PATTERN OF EMERGENCY DEPARTMENT USE BY SHORT-TERM GERIATRIC FREQUENT ATTENDERS

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CAPSTONE PROJECT

Presented to the Department of Medical Informatics and Clinical Epidemiology
and the Oregon Health & Science University
School of Medicine
in partial fulfillment of
the requirements for the degree of

Master of Biomedical Informatics

May 2021

School of Medicine

Oregon Health & Science University

CERTIFICATE OF APPROVAL

This is to certify that the Master's Capstone Project of

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ACKNOWLEDGEMENTS

I would like to thank, first and foremost, Dr. David Dorr for his support and guidance as my capstone advisor. Drs. Jane McCusker and Antonio Ciampi were instrumental in the development and realization of this project. I am deeply indebted to Eric Belzile who did the statistical "heavy lifting" and who was so gracious with his time trying to teach me statistics. I would also like to acknowledge the generous support of the St. Mary's Hospital Research Centre and the St. Mary's Hospital Foundation. Finally, to Alison and Gabriel, thank you for putting up with me during this long journey!

ABSTRACT

OBJECTIVES: Geriatric patients who present to the emergency department (ED) frequently over a short period of time pose significant challenges to the ED physician, who must decide whether they are safe to be discharged. It is not known if the distribution of these visits over time may identify patient groups with different needs or who are at higher risk of adverse outcomes. The purpose of this study is to determine if distinct patterns of use exist in these patients and to describe their patient, visit, and hospital characteristics.

METHODS: Group-based trajectory modelling was used to identify the trajectories of use in the 90 days preceding an index visit to the ED.

PARTICIPANTS: All patients 65 years and older covered under the Quebec public health insurance plan with an index visit between July 2014 to December 2015 inclusively and who had three or more visits to the ED in the 90 days preceding the index visit.

RESULTS: Two percent of geriatric patients (n=10,741) in our study had three visits in the 3 months preceding their index visit, which accounted for 7.1% of all ED visits by the geriatric population over that period. The study group was further divided into patients who had only ED visits without admission and patients who had at least one ED visit that resulted in a hospital admission. The No admission group had three trajectories of ED use leading up to the index visit—continuous probability, increasing probability, and hyperacute probability—and the Admission group had two trajectories—continuous and increasing probability. The trajectories demonstrated differences with respect to the timing of the first visit preceding the index visit and the pattern of visits over time. Patients belonging to these trajectories had different levels of acuity and patterns of illness.

CONCLUSION: Different patterns of use appear to exist in geriatric patients presenting frequently to the ED over a short time interval and may represent clinically relevant subgroups.

CHAPTER 1: INTRODUCTION

CLINICAL VIGNETTE

At sign-over, your colleague transfers an 85-year-old male with vague complaints. Your colleague mentions in passing that the patient has been in the Emergency Department (ED) frequently in the last few weeks, but this is your first contact with this patient. The plan is to discharge the patient if labs and imaging are negative. His work-up is normal, but you are uncomfortable about discharging him knowing that he will probably be back and, the next time, it may be for a hospitalization. His frequent visits suggest an unresolved issue, but no service is willing to admit a patient just because he is making repeat visits to the ED.

Emergency physicians are frequently confronted with this scenario—an elderly patient who has recently had a number of ED visits—and we must make a decision on disposition. Given the episodic nature of care in the ED, these patterns of use of patients may not be recognized or appreciated. An ED visit by an elder is considered to be a "sentinel event" (1) and there is a high probability the patient will return, be hospitalized, or die in the following weeks to months.(2) What is not clear is what has taken place prior to this visit to the ED, which we have arbitrarily labelled as a sentinel event. A visit by a patient to the ED may be more accurately viewed as a single point in a trajectory that may represent the beginning, the end, or somewhere in the middle. A greater understanding of the events prior to the index visit may help to inform current and future management.

A. Scope of the problem

Our geriatric patients (i.e. 65 years of age and older) are important users of the ED and, with the changing age demographic, their impact will increase with time. Visits to the ED by elders

increase disproportionately compared to other age groups,(3) and they are more likely to require admission, die, or, if discharged from the ED, to return to the ED.(4) This clientele already poses important challenges in the ED, and this will be magnified over time, as it is estimated that the percentage of elders in the United States will increase from 17% to 23% by the year 2060.(5) Whereas elders requiring an admission to hospital have a straightforward disposition decision, the challenge for emergency physicians is deciding who can be safely discharged. Numerous factors have been shown to increase the risk of adverse outcome (re-visit, hospital admission, death) following an ED visit, but the ability to predict who is safe to be discharged remains elusive. While prior ED use is a predictor of adverse outcome,(6,7) little is known about how elders use the ED over time and, in particular, those that have had repeated visits to the ED. The goal of this study is to assess whether patients may be grouped according to their pattern of ED utilization and whether patients who follow these trajectories have unique demographic, visit, or hospital characteristics.

B. Outcomes following discharge from the Emergency Department (ED)

Elders who present to the ED and are discharged are at risk of adverse outcomes, defined as a return to the ED, hospitalization, or death. A systematic review by Aminzadeh et al demonstrated that risk of these adverse events was highest in the first 3 months, with an average mortality rate of 10%, ED return rate of 24%, and hospitalization rate of 24%.(8) Less clear is the risk of adverse events in the shorter term. The 3-day re-visit rate has been reported to be 4.4–5.1%,(7,9) increasing to approximately 7.7–11.6% at 7 days.(9-11) At 28 to 30 days, the return rate is 13.1–19.3%, (7,9,10,12) admission is approximately 5% (13), and risk of death is estimated to be 1–1.4%.(7, 13) Of note, studies also suggest that some patients return frequently after the initial ED visit.(10, 12)

C. Risk factors for adverse outcomes following an ED visit

Factors that influence the ability to accurately predict adverse outcomes include patient, visit, and hospital variables. Chronologic age is associated with increasing visits to the ED.(3) Institutionalized elders are more likely to present to the ED,(14) are sicker,(15) and have more return visits (16) compared to their counterparts living in the community. As well, certain sub-groups appear to have increased risk of adverse outcomes including chronic medical conditions (e.g. congestive heart failure [CHF], cancer),(9,17-19) frailty,(20) falls,(21) and cognitive impairment.(22) Mental health conditions (23) and substance abuse (23) are factors found in the general adult population, but it is unclear if they play a similar role in the geriatric population. Visit related variables such as ambulance transport are associated with adverse outcomes.(24,25) Factors related to healthcare delivery also appear to impact outcomes, such as ED size and resources for geriatric patients.(13,26) Hospitalization and ED use prior to an index visit are risk factors for poor outcomes.(6-8) Street demonstrated that frequent geriatric users of the ED were at higher risk of admission and in-patient mortality.(27) However, it is unclear whether this relationship continues with very high frequency use, as the general adult literature suggests these very high frequency users (variably defined) actually have lower likelihood of adverse events.(28-30)

D. Patterns of use

Emergency Department visits prior to an index visit are a risk factor for adverse outcomes; however, patterns of use are less well studied. Much of what is known comes from the literature on elderly frequent users, most commonly defined as four or more visits in a year. Elderly patients are more likely to become frequent users than the general adult population.(31) Studies suggest that 4.4 to 6.6% of geriatric patients fall into this category, constituting 18 to 38% of geriatric ED visits.(32-34) Within this group of frequent users, there are patients who present frequently because

of an acute problem that subsequently resolves as well as more chronic users who continue to present to the ED over time.(34,35) As with the general adult population, there appears to be a subset of geriatric patients that move between short-term and chronic ED usage over time.(19,34, 36)

The manner in which visits occur over time is even less well understood, and what is known is found in studies of the general adult population. Safwenberg demonstrated an association between the time interval between visits and mortality, with the risk of mortality peaking at 7 days after the initial ED visit. Ronksley looked at clusters of ED visits (three within a week) to identify a subgroup of frequent users in the general adult population.(37) A number of articles have examined the patterns of usage of frequent users, and the findings suggest that the characteristics and temporal pattern of re-visits may be predictive of adverse outcomes.(38-40) Poole et al found the slope of the times between ED visits as a marker of visit intensity to be more predictive than the number of visits.(38) Ben-Assuli et al used group-based trajectory modelling (GBTM) to identify distinct patient trajectories and their risk of readmission with subsequent ED visits.(41) While these studies suggest a potential influence of how ED visits take place over time, it is not known whether there may be distinct temporal patterns of use in geriatric patients and whether they represent distinct subpopulations.

E. Goal of this investigation

The purpose of this study is to study the pattern of ED use by geriatric patients attending frequently to the ED over a short period of time to identify potential distinct trajectories and to describe the characteristics of the patients who belong to these trajectories.

CHAPTER 2: MATERIALS AND METHODS

A. Study design and setting

The project design was a retrospective cohort study using data from existing administrative databases from the Quebec Health Insurance Agency (Régie de l'assurance de maladie du Québec or RAMQ) and the Quebec Ministry of Health and Social Services (Ministère de la Santé et Services sociaux or MSSS). As Quebec provides universal health coverage, this database contains information on all ED visits in the province of Quebec.

B. Selection of participants

The study subjects consisted of patients 65 and older covered under the public health insurance who had an index ED visit between July 2014 and December 2015 inclusively. The study period included the 3 months before the index period (i.e. April 2014 to June 2014). An index date ED visit was defined as the date of the first ED visit in the enrollment period, defined as July 2014 to December 2015. For a patient with more than one visit in the enrollment period, the index visit was selected randomly. The 3 months before the index visit were used to study and define patterns of ED visits. The provincial database included visits made to facilities located in more remote areas of Quebec that provided ambulatory care and initial stabilization prior to transfer to a hospital. As this group represented a distinct subgroup, patients who had index visits in these EDs were excluded from the study.

C. Measurements

The data was obtained from the administrative databases of the RAMQ and the MSSS. The MSSS maintains a database of all ED visits in Quebec, and each ED is required to electronically transmit a standardized data set of the details of each visit. The data set from the RAMQ contains

the demographic information of the patients, which was linked to the ED visit using an encrypted identifier. Together, the data set provided demographic information on the patient and information regarding the ED visit, including the time of the visit, mode of arrival to the ED, presenting complaint, discharge diagnosis (ICD-10), and disposition. Table 1 lists the variables retained from the database that were deemed pertinent and reliable. In order to capture a "geriatric profile," some presenting complaints were combined after consultation with clinicians in order to give a composite picture (Table 2). Information regarding geriatric services in each of the hospitals was obtained from the Geriatric Association of Quebec.

There was very little missing data in the variables of the data set with the exception of the ICD-10 codes, for which 5.9% of the visits were missing a diagnostic code.

TABLE 1: VARIABLES

CHARACTERISTIC	VARIABLE	DESCRIPTION
Patient Characteristics	Age	65-74; 75-84; 85+
	Sex	Male, Female
Visit Characteristics	Arrival mode	Ambulance, Ambulatory
	Visit arrival date/time	-
	Triage score	Canadian Triage and Acuity Scale 1-5
	Chief complaint	CEDIS[1] Standardized Classification
	ED Placement	Ambulatory care, Stretcher
	Consultation	Number of consultations
	Principal diagnosis	ICD-10
	ED Length of stay	Hours
	Disposition	Admission, Discharge, Transfer, Death
Hospital Characteristics	ED type[2]	Primary A/B Secondary A (<20 ED stretchers) Secondary B (≥20 ED stretchers) Tertiary
	ED geographic location	Metropolitan/Urban/Rural[2] Montreal
	University affiliation	Yes/No
	Acute Geriatric Unit	Yes/No
	Multidisciplinary Geriatric Team	Yes/No

[1]CEDIS (Canadian ED Information System)

[2]Statistical Area Classification

TABLE 2: PRESENTING COMPLAINT: GERIATRIC PROFILE

CODE	PRESENTING COMPLAINT
103	General weakness
605	Social problem
607	Concern for patient's welfare
700	Altered level of consciousness
701	Confusion
704	Gait disturbance/ataxia

D. Analysis

Group-based trajectory modeling (GBTM) was used to identify groups of patients with similar ED use over time. GBTM was ideally suited to this exploratory study, where it was not known if distinct subgroups existed, as this methodology does not presume that discrete subgroups exist but rather distinct trajectories may explain the overall distribution of visits over time.(42) GBTM does not produce the "true" number of trajectories but rather generates models with various numbers of trajectories that then need to be evaluated. The model fitting procedure of GBTM is an iterative process as outlined below.(43) For clinical interpretability, we made the assumption that the number of possible trajectory groups would be between two and six groups. For each group, the shape of ED use over time was explored from the 1^{st} order (linear) to the 4^{th} order. To select the final model, the models were tested against one another (more complex against less complex) using the log form of the Bayes Factor in which a 6-fold difference was chosen to suggest strong evidence.(44) The final step was to describe the polynomial order that best fit each of the trajectories, re-test using the log form of the Bayes Factor, and ensure that the estimated percentage of patients in each trajectory was at least 5%. To assess the model adequacy (fit), two measures proposed by Nagin were computed: the average posterior probability (APP) and the odds of correct

classification (OCC). An APP of at least 70% and OCC greater than 5 for each trajectory group suggested a model with a good fit.(42) The final step was presenting the resultant trajectory model to a group of clinicians to ensure face validity.

GBTM is a versatile statistical methodology, as the trajectories do not need to be limited to a single outcome. An extension of GBTM known as group-based multi-trajectory modelling (GBMTM) can be used if there is more than one variable to be followed over time. GBMTM defines "a trajectory group in terms of trajectories for multiple indicators not just one indicator" (45) which results in multiple probability curves to describe each group trajectory (i.e. each variable will have its own probability curve).

The sample for this study included all patients who had three visits or more in the 3 months before the index visit. This sample was further divided into patients who had no admissions to hospital (i.e. discharged after each of the ED visits) and patients who had at least one admission at the conclusion of an ED visit. As the sample with no admission had a single outcome of interest (ED visit, yes/no), GBTM was used. As the subgroup with at least one admission to hospital has two possible outcomes (admission, yes/no; no admission, yes/no), GBMTM was used. The model selection for both sub-groups followed the methodology described above.

A sensitivity analysis was performed to evaluate the performance of the resulting models. Ten samples were analyzed where the index visits were chosen randomly from the study period and the same methodology for model construction was applied. Three indicators were used to evaluate how well these samples compared to the original model: the proportion of each group, the visual inspection of the shape of each group trajectory, and the assessment of fit (APP and OCC).

Each resulting trajectory was then described according to various patient, visit, and hospital variables. Pearson chi-square tests (categorical variables) and one way ANOVA (continuous

variables) were used to test the association between patient characteristics and study groups. When more than two groups were compared, pairwise comparisons were conducted using Bonferroni correction. All analyses were conducted using SAS (University Edition; SAS Institute, Inc., Cary, NC) and STATA (version 15.0; StataCorp, College Station, TX).

E. Ethical considerations

Ethics approval for the study was obtained from the Research Ethics Committee at St. Mary's Hospital Centre, Montreal, Quebec and by the Access to Information Commission of Quebec (Commission d'accès à l'information of Quebec).

CHAPTER 3: RESULTS

A. Characteristics of the study population

Details of the study population can be found in Table 3. For the purposes of trajectory analysis, a minimum of three visits prior to the index visit was necessary.(46) Of the 519,484 patients who had an eligible index visit, 10,741 (2.1%) patients had three or more visits, which constituted 40,288 (7.1 %) ED visits.

TABLE 3: CHARACTERISTICS OF THE STUDY POPULATION

NUMBER OF ED VISITS IN THE 3 MONTHS BEFORE INDEX VISIT	NUMBER OF PATIENTS	% OF PATIENTS	TOTAL VISITS	% OF ED VISITS
None	405,779	78.1%	405,779	71.0%
1	80,864	15.6%	80,864	14.2%
2	22,100	4.3%	44,200	7.7%
3 or more	10,741	2.1%	40,288	7.1%
Total	519484	100.0%	571131	100.0%

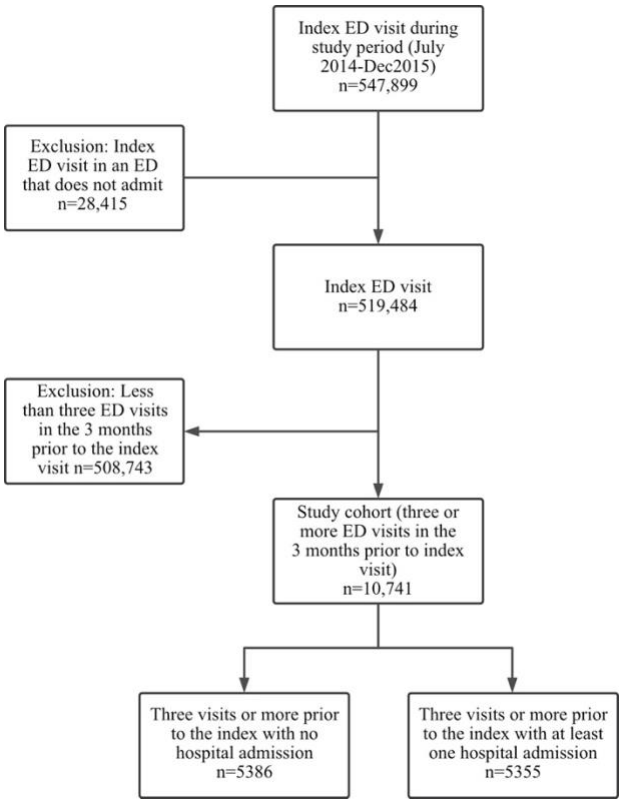

FIGURE 1: FLOWCHART OF DERIVATION OF THE STUDY SAMPLE

B. Trajectory model

The group of patients with three or more visits prior to the index visit was divided into patients who had only ED visits with no hospital admission (No admission group; n=5386) and ED visits with at least one of those visits resulting in an admission to hospital (Admission group; n= 5355). The trajectory model that performed the best according to the criteria established by Nagin was a three-trajectory model for the No admission group and a two-trajectory model for the Admission group. Details of the performance of the models can be found in Table 4. In order to facilitate the comparison of groups, each of the groups was given a descriptor to describe the general tendency of the trajectory, which will be discussed in the following section: Increasing, Continuous, and Hyperacute probability of ED visit.

TABLE 4: SUMMARY OF FINAL MODEL PERFORMANCE

	GROUP	n	APP	OCC	p	Tot_prob	diff	POLYNOMIAL ORDER
No admission	1 (Increasing)	1585	78%	20.4	14.8%	15.1%	0.3%	3
	2 (Hyperacute)	1043	86%	57.4	9.7%	9.6%	0.1%	3
	3 (Continuous)	2758	88%	20.8	25.7%	25.4%	0.3%	3
Admission	1 (Increasing)	1737	74.1%	13.9	16.2%	17.0%	0.8%	4
	2 (Continuous)	3618	85.0%	11.6	33.7%	32.8%	0.9%	4

APP=average posterior probability; diff=p-Tot_prob; n=number; OCC=odds of correct classification; p=observed classification probability (proportion in each group based on the assignments for the maximum posterior probability; Tot_prob: expected classification probability.

No admission group (Figure 2). The model selected for the No admission group yielded three trajectories. Group 1 (Increasing probability) demonstrated a very low probability of visiting the ED until approximately 60 days prior to the index, followed by an increasing probability of an ED visit peaking 15 days prior to the index. Group 2 (Hyperacute probability) maintained a very low likelihood of an ED visit until approximately 15 days prior to the index visit but then showed a rapidly increasing and high probability of an ED visit approaching the index. Compared to the other groups, group 3 (Continuous probability) showed a nearly stable probability of an ED visit throughout the 90 days.

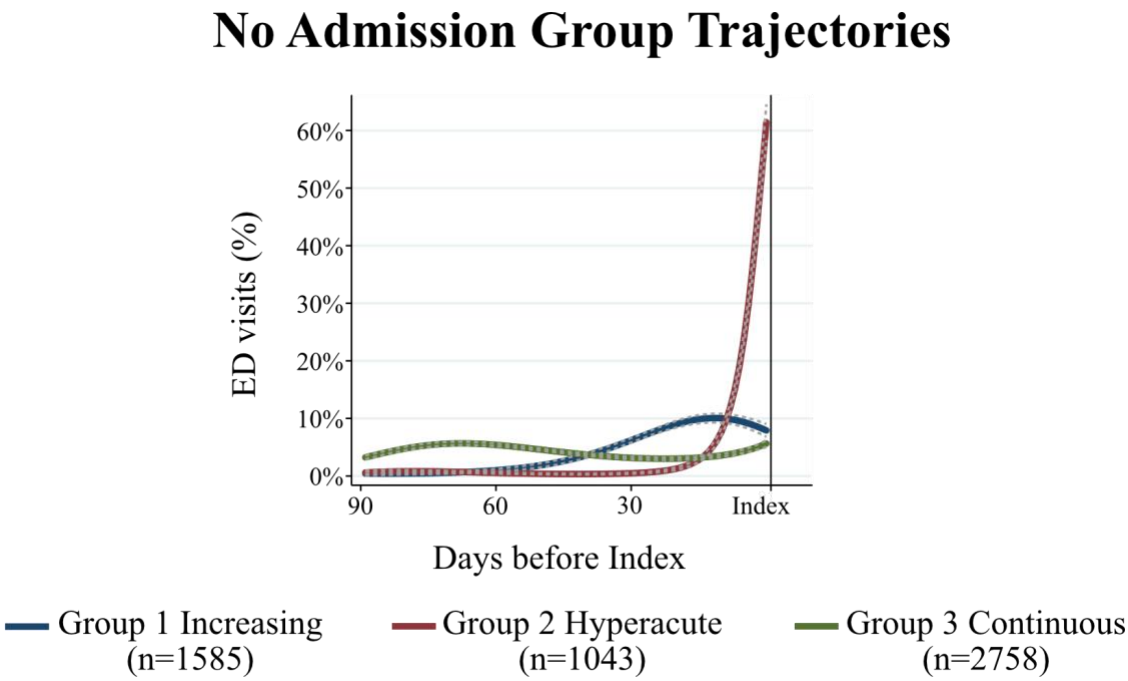

FIGURE 2: NO ADMISSION GROUP TRAJECTORIES

Admission group (Figure 3). The model selected for the Admission group yielded two trajectories. As GBMTM was used, each trajectory group is represented by two curves (blue for the probability of an ED visit without admission; red for the probability of an ED visit with admission) with the dashed curve representing the cumulative probability of any ED visit at a given time point before the index visit. It is important to note that the scale of the Y-axis is smaller (by an order of 6) for the Admission group trajectories compared to the No admission group. Admission group 1 (Increasing probability) demonstrated a low baseline probability of an ED visit without admission, which then began to increase 60 days prior to the index visit and continued to increase up to the index. The probability of an ED visit resulting in admission began to increase at approximately 45 days and peaked at 15 days prior to the index. Group 2 (Continuous probability) showed a baseline but nearly constant probability of an ED visit without admission over the 90

days prior to the index with a slight rise approaching the index. This group showed a near stable risk for ED with admission until beginning to fall 30 days prior to the index.

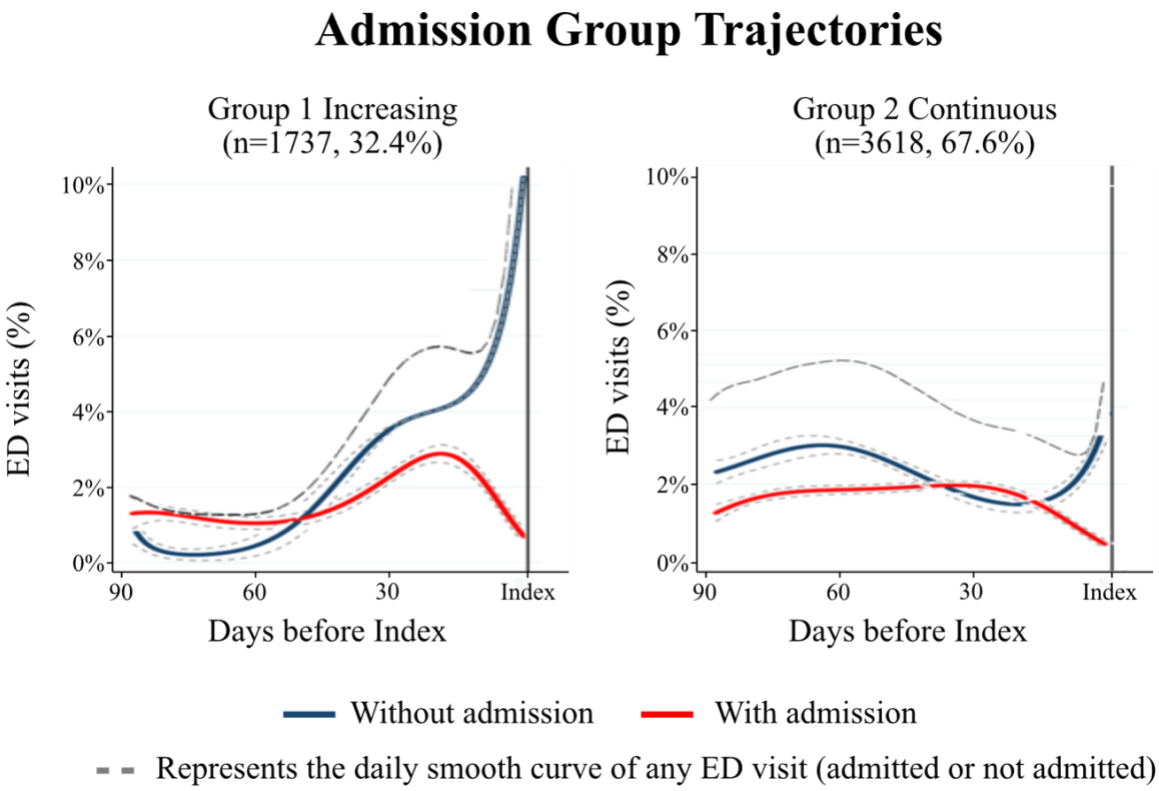

FIGURE 3: ADMISSION GROUP TRAJECTORIES

C. Group index visit characteristics

1. Differences between the No admission and Admission groups (Table 5)

In comparing the characteristics of the index visit, the Admission group was older compared to the No admission group (76.3 vs 78.7, $p<0.001$). There was no difference in the number of visits between groups (No admission group, 3.8; Admission group, 3.7). Visit characteristics demonstrated a higher triage acuity, more arrivals by ambulance, and greater need for a stretcher (versus waiting room) in the Admission group. More consultations were

requested and the median ED length of stay was longer in the Admission group. Patients in the Admission group tended to have more diagnoses attributable to pathology requiring admission (i.e. cardiac, respiratory, cancer versus skin, musculoskeletal, trauma; p<0.001) (Appendix 1). Mental health disorders were not significantly different between the two groups. There were statistically significant differences in presenting complaints between the Admission and No admission groups, with the Admission group having more ED visits for chest pain, dyspnea, and a geriatric profile versus significantly more expected return visits (15.7% were coded as returns) in the No admission group. With respect to hospital characteristics, the Admission group tended to present to larger hospitals (i.e. tertiary/secondary B) and to metropolitan and urban centers.

TABLE 5: DESCRIPTIVE STATISTICS OF THE INDEX VISIT (NO ADMISSION AND ADMISSION GROUPS)

CHARACTERISTICS AT INDEX VISIT	NO ADMISSION GROUP n=5386	ADMISSION GROUP n=5355	p-value
Patient characteristics:			
Age, %			<0.001
65–74	46%	35%	
75–84	37%	39%	
85+	16%	26%	
Mean (SD)	76.3 (7.5)	78.7 (8.0)	<0.001
Female, %	50%	50%	0.796
Visit Characteristics:			
Triage code (CTAS), %			<0.001
1 (Resuscitation)	1%	3%	
2 (Emergent)	7%	13%	
3 (Urgent)	28%	41%	
4 (Less Urgent)	35%	31%	
5 (Non Urgent)	30%	11%	

Arrival mode, %			<0.001
Walk-in	71%	40%	
Ambulance	28%	58%	
Other	1%	2%	
Autonomy, %			<0.001
Stretcher	25%	48%	
Ambulatory	75%	52%	
Consult in ED, %			<0.001
No	75%	53%	
1	14%	24%	
2+	11%	24%	
LOS (hrs), median [Q1-Q3]	5.1 [2.3-12.0]	11.6 [5.1-26.4]	<0.001
Hospital characteristics:			
Hospital type, %			<0.001
Tertiary care	29%	33%	
Secondary-A (<20 stretchers)	20%	19%	
Secondary-B (≥20 stretchers)	22%	30%	
Primary	29%	18%	
Geographical location, %			<0.001
Metropolitan	51%	61%	
Urban/Suburban	27%	25%	
Rural	23%	14%	

CTAS=Canadian Triage and Aquity Scale; ED=emergency department; LOS=length of stay; SD=standard deviation.

2. No admission group (Table 6, Appendix 1: Index discharge diagnoses and presenting complaints)

The index visit characteristics of the Hyperacute trajectory group were significantly different from the Increasing and Continuous groups. Patients in the Hyperacute trajectory were younger and possibly less sick, as suggested by lower acuity triage scores, less stretcher

use, and shorter length of stays (p<0.001). This group also had significantly higher discharge diagnoses of skin disorders (17.4%; primarily cellulitis), lower R (symptom) codes, and more missing data. As well, this group had a high rate of expected return to the ED based on their presenting complaint (30.8%, p<0.001). Of note, the Hyperacute group was more likely to present to primary EDs. The characteristics of the Increasing and Continuous groups were similar. There appeared to be a trend for the Continuous group to be more acute as demonstrated by higher triage acuity (CTAS 1-3 41 vs 36%; p=0.002); however, ambulance transport, stretcher use, length of stay, and consultations were similar. The discharge diagnoses by ICD-10 categories were similar between the two groups; however, more patients presented with cellulitis in the Increasing group (p<0.001). Although there was a trend for more chronic obstructive pulmonary disease (COPD) and CHF diagnoses in the Continous group, it did not reach statistical significance. Presenting complaint codes were also very similar with the exception of more return visits in the Increasing group (15.5% vs 10.1%; p<0.001). The hospital characteristics were similar for the two groups.

TABLE 6: DESCRIPTIVE STATISTICS OF THE INDEX VISIT FOR THE NO ADMISSION TRAJECTORY GROUPS

	NO ADMISSION (n=5386)			
CHARACTERISTICS AT INDEX VISIT	**GROUP 1 INCREASING** (n=1585)	**GROUP 2 HYPERACUTE** (n=1043)	**GROUP 3 CONTINUOUS** (n=2758)	**p-value**
Patient characteristics:				
Age, %				<0.001
65–74	46%	52%	44%	
75–84	38%	35%	39%	
85+	16%	13%	17%	
Mean (SD)	76.4 (7.4)	75.2 (7.2)	76.7 (7.6)	<0.001
Female, %	49.0%	46.0%	53%	<0.001

Visit Characteristics:				
Triage code (CTAS), %				<0.001
1 (Resuscitation)	1%	1%	1%	
2 (Emergent)	7%	3%	8%	
3 (Urgent)	28%	15%	32%	
4 (Less Urgent)	38%	23%	37%	
5 (Non-Urgent)	26%	58%	22%	
Arrival mode, %				<0.001
Walk-in	70%	86%	66%	
Ambulance	29%	14%	33%	
Other	1%	1%	1%	
Autonomy, %				<0.001
Stretcher	27%	13%	29%	
Ambulatory	73%	87%	71%	
Consult in ED, %				<0.001
No	74%	83%	73%	
1	14%	10%	15%	
2+	12%	7%	12%	
LOS (hrs), median [Q1-Q3]	5.8 [2.5-12.2]	2.5 [1.1-6.1]	5.9 [3.0-14.6]	<0.001
Hospital characteristics:				
Hospital type, %				<0.001
Tertiary care	30%	22%	29%	
Secondary-A (<20 stretchers)	20%	21%	20%	
Secondary-B ≥20 stretchers)	23%	16%	23%	
Primary	26%	40%	27%	
Geographical location, %				<0.001
Metropolitan	53%	41%	53%	
Urban/Suburban	27%	30%	26%	
Rural	20%	29%	21%	

CTAS=Canadian Triage and Aquity Scale; ED=emergency department; LOS=length of stay; SD=standard deviation.

3. Admission group (Table 7, Appendix 1: Index discharge diagnoses and presenting complaints)

The Continuous trajectory group tended to be older and have higher triage acuity, ambulance use, and length of stay ($p<0.001$) compared to the Increasing group. The number of consultations and hospital type distribution were comparable among the two groups. The ICD-10 distribution was similar with some differences that reached statistical significance but had unclear clinical significance (Appendix 1). However, the Increasing group tended to have fewer COPD (2.9 vs 5.3%; $p=0.001$) and cancer ($p<0.027$) diagnoses and higher rates of cellulitis (3.0% vs 1.4% , $p<0.001$). Mental health disorders (ICD-10 F category) appeared to be more prevalent in the Increasing group. However, within this ICD-10 category, psychiatric disorders and delerium/dementia showed no statistical difference, but there were more alcohol-related disorders in the Increasing group (0.5 % vs 0.1%; $p=0.007$). Reasons for presenting to the ED were also similar between the two groups with the exception of dyspnea, which was more likely in the Continuous group (19% vs 14.2%; $p<0.001$), and more expected returns in the Increasing group (13.6% vs 6.1%; $p<0.001$).

TABLE 7: DESCRIPTIVE STATISTICS OF THE INDEX VISIT FOR ADMISSION TRAJECTORY GROUPS

	ADMISSION GROUP (n=5355)		
CHARACTERISTICS AT INDEX	**GROUP 1 INCREASING** (n=1737)	**GROUP 2 CONTINUOUS** (n=3618)	**p-value**
Patient characteristics:			
Age, %			<0.001
65–74	38%	33%	
75–84	37%	40%	
85+	25%	26%	
Mean (SD)	78.1 (8.0)	79.0 (8.0)	<0.001
Female, %	50%	50%	0.842

Visit Characteristics:			
Triage code (CTAS), %			<0.001
1 (Resuscitation)	2%	3%	
2 (Emergent)	12%	14%	
3 (Urgent)	38%	43%	
4 (Less Urgent)	32%	31%	
5 (Non-Urgent)	16%	9%	
Arrival mode, %			<0.001
Walk-in	45%	38%	
Ambulance	53%	61%	
Other	2%	1%	
Autonomy, %			0.020
Stretcher	45%	49%	
Ambulatory	55%	50%	
Consult in ED, %			0.450
No	53%	52%	
1	23%	24%	
2+	24%	24%	
LOS (hrs), median [Q1-Q3]	10.7 [4.5-25.5]	11.9 [5.3-26.8]	<0.001
Hospital characteristics:			
Hospital type, %			0.396
Tertiary care	33%	34%	
Secondary-A (<20 stretchers)	19%	19%	
Secondary-B (≥20 stretchers)	30%	30%	
Primary	18%	18%	
Geographical location, %			0.300
Metropolitan	60%	62%	
Urban/Suburban	26%	24%	
Rural	14%	14%	

CTAS=Canadian Triage and Acuity Scale; ED=emergency department; LOS=length of stay; SD=standard deviation.

D. Patterns of use

The number of visits did not differ significantly between the Admission group and the No admission group. However, the location of their visits did differ, with 60% of the No admission group presenting to the same ED for all of their previous visits versus 53% in the Admission group ($p<0.001$).

To further describe the patterns of use, the first visit prior to the index and the total visits were studied for each of the trajectories. There were differences between the trajectories with respect to the timing of the first visit relative to the index and whether the presenting complaint was the same as the index visit (Appendix 2). The distribution of the total visits and types of visits (admission or no admission) also demonstrated differences (Appendix 3). Below is a summary of the characteristics of each of the trajectories.

1. No admission group (Figures 4, 5)

   Group 1 (Increasing). The average time from index to closest previous visit was 9.8 days, with 98.1% of the patients having a visit within the 30 days before the index. Seventy-four percent of all the visits in this trajectory group took place within 30 days and 98% within 60 days.

   Group 2 (Hyperacute). Patients in this group had an average of 1.9 days separating the index from the first preceding ED visit. All of the patients in this group had their first visit within 1 week, and 59.6% of the patients had the same presenting complaint as the index. The majority of visits were concentrated near the index visit, with 72% of all the visits occurring within 7 days of the index. Patients also tended to use the same ED for all of their visits (70%).

Group 3 (Continuous). The patients in this group had an average of 24.6 days separating the index from the previous visit. Sixty-five percent of patients had their first visit within the preceding 30 days, 27.1% had their first visit in the 31- to 60-day interval, and 8% in the 61- to 90-day interval. The visits of the Continuous probability group were more evenly distributed across the 90-day period (26% in the first 30 days, 35% in the middle 30 days, and 39% in the last 30 days) compared to the other two trajectories.

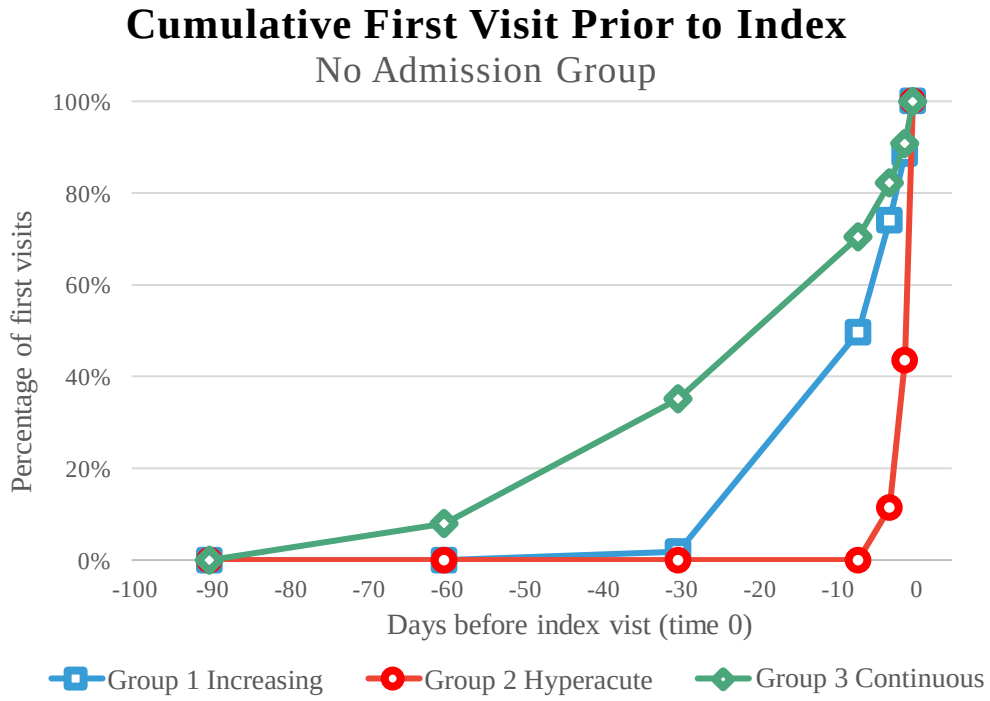

FIGURE 4: CUMULATIVE FIRST VISIT PRIOR TO INDEX: NO ADMISSION GROUP

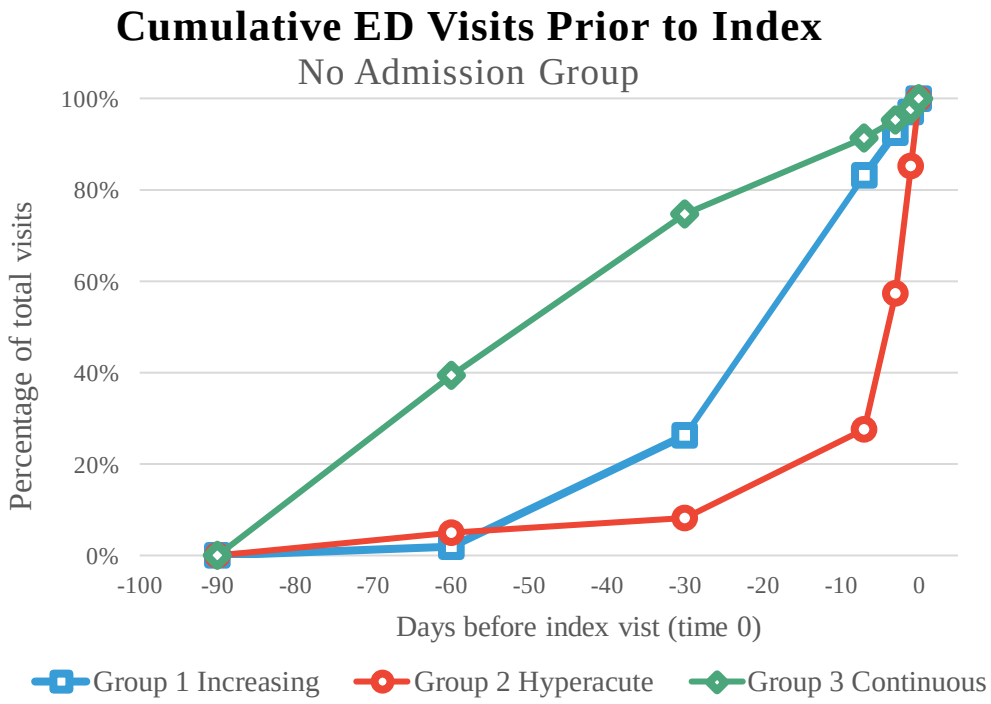

FIGURE 5: CUMULATIVE TOTAL ED VISITS: NO ADMISSION GROUP

2. Admission group (Figures 6, 7)

Group 1 (Increasing). The average time between the closest visit and the index was 9.3 days, with 99.2% patients having their first visit in the 30 days preceding the index. For that closest visit to the index, 38% had the same presenting complaint as the index. Sixty eight percent of the all the visits in the increasing risk group took place within 30 days of the index visit, with 80% of all ED visits without admission taking place during this same time. For ED visits with an admission, 51% took place in the first 30 days and the remainder over the next two 30-day intervals (28% and 21%, respectively).

Group 2 (Continuous). The average time between the index and the previous visit was 24.7 days. The first visit from the index tended to be later in this group compared to the Increasing group, with only 66.9% of patients having their first visit within 30 days, 28.4% in the middle

30-day interval, and 4.7% in the 61–90 days from the index. The distribution of visits differed from the Increasing group, with only 25% of all visits in this group taking place in the preceding 30 days and the remainder equally divided in the other two 30-day intervals. Visits with admission and without admission followed a similar pattern to the total visits, with near equal distribution during the three 30-day periods. Of note, this group was more likely to have two or more admissions in the 90 days prior to the index than the No admission group ($p<0.001$), and 10% had three consecutive ED visits with admission.

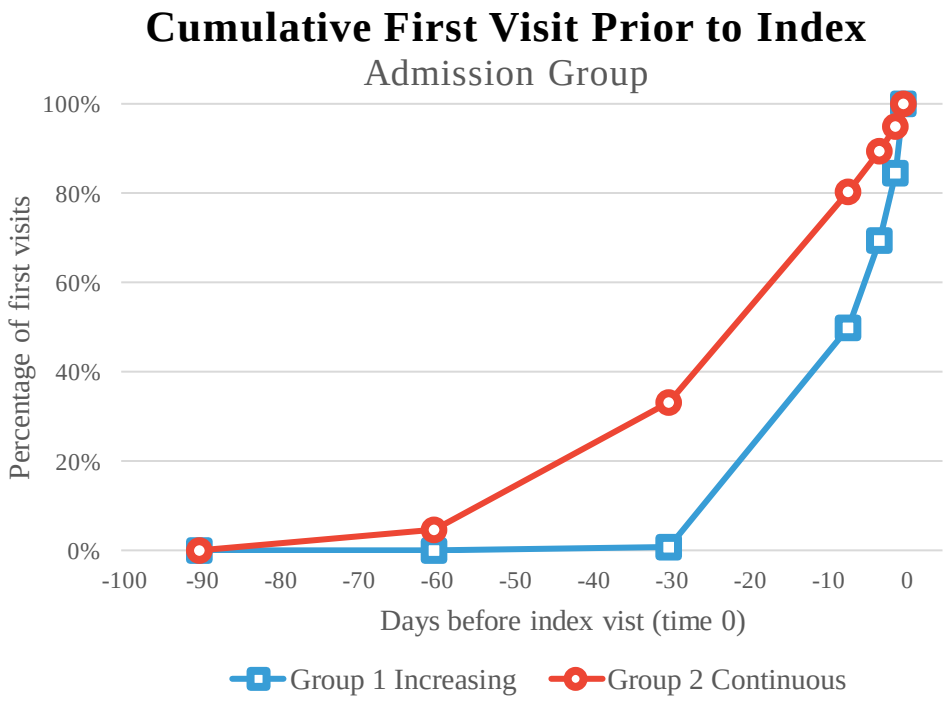

FIGURE 6: CUMULATIVE FIRST VISIT PRIOR TO INDEX: ADMISSION GROUP

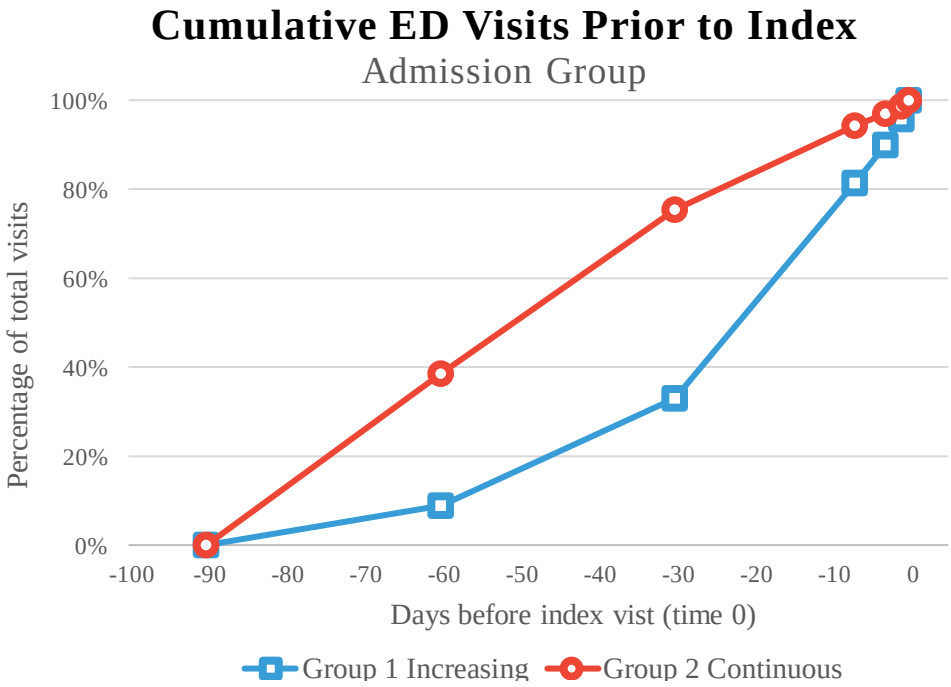

FIGURE 7: CUMULATIVE TOTAL ED VISITS: ADMISSION GROUP

CHAPTER 4: LIMITATIONS

A number of limitations of the study should be considered in the interpretation of our results. One important element that was absent from the database was the in-patient length of stay for patients who were admitted. If the patient was admitted to hospital, their probability of re-presenting to the ED would be zero for the duration of their in-patient stay. This factor would alter the probability of an ED visit (total ED visits; ED visit with and without admission) by lowering the denominator (patients at risk at a particular point in time) and could explain, in part, the declining probability of an ED visit with admission near the index. We studied the group of patients with no admissions separately from the group with at least one admission in order to have a group free of this limitation. Future studies with in-patient length of stay data would help to clarify this impact; however, we believe the general trend would remain the same. A similar but lesser impact could also be seen in the context of the length of stay in the ED. Patients staying in the ED for more than 24 hours would render another ED visit impossible for the duration of their stay and would influence the number of patients that could be at risk. As this would typically be less than 48 hours, the effect on the trajectory model was felt to be negligible.

Transfers from one institution to another could also have impacted the trajectories, especially for patients residing in metropolitan centres. For the purposes of the study, transfers to another facility were considered as discharges without admission, although in many cases the resulting ED visit at the receiving hospital would be an admission. It was felt that treating these visits in this manner reflected the clinical reality and was consistent with patients being discharged and asked to return for further care, with the exception that the likelihood of admission on the subsequent visits would be very high. The consequence of this approach was that an ED visit that ended with a transfer would typically translate into two visits closely associated in time and ending

with, most often, an admission. As well, this would impact calculations of patients presenting with the same complaint and could explain, in part, the large number of hospitals visited. The transfer rate was found to be low (4.4 % of all visits), and it was felt that it would have negligible impact on the resulting model. This effect would be expected to be most prevalent in Montreal, as patients are not infrequently transferred either for specialized care or because the patient is considered to "belong" to another hospital according to regional transfer rules.

Although the data in the database were quite complete, there were a few shortcomings that limited our ability to describe the patient characteristics in each of the trajectory groups. Available literature suggests that patients living in long-term care facilities may exhibit different use of the ED.(16,47) Unfortunately, the quality of this information in the database was insufficient to include this variable in our analysis. It would have been informative to understand how this group of patients is represented relative to community dwelling elders in each of the trajectories. The interpretation of discharge diagnoses (ICD-10) must be taken with caution as 5.9% of the cases did not have a discharge diagnosis and the quality of the data entry could not be assured. We included the presenting complaint in our study as there is a standardized coding of triage complaints in Canada (CEDIS) and which helped, in some instances, to corroborate the final diagnosis, particularly when the R-codes (symptom-based codes) were used.

CHAPTER 5: DISCUSSION

Most of the literature to date has looked at the rate of ED return at specific time periods following an index visit or the total number of visits prior to an index visit over time. To our knowledge, our study is one of the first to attempt to describe the pattern of ED visits in a continuous manner leading up to an index visit. Ben-Assuli et al used GBTM to describe distinct patient trajectories based on their longitudinal risk of 30-day hospital readmission for the general adult frequent attender population and those with certain co-morbidities over a 4-year period.(41) Our work differs in that we focused on the geriatric population and looked at a short time period leading up to an index visit to address a common clinical scenario. We attempted to generate trajectories based on three or more visits within 90 days prior to an index, whereas their work extended over a 4-year period with a minimum of five ED presentations during that time. In addition, their study constructed the trajectories over the course of the ED visits, whereas our study looked at the time interval in days between the visits.

Our study focused on the geriatric frequent user and whether there were different patterns of use leading up to index visits. Our results suggest that distinct patterns of visits exist in this subset of patients. We found that a previous admission in the 3 months prior to the index visit was an important factor identifying a distinct cohort that were more acute at presentation to the ED, sicker, and had more geriatric presenting complaints. Despite this difference between the Admission and No admission groups, two general patterns of use were suggested by our study. One trajectory of increasing probability was characterized by the majority of visits within the 30 days prior to the index and nearly all visits by 60 days. The other trajectory, continuous probability, had a nearly equally weighted probability of presenting to the ED throughout the 90 days leading up to the index. A third trajectory, which we described as hyperacute, was noted only in the No

admission group, and this group had nearly all visits within 7 days of the index. Patients belonging to this trajectory group were different compared to the rest of the No admission group. They were less sick, had shorter ED length of stay, more expected returns, and cellulitis diagnoses at discharge. Patient, visit, and hospital characteristics of the Increasing and Continuous groups in the No admission sample did not yield significant differences to account for the different patterns of use, although part of the difference in patterns could be explained by higher expected returns and rates of cellulitis in the Increasing group. The Continuous group in the Admission group was older and sicker compared to the Increasing probability group, which could explain the elevated risk of an ED visit throughout the 90 days prior to the index visit. The Increasing group also had a higher rate of expected return visits, but this was not explained by high rates of cellulitis. Future studies would benefit from controlling for expected returns and cellulitis diagnoses to determine the degree of influence on the trajectories.

Our study contributes to the existing literature on elderly frequent attenders by adding a temporal perspective to the sub-groups proposed by other researchers. Several investigators have postulated that some frequent attenders are sicker and have more chronic disease,(48-50) which could correspond to our Continuous groups, in particular those that have had a previous admission in the prior 90 days. Another group has been described by Hastings as the "acute carederly" (48) which could correspond to the Increasing group, where patients are generally well but then develop an acute issue resulting in multiple visits over a short period of time. Birmingham described a subgroup of frequent users presenting for minor care,(49) and this may include patients in the Hyperacute group, where there is a high intensity of visits over a very short period. While this group may represent mostly expected returns and have low acuity, the question arises as to whether there may also be a subset within this group that are not expected to return and could be at high risk of poor outcomes.

Our study highlighted some particular aspects of how the ED is used by elderly frequent attenders in Quebec. The Hyperacute risk group suggests a subset of frequent attenders that are returning to the ED for care. Given the combination of a high rate of cellulitis and a short length of stay, one potential explanation could be that some of these patients are returning for intravenous antibiotics. As well, over 30% in this group were coded as expected returns. In the overall study sample, 76% of the ED visits coded as an expected return were patients returning for a consultation. From this, it would appear that, in the Hyperacute trajectory group, the ED is being used for on-going medical care or evaluation. Although there was a larger representation of rural and smaller hospitals in this trajectory group, this pattern was also present in larger hospitals. This raises the question as to whether these patients could be better served in an alternate care setting, which could be more cost effective, and whether this could be a potential intervention to reduce the burden of already overcrowded EDs. Another surprising finding was the number of hospitals our study population attended during their care, with only 53% of patients in the Admission group presenting to the same hospital for all their visits. This may primarily be an issue in Montreal given its high concentration of EDs and could reflect an unintended consequence of how ambulances are distributed and of the governing rules for transfer. As a result, clinicians may not identify patients as frequent attenders, which shows that, from a system standpoint, the care of the most complex and vulnerable populations is fragmented and haphazard. From a research standpoint, single institution studies may not capture all visits and may give an incomplete pattern of usage.

While our model suggests possible trajectories over the 90 days prior to the index, much remains to be understood about these visits within the time period. One item of interest is that there was a percentage in the Continuous groups (4.7% in the Admission group; 8% in the No admission group) that had all of their visits between 60 and 90 days before the index. This suggests a clustering of visits in those 30 days, which supports the work done by Ronskey et al, who found

that, within the group of high intensity users, some users had their visits clustered over a short period of time.(37) Our study did not look at the clustering of visits during the 90 days, and knowledge of the extent of this type of usage would further help us understand how elders use the ED.

One of the strengths of our study was that we had access to all of the geriatric ED visits in Quebec during the study period, which allowed us to paint a portrait of the use of geriatric frequent attenders. Our work focused on a very specific population over a short period of time in order to understand a scenario that is encountered daily in EDs. When confronted with this situation, it is not clear for the clinician how to interpret the frequent use. Is this pattern of use a risk factor and, if so, to what extent? Future work in this area could assess whether these trajectories have different risks of adverse outcomes and different patterns of use moving beyond the index visit. If these patterns of use are associated with increased risk, this may help identify a subset of patients at particularly high risk of short term adverse outcomes. The ability to quantify the risk would help to advocate for admission or early community follow-up. This could help to address the central question of the clinical vignette and inform decision making on the safe discharge of geriatric patients.

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APPENDIX 1: INDEX VISIT DISCHARGE DIAGNOSES AND PRESENTING COMPLAINTS

NO ADMISSION AND ADMISSION GROUPS

	NO ADMISSION GROUP (n=5386)	ADMISSION GROUP (n=5355)	p-value
DIAGNOSTIC CATEGORIES (ICD-10)			
A00–B99 Certain infectious and parasitic diseases	2.2%	3.4%	<0.001
C00–D48 Neoplasms	2.4%	4.1%	<0.001
D50–D89 Diseases of the blood and blood-forming organs	0.9%	1.6%	<0.001
E00–E90 Endocrine, nutritional, and metabolic diseases	1.3%	3.0%	<0.001
F00–F99 Mental and behavioural disorders	3.5%	3.3%	0.608
G00–G99 Diseases of the nervous system	1.5%	1.2%	0.346
H00–H99 Diseases of the eye, adnexa. ear, and mastoid	1.7%	0.5%	<0.001
I00–I99 Diseases of the circulatory system	6.7%	11.7%	<0.001
J00–J99 Diseases of the respiratory system	6.6%	12.0%	<0.001
K00–K93 Diseases of the digestive system	5.4%	5.9%	0.231
L00–L99 Diseases of the skin and subcutaneous tissue	8.2%	2.6%	<0.001
M00–M99 Diseases of the musculoskeletal system	8.9%	4.3%	<0.001
N00–N99 Diseases of the genitourinary system	5.7%	4.4%	0.003
R00–R99 Symptoms, signs and abnormal clinical and laboratory	28.9%	30.5%	0.069
S00–T98 Injury, poisoning	9.0%	6.6%	<0.001
V01–Y98 External causes of morbidity and mortality	–	–	–
Z00–Z99 Factors influencing health status	7.2%	4.7%	<0.001
U00–U99 Codes for special purposes	–	–	–
SPECIFIC DIAGNOSES			
Atrial Fibrillation (I480-481)	1.0%	1.3%	0.082
Alcohol (F10)	0.3%	0.2%	0.282
CAD (I20-I21)	0.8%	1.6%	<0.001
Cellulitis (L039)	6.3%	1.9%	<0.001
CHF, Fluid overload (I500,E877)	1.3%	4.9%	<0.001
COPD, COPD exacerbation (J440,J441)	1.8%	4.5%	<0.001
Delirium-Dementia (F01-F03,F05)	0.7%	1.2%	0.018
Endocrine-diabetes	0.3%	0.6%	0.034
Mental disorders (F20-F99)	2.4%	1.9%	0.067
Pneumonia(J189)	2.0%	4.6%	<0.001
Trauma (S0-T357)	7.5%	5.1%	<0.001
UTI, pyelonephritis (N390, N10)	3.5%	2.9%	0.055
SPECIFIC PRESENTING COMPLAINTS			
Abdominal Pain	6.2%	6.7%	0.287
Chest Pain	4.1%	5.5%	<0.001
Dyspnea	6.2%	17.4%	<0.001
Geriatric Profile	6.7%	13.1%	<0.001
Intoxication	0.3%	0.3%	0.845

Mental Health	1.4%	1.3%	0.639
Pain	11.9%	7.2%	<0.001
Return	15.7%	8.5%	<0.001

NO ADMISSION GROUP TRAJECTORIES (n=5386)

	GROUP 1 (Increasing) (n=1585)	**GROUP 2 (Hyperacute)** (n=1043)	**GROUP 3 (Continuous)** (n=2758)	**p-value**
DIAGNOSTIC CATEGORIES (ICD-10)				
A00–B99 Certain infectious and parasitic diseases	2.2%	1.7%	2.3%	0.522
C00–D48 Neoplasms	2.7%	1.2%	2.6%	0.045
D50–D89 Diseases of the blood and blood-forming organs	0.8%	0.3%	1.1%	0.078
E00–E90 Endocrine, nutritional, and metabolic diseases	1.4%	0.5%	1.6%	0.042
F00–F99 Mental and behavioural disorders	4.3%	2.7%	3.3%	0.088
G00–G99 Diseases of the nervous system	1.5%	1.0%	1.6%	0.458
H00–H99 Diseases of the eye, adnexa, ear, and mastoid	2.0%	1.0%	1.9%	0.179
I00–I99 Diseases of the circulatory system	7.2%	4.7%	7.1%	0.035
J00–J99 Diseases of the respiratory system	6.5%	3.8%	7.7%	<0.001
K00–K93 Diseases of the digestive system	6.2%	3.9%	5.4%	0.062
L00–L99 Diseases of the skin and subcutaneous tissue	7.2%	20.3%	4.6%	<0.001
M00–M99 Diseases of the musculoskeletal system	9.1%	7.2%	9.4%	0.127
N00–N99 Diseases of the genitourinary system	5.5%	5.6%	5.9%	0.87
R00–R99 Symptoms, signs and abnormal clinical and laboratory	28.4%	22.9%	31.2%	<0.001
S00–T98 Injury, poisoning	8.8%	8.2%	9.5%	0.503
V01–Y98 External causes of morbidity and mortality	–	–	–	–
Z00–Z99 Factors influencing health status	6.4%	14.9%	5.0%	<0.001
U00–U99 Codes for special purposes	–	–	–	–
SPECIFIC DIAGNOSES				
Atrial Fibrillation (I480-481)	1.1%	0.5%	1.1%	0.232
Alcohol (F10)	0.3%	0.0%	0.4%	0.154
CAD (I20-I21)	0.8%	0.3%	1.0%	0.181
Cellulitis (L039)	5.0%	18.0%	2.9%	<0.001
CHF, Fluid overload (I500,E877)	1.1%	0.2%	1.7%	0.002
COPD, COPD exacerbation (J440,J441)	1.9%	0.2%	2.4%	<0.001
Delirium-Dementia (F01-F03,F05)	0.8%	0.7%	0.7%	0.974
Endocrine-diabetes	0.5%	0.0%	0.4%	0.138
Mental disorders (F20-F99)	3.2%	1.9%	2.1%	0.059
Pneumonia(J189)	2.0%	1.5%	2.1%	0.461
Trauma (S0-T357)	7.2%	6.7%	8.0%	0.411

UTI, pyelonephritis (N390, N10)	3.2%	2.8%	4.0%	0.202
SPECIFIC PRESENTING COMPLAINTS				
Abdominal Pain	6.2%	3.0%	7.3%	<0.001
Chest Pain	3.9%	1.0%	5.3%	<0.001
Dyspnea	6.2%	1.9%	7.8%	<0.001
Geriatric Profile	7.9%	3.5%	7.2%	<0.001
Intoxication	0.4%	0%	0.3%	0.108
Mental Health	1.3%	1.0%	1.6%	0.250
Pain	12.4%	6.3%	13.6%	<0.001
Return	15.5%	30.8%	10.1%	<0.001

ADMISSION GROUP TRAJECTORIES (n=5355)

	GROUP 1 (Increasing) (n=1737)	**GROUP 2 (Continuous)** (n=3618)	**p-value**
DIAGNOSTIC CATEGORIES (ICD-10), n (%)			
A00–B99 Certain infectious and parasitic diseases	3.3%	3.5%	0.794
C00–D48 Neoplasms	3.3%	4.6%	0.027
D50–D89 Diseases of the blood and blood-forming organs.	1.5%	1.7%	0.636
E00–E90 Endocrine, nutritional, and metabolic diseases	2.1%	3.4%	0.011
F00–F99 Mental and behavioural disorders	4.2%	2.8%	0.009
G00–G99 Diseases of the nervous system	1.3%	1.2%	0.909
H00–H99 Diseases of the eye, adnexa, ear, and mastoid	0.4%	0.6%	0.417
I00–I99 Diseases of the circulatory system	11.5%	11.9%	0.676
J00–J99 Diseases of the respiratory system	10.0%	12.9%	0.002
K00–K93 Diseases of the digestive system	6.5%	5.6%	0.209
L00–L99 Diseases of the skin and subcutaneous tissue	3.7%	2.1%	<0.001
M00–M99 Diseases of the musculoskeletal system	4.5%	4.2%	0.595
N00–N99 Diseases of the genitourinary system	4.5%	4.4%	0.957
R00–R99 Symptoms, signs and abnormal clinical and laboratory	31.1%	30.2%	0.506
S00–T98 Injury, poisoning	6.3%	6.7%	0.578
V01–Y98 External causes of morbidity and mortality	–	–	–
Z00–Z99 Factors influencing health status	5.8%	4.1%	0.006
U00–U99 Codes for special purposes	–	–	–
SPECIFIC DIAGNOSES			
Atrial Fibrillation (I480-481)	0.7%	1.6%	0.005
Alcohol (F10)	0.5%	0.1%	0.004
CAD (I20-I21)	1.5%	1.6%	0.862
Cellulitis (L039)	3.0%	1.4%	<0.001
CHF, Fluid overload (I500,E877)	4.4%	5.2%	0.233
COPD, COPD exacerbation (J440,J441)	2.9%	5.3%	<0.001
Delirium-Dementia (F01-F03,F05)	1.5%	1.0%	0.113
Endocrine-diabetes	0.5%	0.7%	0.329

Mental disorders (F20-F99)	2.2%	1.7%	0.202
Pneumonia(J189)	4.1%	4.9%	0.210
Trauma (S0-T357)	4.6%	5.4%	0.229
UTI, pyelonephritis (N390, N10)	2.7%	2.9%	0.559
SPECIFIC PRESENTING COMPLAINTS			
Abdominal Pain	7.5%	6.3%	0.089
Chest Pain	5.4%	5.5%	0.793
Dyspnea	14.2%	19.0%	<0.001
Geriatric Profile	12.7%	13.2%	0.619
Intoxication	0.5%	0.2%	0.133
Mental Health	1.6%	1.2%	0.232
Pain	6.3%	7.0%	0.086
Return	13.6%	6.1%	<0.001

APPENDIX 2: CHARACTERISTICS OF THE FIRST VISIT BEFORE THE INDEX VISIT

NO ADMISSION GROUP

	TRAJECTORY 1 (Increasing) n=1585		TRAJECTORY 2 (Hyperacute) n=1043		TRAJECTORY 3 (Continuous) n=2758	
	Count	**%**	**Count**	**%**	**Count**	**%**
Time between previous ED visit and INDEX (days) in the						
1 day before	181	11.4	589	56.5	252	9.1
2-3 days before	231	14.6	335	32.1	238	8.6
4-7 days before	385	24.3	119	11.4	326	11.8
8-30 days before	758	47.8	0	0.0	973	35.3
31-60 days before	30	1.9	0	0.0	748	27.1
61-90 days before	0	0	0	0.0	221	8
Mean in days (SD)	9.8 (8.0)		1.9 (1.3)		24.6 (21.2)	
Same presenting complaint as index visit (p<0.001)	37.2%		59.6%		31.5%	

ADMISSION GROUP

	TRAJECTORY 1 (Increasing) n=1737		TRAJECTORY 2 (Continuous) n=3618	
	Count	**%**	**Count**	**%**
Time between first previous ED visit (any) and INDEX in the				
1 day before	270	15.5	181	5.0
2-3 days before	263	15.1	204	5.6
4-7 days before	338	19.5	329	9.1
8-30 days before	852	49.1	1708	47.2
31-60 days before	14	0.8	1026	28.4
61-90 days before	0	0.0	170	4.7
Mean in days (SD)	9.3 (7.6)		24.7 (18.3)	
Same presenting complaint as index (p<0.001)	38.3%		33.2%	
	Count	**%**	**Count**	**%**
Time between first previous admission visit and INDEX in the				
1 day before	6	0.4	8	0.2
2-3 days before	27	1.6	29	0.8

4-7 days before	92	5.3	121	3.3
8-30 days before	933	53.7	1227	33.9
31-60 days before	415	23.9	1452	40.1
61-90 days before	264	15.2	781	21.6
Mean in days (SD)	31.7 (23.3)		40.7 (22.7)	
Time between the first previous ED without admission visit and INDEX in the	**Count**	**%**	**Count**	**%**
1 day before	265	15.4	174	5.3
2-3 days before	242	14.1	175	5.3
4-7 days before	294	17.1	229	6.9
8-30 days before	825	48.0	877	26.5
31-60 days before	94	5.5	1140	34.4
61-90 days before	0	0	719	21.7
Mean in days (SD)	11.6 (10.0)		36.7 (25.4)	

APPENDIX 3: DISTRIBUTION OF TOTAL VISITS BEFORE THE INDEX VISIT

NO ADMISSION GROUP

	TRAJECTORY 1 (Increasing) n=1585		**TRAJECTORY 2 (Hyperacute)** n=1043		**TRAJECTORY 3 (Continuous)** n=2758	
	Visits	**% of visits**	**Visits**	**% of visits**	**Visits**	**% of visits**
Time between the previous ED visit and INDEX in the						
1 day before	0.11	2.9%	0.56	14.9%	0.56	14.9%
2-3 days before	0.17	4.5%	1.06	27.9%	0.09	2.4%
4-7 days before	0.35	9.3%	1.13	29.7%	0.15	3.9%
8-30 days before	2.14	56.9%	0.74	19.5%	0.63	16.6%
31-60 days before	0.92	24.5%	0.12	3.2%	1.35	35.5%
61-90 days before	0.07	1.9%	0.19	5.0%	1.50	39.5%
Total Visits	3.8	100%	3.8	100%	3.8	100%

ADMISSION GROUP

	TRAJECTORY 1 (Increasing) n=1737		**TRAJECTORY 2 (Continuous)** n=3618	
Time between first previous ED visit and INDEX in the	**Visits**	**% of visits**	**Visits**	**% of visits**
1 day before	0.16	4.2%	0.1	1.3%
2-3 days before	0.22	5.9%	0.06	1.6%
4-7 days before	0.33	8.9%	0.11	3.0%
8-30 days before	1.79	48.2%	0.7	18.9%
31-60 days before	0.89	24.0%	1.37	36.9%
61-90 days before	0.33	8.9%	1.42	38.3%
Total Visits	3.7	100%	3.7	100%
Time between first previous ADM visit and INDEX in the	**Visits**	**% of visits**	**Visits**	**% of visits**
1 day before	0.00	0.2%	0.00	0.1%
2-3 days before	0.02	1.4%	0.01	0.6%
4-7 days before	0.05	3.6%	0.03	1.9%
8-30 days before	0.64	45.7%	0.38	23.8%
31-60 days before	0.40	28.6%	0.65	40.6%
61-90 days before	0.29	20.7%	0.56	35.0%
Total Visits	1.4	100%	1.6	100%

Time between first previous ED without admission visit and INDEX in the	Visits	% of visits	Visits	% of visits
1 day before	0.15	6.6%	0.05	2.3%
2-3 days before	0.20	8.6%	0.05	2.4%
4-7 days before	0.27	11.6%	0.07	3.4%
8-30 days before	1.16	50.0%	0.32	15.6%
31-60 days before	0.50	21.6%	0.71	34.6%
61-90 days before	0.04	1.7%	0.86	42.0%
Total Visits	2.3	100%	2.1	100%

PATTERNS OF VISITS (ADMISSION/NO ADMISSION) IN THE ADMISSION GROUP

	GROUP 1 (Increasing)		GROUP 2 (Continuous)	
Most common patterns for the 3 closest visits before index ("X1"-"X2"-"X3"); X3 is the closest to the index	Count	%	Count	%
ADM-ED-ED	510	29%	420	12%
ED-ED-ADM	310	18%	865	24%
ED-ADM-ED	295	17%	719	20%
ED-ED-ED	228	13%	166	5%
ADM-ED-ADM	165	10%	306	8%
ED-ADM-ADM	65	4%	501	14%
ADM-ADM-ADM	19	1%	357	10%
Other pattern	145	8%	284	7%

ADM=Admission; ED=No admission.