groupings were chosen, and why	Pg 5		
Statistical methods	12	(a) Describe all statistical methods, including those used to control for confounding (b) Describe any methods used to examine subgroups and interactions (c) Explain how missing data were addressed (d) *Cohort study*- If applicable, explain how loss to follow-up was addressed *Case-control study*- If applicable, explain how matching of cases and controls was addressed *Cross-sectional study*- If applicable, describe analytical methods taking account of sampling strategy (e) Describe any sensitivity	(a) Pg 6 (b) Pg 6 (c) Pg 6 (d) N/A (e) N/A		

		analyses			
Data access and cleaning methods		..		RECORD 12.1: Authors should describe the extent to which the investigators had access to the database population used to create the study population.	(12.1) Pg 18
				RECORD 12.2: Authors should provide information on the data cleaning methods used in the study.	(12.2) Pg 5
Linkage		..		RECORD 12.3: State whether the study included person-level, institutional-level, or other data linkage across two or more databases. The methods of linkage and methods of linkage quality evaluation should be provided.	(12.3) N/A
Results					
Participants	13	(a) Report the numbers of individuals at each stage of the study (*e.g.*, numbers potentially eligible, examined for eligibility, confirmed eligible, included in the study, completing follow-up, and analysed) (b) Give reasons for non-participation at each stage. (c) Consider use of a flow diagram	(a) Pg 8, 10 (b) N/A (c) N/A	RECORD 13.1: Describe in detail the selection of the persons included in the study (*i.e.,* study population selection) including filtering based on data quality, data availability and linkage. The selection of included persons can be described in the text and/or by means of the study flow diagram.	(13.1) Pg 8, 10
Descriptive data	14	(a) Give characteristics of study participants (*e.g.*, demographic, clinical, social) and information on exposures and potential confounders (b) Indicate the number of participants with missing	(a) Pg 8,9 (b) Pg 8,9		

		data for each variable of interest (c) *Cohort study*- summarise follow-up time (*e.g.*, average and total amount)			
Outcome data	15	*Cohort study*- Report numbers of outcome events or summary measures over time *Case-control study*- Report numbers in each exposure category, or summary measure of exposure *Cross-sectional study*- Report numbers of outcome events or summary measures	8,9		
Generalisability	21	Discuss the generalisability (external validity) of the study results	Pg 15		
Other Information					
Funding	22	Give the source of funding and the role of the funders for the present study and, if applicable, for the original study on which the present article is based	Pg 18		
Accessibility of protocol, raw data, and programming code		..		RECORD 22.1: Authors should provide information on how to access any supplemental information such as the study protocol, raw data, or programming code.	(22.1) Pg 18

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CHAPTER SIX

Discussion

Introduction

Patient classifications for defining avoidable ED visits have been unreliable due to differing criteria, lack of validity testing, and overall misuse. My thesis contributes a novel epidemiological patient classification that identifies avoidable ED visits in administrative data. In developing the EDAC, I evaluated patient characteristics and physician interventions to derive a classification algorithm grounded in content and face validity. The EDAC was tested against a criterion standard to determined external validity and therefore, its generalizability as a classifier for broad implementation in health care research.

The first two studies of this thesis involved modified Delphi consensus analyses of ED physician interventions and patient characteristics available in administrative ED data. The first consensus study determined 103 of 150 physician interventions could be conducted in non-ED subacute care centres. The second consensus study found four of nine patient characteristics were useful to classify patients that could have been safely managed by non-ED care. The EDAC's algorithm was constructed from these results, grounded in strong consensus from emergency and family medicine physicians. These studies set the foundation for validity testing in the proceeding chapters.

The third study of my thesis found that patient characteristics associated with ED physician interventions suitable for non-ED care were similar to the characteristics identified in the second consensus study. The results of this study showed that the patient characteristics associated with the interventions were the same as those

identified by emergency and family medicine physicians. This study demonstrated that my foremost contribution to the classification criteria, inclusion of ED physician interventions, did represent the patient population it was meant to represent, according to physicians. This study provided evidence of face validity for the classification criteria.

The fourth study examined the EDAC's classification criteria against a criterion standard of ED physicians in ED data. This study established ED physician judgments were a reliable reference for comparison to the EDAC. This analysis found the EDAC was highly correlated with the reference standard and exhibited high accuracy to specify avoidable ED visits. This study contributed evidence the EDAC had criterion validity, a crucial component for the generalizability of the EDAC to new ED settings. This study was the first to evaluate the validity of a patient classification against a blinded panel of ED physicians to determine whether a retrospective ED visit could have been managed safely by non-ED care.

The fifth study compared published classifications to ED physician judgments when identifying avoidable ED visits, and to describe the accuracy of their prevalence estimates. The analyses revealed the EDAC was the most accurate classifier of avoidable ED visits and highly correlated with ED physician judgments compared to all other classifications. This study was the first to evaluate and compare all readily known patient classifications that use Canadian administrative ED data to delineate avoidable ED, including the EDAC, which was developed in this thesis.

Comparison to Relevant Literature

Each study in this thesis has its own set of comparisons to the literature, as noted in their respective chapters. However, there are additional comparisons to the

literature worth noting. First, assembling items for an epidemiological patient classification is not novel in the field, but the EDAC was uniquely developed around ED physician interventions instead of traditional ED diagnostics.[1,2] Second, relevant research estimates half of ED physician's interventions could be performed in non-ED centres, lower than our findings of 68%.[3] This is likely due to our analysis of interventions conducted on non-emergent patients only. Interventions conducted on emergent patient are less feasible or safe to perform outside of an ED, thus inclusion of emergent patients in our study would have undoubtedly lowered the overall proportion of ED interventions suitable for performance in non-ED centres. Third, there is little information in the literature regarding how some previously published classifications were developed, by whom, or their methodology. Moreover, there is minimal evidence in the field investigating validity of these avoidable ED classifiers.[4–6]

This thesis established ED physicians as reliable classifiers of ED visits, a result consistent with the literature.[7] However, the literature also describes situations where ED physicians showed poor reliability when classifying appropriate and inappropriate ED visits.[8–10] These results differs from my thesis, which I theorize is due investigators defining an "appropriate" visit too broadly, which differed from our studies that focused on where healthcare could have been delivered and not if healthcare was necessary.[8] To counter this methodologic weakness, I provided physicians with a concise definition of avoidable ED visits, recommended ED physicians use a conservative approach to classify ED visits (e.g., low risk-tolerance), and requested physicians only provide judgements on where an ED visit could have been conducted (not if the visit was warranted).[11]

There is a clear lack of literature that compares or evaluates previously published classifications to one-another, highlighting the importance chapter five.[2] Typically, the literature cites evidence of validity in evaluations of the classifications ability to predict a discharged ED visit outcome.[12–14] However, this approach is unfitting to test validity given that ED outcome is a characteristic included in many classifications, and predicting a discharged outcome is not equivalent to classifying avoidability, given many patients discharged from the ED are not classified as avoidable ED visits.[2,15,16] My thesis is the first to compare classifications to a criterion standard and to one-another, which allows for a more appropriate examination of classification performance.

Implications of Thesis Findings

This thesis presents compelling evidence the EDAC is a highly accurate method to categorize avoidable ED visits. In comparison to previous classifications that exhibited subpar to moderate performance, the EDAC represents a significant improvement in the field of ED epidemiology. The lack of validity in other classifications may be attributed to inadequate methodologies employed to develop inclusion criteria, insufficient validity testing, or their utilization for purposes for which they were not designed. Thus, it is important to exercise caution when interpreting outputs from these classifications as measures of avoidable ED visits.

Expected Application of the Thesis and Potential Misuse

The findings of this thesis hold significant importance for policy stakeholders seeking to address ED overcrowding, optimize health care resource utilization, improve care continuity and potentially reduce health spending. The EDAC is expected to replace underperforming previous classifications at the regional and provincial levels.

Current quality indicators used by policy stakeholders that measure avoidable ED visits are antiquated, or not suitable (often ACSC). By replacing or augmenting ACSC with the EDAC as an indicator of ED visits that could have been avoided, stakeholders and researchers will gain a clearer understanding of patient cohorts inappropriately utilizing the ED when non-ED care is available. The EDAC and ACSC are distinct measures of ED visits and should be treated as separate indicators for stakeholder assessment. Including the EDAC in stakeholder reports would revolutionize the understanding of avoidable ED visits across the province, and motivate institutions (e.g., long term care, virtual care teams, public health teams) to develop targeted strategies, based on the EDAC, that provide alternative options to patients when their conditions are likely to result in avoidable ED visits. Furthermore, the EDAC can serve as an indirect measure of access to primary care and the healthcare system's capacity to manage patients with primary care conditions by understanding patient trends of ED use for primary care treatable conditions. Lastly, the EDAC is readily translatable for population-adjusted analyses, enabling policymakers to assess relevant statistics that are crucial to support their decisions. For instance, changes in avoidable ED visits over a specified time can be computed by determining the number of avoidable visits (numerator) within a given population (denominator), per 100,000 residents (rate). This rate allows for meaningful comparisons amongst jurisdictions and patient cohorts, and facilitates monitoring of progress in reducing population-adjusted avoidable ED visits over time.

While the EDAC cannot determine which non-ED centre is appropriate to provide patient care, its high correlation and accuracy with ED physicians makes it a significant step forward for ED epidemiological research. My thesis findings have been

communicated to policy stakeholders at the Ministry of Health (MOH) Emergency Services Branch in Ontario, Canada, and will be presented to ICES following the publication of chapter four.

The implementation of the EDAC holds considerable potential for informing interventions aimed at enhancing healthcare delivery and minimizing avoidable ED visits. This, in turn, could contribute to alleviating overcrowding and reducing instances of ED misuse. The EDAC can also be used to examine trends of avoidable ED visits, and investigate the influence of neighbourhood characteristics (e.g., access to primary or urgent care) on avoidable ED visitation. Understanding these factors will inform intervention development to address geospatially care gaps that generate to ED visits. Additionally, the EDAC can guide interventions that promote integration with primary care, virtual care, or paramedic transport to non-ED care centers. Finally, patient conditions related to traumatic injury, abnormal signs and symptoms (general), musculoskeletal system diseases, mental health disorders, and respiratory diseases should be of specific interest for intervention development to mitigate avoidable ED visits.

Special attention should be given to ensuring that the application of the EDAC aligns with its intended purpose and is not misused. As described in this thesis, improper application of an epidemiological classification could have serious consequences, including inaccurate prevalence estimations, misidentification of patient cohorts and potentially unsafe targeting of patients for new care models. It is imperative that in scientific journals, where this thesis has been and will be published, the EDAC is

clearly described as a measure for identifying avoidable ED visits rather than detailing preventable, unnecessary, appropriate or inappropriate ED use.

To prevent misapplication by researchers and stakeholders, I have taken and will continue to take several measures to mitigate misuse of the EDAC. Firstly, I will ensure that the EDAC is disseminated through publication in rigorously peer-reviewed journals. Secondly, I will maintain a clear definition and criteria for the EDAC in all publications and reports to reduce ambiguity and misinterpretation. Thirdly, I will make every attempt to ensure that all research associated with this thesis is continuously cited in further research, enhancing transparency regarding the methodology used to develop the classification. Fourthly, I will periodically review the application of the EDAC in academia and address any emerging issues as they arise. Lastly, I intend to publish a clear and articulate editorial article alongside publication of Chapter 5, explicitly outlining the intended application and use of the EDAC, and offer cautionary examples of past misuses of classifications used to describe avoidable ED visits inappropriately.

Strengths and Limitations

This thesis has several overall strengths not specifically highlighted in the study chapters. Chapters two and three used population-based administrative data resources of Ontario. The use of population-based data has the advantage of analyzing all ED patients across the entire health system over time. Population-based data improves the overall generalizability of the results with reduction in selection bias or single site samples. An overall strength of the EDAC is it only requires administrative data resources to compute the ternary classes. The EDAC is poised for rapid uptake as it can be incorporated with existing data platforms, is simple to implement, and the

concept of the classification is easy to understand.[17] Given all jurisdictions in Ontario, and likely Canada, collect the five patient characteristics required by the EDAC in each ED visit, the EDAC is highly implementable. Use of the EDAC internationally will depend on similarity of ED systems to Canada, the collection of the EDAC's criteria, and the structure and services of their emergency and primary care systems.

However, this thesis has its limitations. While experimental validity was tested in one academic hospital, further validity testing could be conducted in multiple hospitals in differing regions of Ontario to examine the robustness of the classification. Implementation of the EDAC could be limited when characteristics of the classification criteria are missing (most notably the ED physician intervention). Administrative data is susceptible to missingness in data fields, an inherent limitation of using secondary data sources. Physician interventions were originally chosen for inclusion in consensus research from non-emergent patients transported by paramedics, not all non-emergent patients in the ED. Finally, the EDAC was not validated to determine which non-ED centre could have conducted the ED visit in chapter four (e.g., urgent care and/or general practice); the EDAC can only delineate avoidable visits for non-ED healthcare centres generally.

Next Steps in this Program of Research

The EDAC developed in this thesis has significant potential to modify primary care delivery, health policy, paramedic models of care and the broader health system. The EDAC can be integrated with administrative databases (e.g., NACRS) as a new variable for researchers to extract, allowing for analyses of avoidable ED visits on the municipal, regional and population levels.

Further research is needed to analyze patient characteristics not included in this thesis which could improve the EDAC's accuracy and correlation to a criterion standard (e.g., status after triage, provider service, other problem, Glasgow Coma Scale). The EDAC can be applied in paramedic research to examine patient characteristics of avoidable ED visits before ED arrival, and analyze their ability to predict avoidable ED visits. This research could inform the development of a new care model for paramedics to transport specific non-emergent patients to alternative settings, such as urgent care centres, and develop experimental methods for a future trial.

Conclusion

Overcrowding remains a significant challenge for ED's as patients continue to seek ED care even when non-ED care is potentially suitable. Understanding the prevalence and characteristics of avoidable ED visits is important to research aimed at reducing ED visitation, though published patient classifications have been ineffective in doing so. My thesis developed a robust and precise patient classification that can identify avoidable ED visits in administrative data, with the potential to inform and guide policy and health care delivery decisions.

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