THE ASSOCIATION OF THE FREQUENCY OF COMMUNITY PARAMEDICINE SESSIONS AND 9-1-1 CALLS IN ONTARIO SUBSIDIZED HOUSING: A MULTILEVEL ANALYSIS

THE ASSOCIATION OF THE FREQUENCY OF COMMUNITY PARAMEDICINE SESSIONS AND 9-1-1 CALLS IN ONTARIO SUBSIDIZED HOUSING: A MULTILEVEL ANALYSIS

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Lay Abstract

Older adults experience high rates of chronic diseases, especially older adults living in subsidized housing. Community paramedicine has recently emerged as a way of addressing the healthcare needs of older adults living in subsidized housing, while simultaneously decreasing the burden on EMS. CP@clinic is a community paramedicine programme aimed at improving the health of older adults and reducing the demand on EMS. To make recommendations to the paramedic services operating CP@clinic, I sought to understand the association between the frequency of CP@clinic sessions and the number of EMS calls per apartment unit in Ontario. Based on the results, CP@clinic sessions were associated with higher incident rate of EMS calls, after accounting for building size, reflecting the trend of rising EMS calls in Ontario. Overall, paramedic services may see improved EMS call outcomes with two or more CP@clinic sessions per month but should offer the programme according to their organizational capacity.

Abstract

Older adults, especially those who are of low socioeconomic status, experience higher rates of mortality and chronic disease. As a result, older adults are frequent users of emergency medical service (EMS), comprising approximately 38-48% of all EMS calls. In response to higher EMS demands, community paramedicine has recently emerged as a non-traditional model whereby paramedics provide care in a community-based setting. CP@clinic is a community paramedicine programme that focuses on disease prevention and health promotion with the goal of reducing EMS demand. Given the knowledge that older adults who live in subsidized housing have poorer health outcomes, CP@clinic has been implemented in several subsidized housing building across Ontario. A program evaluation of CP@clinic is currently underway to make recommendations to paramedic partner stakeholders regarding program delivery. As part of this evaluation, I sought to understand the association of the number of CP@clinic sessions held per month and EMS calls per apartment unit. De-identified EMS call data were collated from 9 paramedic services across Ontario from February 2015 to December 2019. I conducted a three-level multilevel regression analysis, with EMS calls per apartment unit as the outcome. The primary analysis found that a one-session increase in the number of sessions held per month was associated with an average 2.4% higher incident rate of EMS calls, adjusted for building size. A secondary analysis, with the number of sessions per month as a categorical variable, revealed that two CP@clinic sessions per month had the smallest association with EMS calls, adjusted for building size. Based on these results, it is recommended that paramedic services offer two or more CP@clinic sessions per month. Future research should investigate the factors that impact each services' ability to offer the CP@clinic programme.

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Table of Contents

List of Figures

List of Tables

List of Abbreviations

c-RCT	Cluster randomized-controlled trial
CCM	Wagner’s Chronic Care Model
CP@clinic	Community paramedicine at clinic
CVD	Cardiovascular disease
ED	Emergency department
EMS	Emergency medical services
HRQoL	Health-related quality of life
ICC	Intraclass correlation coefficient
NASEMSO	National Association of State EMS Officials
NOSORH	National Organization of State Offices of Rural Health
NRHA	National Rural Health Association
RCT	Randomized-controlled trial
SES	Socioeconomic status
VIP	Vulnerable Individuals in Primary Care

Declaration of Academic Achievement

Rhiannon Cooper was responsible for all aspects of this thesis, including data analysis, and thesis preparation.

Dr. Ricardo Angeles assisted with data collection in Chapter 2, and all participating paramedic services assisted with data collation.

The thesis committee advised on all aspects of this thesis.

CHAPTER 1 - INTRODUCTION

1.1 Background

Canada is experiencing a demographic shift where older adults are the most rapidly growing population subgroup (1). Older adults experience more chronic diseases than any other age group in Canada, many of which are preventable and manageable (2). Beyond physical health, older adults experience poor mental health, including depression and loneliness, specifically those who are of low socioeconomic status (SES) (3–5). As a result, there is a growing strain on the healthcare system as older adults require more care, but the infrastructure to support their needs is not in place (1,6). One facet of the healthcare system that is experiencing strain in Canada are emergency departments (ED) and emergency medical services (EMS). A cross-sectional study conducted in Nova Scotia found that older adults comprised approximately half of all EMS calls during the study period (7). A study conducted in all states and territories of the United States found that one in three EMS calls were for older adults (8). Relatedly, a prospective study in the United States found that one in six older adults would be re-transported back to the emergency department within 30 days of the initial call to EMS (9). Interventions aimed at preventing frequent EMS calls by older adults are of interest to reduce the burden on paramedics, who transport patients and provide emergency care, we well as ED's.

1.2 Emergency medical services in Canada

In Canada, each province and territory are responsible for their own EMS. As the demand on EMS increases, planning resources to accommodate variability in call volumes is imperative but also difficult (10). However, advances in technology and the collection of large quantities and types of data have enabled EMS agencies to access real-time call volumes and types (10). The increase in availability of EMS data has also allowed for EMS researchers to use call volume and type data to make inferences about population health.

Traditionally, paramedics in Canada practice at four levels: emergency care responder, primary care paramedic, advanced care paramedic, and critical care paramedic (11). As such, paramedics are vital to the operations of Canada's healthcare system, and act as an essential link to further care when required. In Canada, each province and territory define their own scope of practice which introduces variability in practice at both the regional and community level (12).

1.3 Rising Rates of EMS Calls

EMS calls in Canada are rising and are expected to continue rising into the near future (13). In part, this trend may be attributed to the increase in Ontario's population, however, the increase in EMS calls seen is over and above that of the increase in population (13). Older adults have been shown to be frequent users of emergency medical services as they experience high rates of chronic diseases such as diabetes and cardiovascular disease (14–17). In Hamilton, Ontario, the most frequent EMS callers are older adults residing in subsidized housing (18). Health promotion programmes have been proposed to interrupt the trend of rising EMS calls in Canada, and to reduce the burden on EMS and ED's.

1.4 History of community paramedicine

As the healthcare needs of Canadians shift, the role and scope of the paramedic has begun to evolve. Community paramedicine, is an emerging model of care, where paramedics apply their training and skills in a community-based capacity, often branching from the traditional emergency response and transportation model (19). Plans to adopt community paramedicine began in 1996 as the EMS Agenda for the Future proposed that EMS take on an evolved role in the contribution to population health through applying their skills in a community-based environment (20). In 2003/2004 the National Rural Health Association (NRHA), the National Association of State EMS Officials (NASEMSO), and the National Organization of State Offices of Rural Health (NOSORH) tabled a United States national consensus to lead the development of the Rural & Frontier EMS Agenda for the Future, an expansion of the EMS Agenda for the future (21). The agenda was meant to further the integration of paramedics into the rural healthcare system, to address the healthcare challenges faced in rural areas. As the Rural & Frontier EMS Agenda for the Future was in development, other countries and jurisdictions, including Scotland, Australia, and Canada (21), began implementing their own community paramedicine programmes. Internationally, Australia recognized the opportunity to expand the role of paramedics and proposed a rural community paramedicine model of care, incorporating rural community engagement, emergency response, situated practice, and primary healthcare (22,23). In Canada, a rural community paramedicine model was introduced in a population based in Nova Scotia with a high proportion of older adults (24). Both programs saw improved health outcomes post-implementation. Since its initial implementation in rural areas to meet geographical challenges and staffing shortages, many jurisdictions internationally have implemented community paramedicine as a way of addressing the healthcare needs of older adults, who experience high rates of chronic diseases. Early adopters of community paramedicine in the United Kingdom saw community paramedicine as a strategy to reduce unnecessary ED transfers in the older adult population (25). In 2010 a community paramedicine programme was developed in the United States for older adults living in rural areas in order to address their healthcare needs (26). The implementers recognized the need for specific geriatric education for paramedics, as well as allowing paramedics to serve as a link to primary care practitioners (26). Three health domains were assessed by paramedics: falls, depression, and medication management and paramedic services were able to adjust screening based on the needs of the community. They found that the programme served as an effective link between other medical services, allowed for effective screening of high-risk health conditions, and interventions when required. However, an assessment of the impact of community paramedicine on EMS operations had not yet been undertaken in North America. Beyond EMS impacts, community paramedicine was viewed as having the potential to positively affect the health outcomes of older adults, especially the vulnerable population of older adults living in subsidized housing (27).

1.5 The Health of Older Adults Residing in Subsidized Housing

Older adults experience chronic disease at rates that are higher than any other age group in Canada (28). Diabetes and hypertension often go undiagnosed and/or uncontrolled within this population, leading to poorer long-term health outcomes (29,30). Among this population, older adults residing in subsidized housing, who are of low socioeconomic status (SES), experience higher mortality rates and lower health-related quality-of-life (HRQoL) as a result of chronic diseases (31,32). Additionally, this stratum experiences a high risk of falls, diabetes, and cardiovascular disease. Beyond chronic diseases, low-income older adults also experience social isolation and loneliness (33,34).

Preventative measures for poor health outcomes have been investigated for the older adult population. Of note, community-based health promotion programmes that account for diverse socioeconomic backgrounds have been recommended (35). A qualitative study found that mistrust in the healthcare provider-older adult patient relationship was a barrier to older adults receiving necessary care, and that community-based health promotion programmes should focus on building trust (35). Regarding health outcomes, programmes that engage older adults in their own health and wellbeing have been shown to be effective in improving health behaviours, leading to improved health outcomes (36). Early community paramedicine programmes in the United Kingdom and Australia have been shown to improve patient outcomes of older adults and that paramedics can safely practice within a community scope (37). Further community paramedicine programmes were developed and implemented in North America.

1.6 Community paramedicine at clinic

Community paramedicine programmes targeted at addressing the challenges faced in the healthcare system by older adults in North America were implemented Ontario, Canada in the 2000's. In 2010, researchers in the Vulnerable Individuals in Primary Care (VIP) lab at McMaster University took notice of rising 9-1-1 calls in subsidized housing across Hamilton, Ontario (38). With the understanding the older adults in Canada are a growing demographic and often have healthcare needs left unmet by the current system a community paramedicine programme meant for older adults living in subsidized housing was developed (38). The community paramedicine at clinic programme (CP@clinic) allowed modified paramedics, those who are unable to perform traditional duties due to injury or personal limitations, to offer health promotion and primary care prevention sessions for cardiovascular and diabetes risk to older adults living in subsidized housing. The program followed Wagner's Chronic Care Model (CCM) (39), a primary-care model with the overall goal of improving the quality of life for those living with chronic disease(s). Within this framework, six elements are incorporated to ensure linkage between healthcare providers and patients and to ameliorate health outcomes. Delivery system design, self-management support, decision support, clinical information services, community resources and health system organization were taken into the consideration during the design of CP@clinic (40). The adapted framework (Figure 1) positions

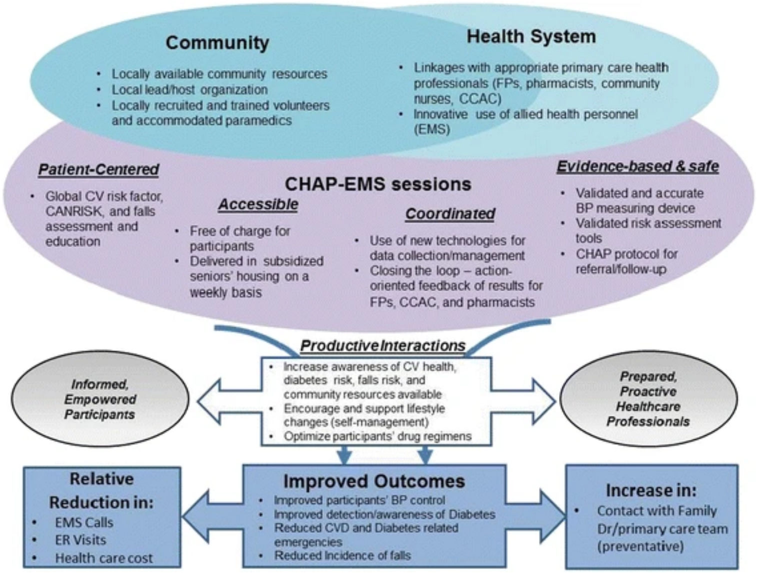

Figure 1: Theoretical Framework for CP@clinic. Agarwal et al., 2015 (41)

resources from at the community and health system level as enabling the CP@clinic sessions (41). The sessions are patient-focused, accessible, coordinated, and evidence-based to allow to optimal outcomes including productive health systems interactions, improved health outcomes, and decreased 9-1-1 calls.

The initial CP@clinic pilot, based in Hamilton, Ontario, led to improved diabetes, cardiovascular disease (CVD) outcomes, and falls outcomes, while also reducing the number of EMS calls within subsidized housing (41). The success of the pilot community paramedicine programme led to its implementation in other municipalities across Ontario. A cluster-randomized controlled trial (c-RCT) of CP@clinic was conducted in five Ontario communities, both urban and rural (42). Weekly drop-in sessions were held for older adults living in subsidized housing where cardiovascular, diabetes and falls risk were assessed. Modified paramedics delivered health promotion and education, while also discussing modifiable risk factors for disease such as tobacco use, diet, and physical inactivity. The primary outcome, number of monthly EMS calls per 100 apartment units, decreased in the intervention group, while health related quality of life improved.

Beyond lowered EMS calls, participants in CP@clinic have expressed the positive impacts the program has had on their physical and mental health (5). Participants noted their current unmet needs in the healthcare system and found that CP@clinic filled a gap in addressing those needs. They also noted that the health promotion portion of the program enabled them to gain an understanding about their health and take control. Having the paramedics in the buildings led to a feeling of social connectedness for some residents, even furthering communication between building residents as they waited for their appointment time.

After the success of the c-RCT, CP@clinic was implemented as a regular health care program and 18 paramedic services have since begun offering the program in various housing buildings across Ontario. Additionally, CP@clinic is currently funded by Health Canada for national scale-up. While the CP research team provides the structure of the program (e.g., training, assessments, paramedic actions) and guidance on implementation (e.g., target populations, settings), each paramedic service ultimately decides on the number of locations and frequency of sessions based on their organizational capacity. In this way, paramedics are deeply involved in the delivery of the programme and are invested in understanding the results of programme.

1.7 Program evaluation

A hallmark of the CP@clinic programme is communication directly back to stakeholders. The impact on EMS calls and health outcomes within each building is available in real-time and is reported back to each paramedic service. As such, program evaluation has become a major aspect to regular delivery of CP@clinic.

Evaluation of public health programmes is an essential aspect to understanding the efficacy of the programme (43,44). Through an evaluation process, implementers can understand if a program is meeting certain outcomes, having the intended impact, and can report findings back to stakeholders (43). Currently, CP@clinic is undergoing a program evaluation to report findings back to paramedic services and funding agencies. In 2020, the CP@clinic team undertook a cost-effectiveness analysis, from the perspective of paramedic services, in order to understand if the program was cost-effective when compared to usual care (45). Indeed, CP@clinic was found to be more cost-effective than usual care in subsidized housing.

However, more questions remain to be answered surrounding aspects of the programme operations. Since each paramedic service is responsible for organizing and delivering the programme, there is variability in delivery. One parameter that greatly varies between buildings is the number of sessions offered by paramedics. The resources and number of staff available to operate the programme may impact how many sessions are able to be held in each building.

1.8 Current study

The impact of the variability of the number of sessions held between buildings and locations on 9-1-1 calls is of interest. From a program evaluation standpoint, understanding the impact of the number of sessions on 9-1-1 calls would allow for each paramedic service to adjust delivery of CP@clinic accordingly. Therefore, the primary research question to be answered by this project is: **what is the association of the frequency (sessions per month) of CP@clinic sessions and the rate of monthly EMS calls, adjusted for building size?** To expand on this research question further, a secondary question will be asked: **what is the association between each number of CP@clinic sessions per month and the rate of monthly EMS calls, adjusted for building size?** Through considering clustering both at the regional and building level, the findings of this study will be communicated back to stakeholders to help paramedic services optimize their programme delivery.

CHAPTER 2 – METHODS

2.1 Study Design and Setting

We conducted a retrospective analysis of building-level repeated measures EMS call data from nine regions across Ontario, Canada: Guelph, Hamilton, Sudbury, York, Peel, Halton, Grey, Timmins, and Essex-Windsor (Figure 2). Each region is served by its own paramedic service and all services delivered the CP@clinic program in subsidized housing buildings. The unit of study is subsidized housing buildings clustered within each of the nine regions and buildings are occupied by older adults aged 55 and over. The subsidized housing buildings included in this analysis had admission policies that only allowed for adults 55 years of age or older, therefore allowing the population to consist of only older adults.

2.2 Measures

EMS data were collated by each paramedic service from their individual databases for the timeframe of January 2013 to December 2019. The initial wide timeframe was intended to capture the variation in CP@clinic start date between buildings and regions. Each subsidized housing building was assigned a unique ID to eliminate identifying information. A Research Associate in the VIP research lab contacted each paramedic service with a data request to obtain the data.

Each region, and buildings within regions, began and ended CP@clinic delivery at varying times. Due to the complexity of numerous timelines, I generated a Gantt chart to visualize the time each building within regions began and ended the implementation of CP@clinic. The CP@clinic research team conducted an RCT involving multiple Ontario regions from 2014 to 2016. Post-RCT, CP@clinic began to scale-up across Ontario. Guelph, Hamilton, Sudbury, and York participated in this post-RCT period. During this time, CP@clinic continued to be implemented in each building in an unstructured manner. This meant that the paramedic services had discretion over the

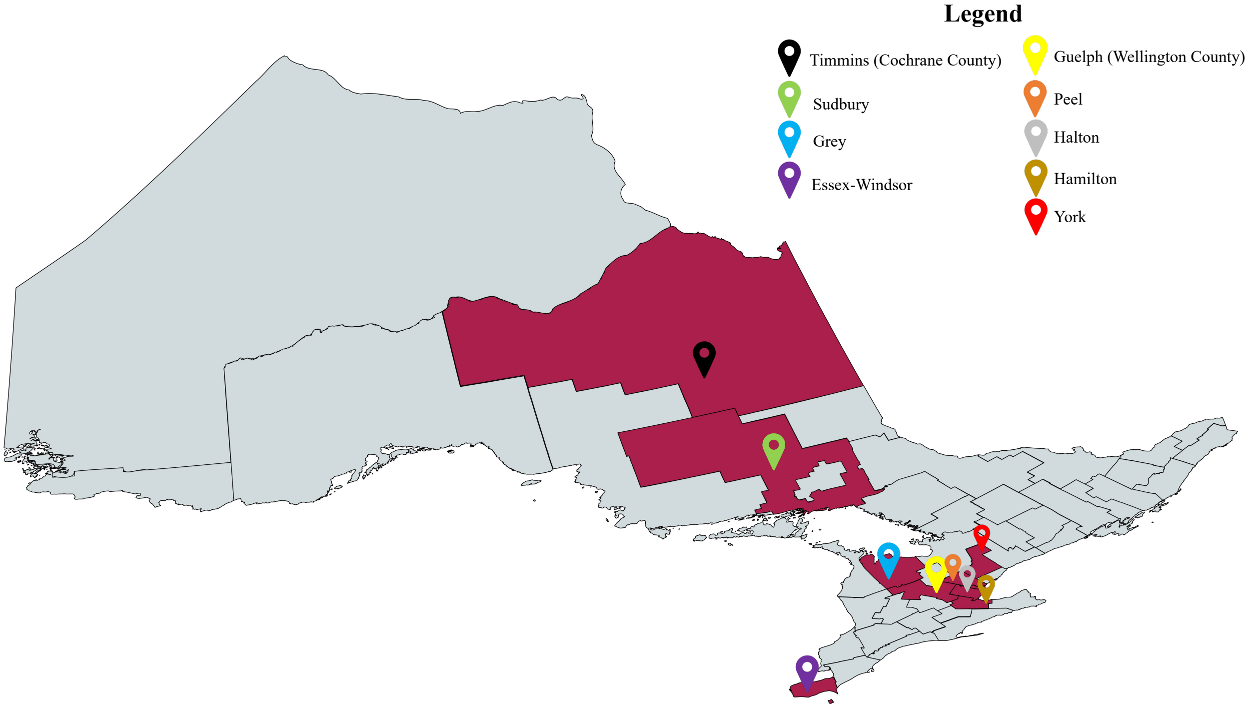

Figure 2: Map of Ontario: Regions Included in the Analyses

frequency of sessions and staffing levels based on their organizational capacity and resources. Therefore, to understand the real-world, unstructured association of the number of CP@clinic sessions on EMS calls, only post-randomized-controlled trial (RCT) intervention data was included for Guelph, Hamilton, Sudbury, and York. Peel, Timmins, Grey, Halton, and Essex-Windsor did not participate in an RCT period. As a result, programme delivery was at the discretion of the paramedic services from each of their programme initiation. Every non-RCT building began contributing time to the dataset at their first CP@clinic session. All buildings, regardless of RCT status, contributed time to the dataset until December 2019 even if the sessions ended prior to this date.

The key independent variable of interest, the number of CP@clinic sessions held per month, was collated from the CP@clinic database for the full period of January 2013 to December 2019. Potential confounders included the number of apartment units per building and the number of staff operating the sessions. The number of apartment units was obtained from CP@clinic records. Data pertaining to the number of staff operating each session was not collected on a regular basis by either the paramedic services or the CP@clinic team for non-RCT regions. To obtain this information, I contacted the CP@clinic coordinator at each paramedic service directly and asked: “On average, how many staff delivered CP@clinic sessions from the timeframe of January 2013 to December 2019?”.

Since larger buildings experience higher call volumes than smaller buildings, building size was a direct confounding variable. As such, the outcome was analyzed as a rate through the addition of an offset variable for number of apartment units. The buildings included in the analysis ranged from having 22 apartment units to 536 apartment units and standardizing the outcome is in accordance with previous work by the CP@clinic research team (42).

2.3 Data Analysis

I conducted an exploratory analysis of the data through descriptive statistics calculations and visualizations of the EMS call trajectory over time. Means and standard deviations were used to summarize all building-level measures. Distributions of each variable were visualized, and an empirical growth plot was made to visualize the change in EMS calls over time in each building and location.

The data were structured at different levels with repeated measures nested within buildings, nested within regions (Table 1, Figure 3). As such, multilevel modeling was deemed an ideal analysis technique for its capabilities in accounting for clustering. Multilevel modeling allows the hierarchal

Table 1: Multilevel diagram

Sub-Index	**Level**	**Variables**
i (9)	Region	Region (e.g., Hamilton, Guelph etc.)
j (64)	Building	Building ID
t (2346)	Repeated measures	Number of sessions held per month Number of staff*
		Dependent variable: Monthly EMS calls per unit

Note: * denotes potential confounder

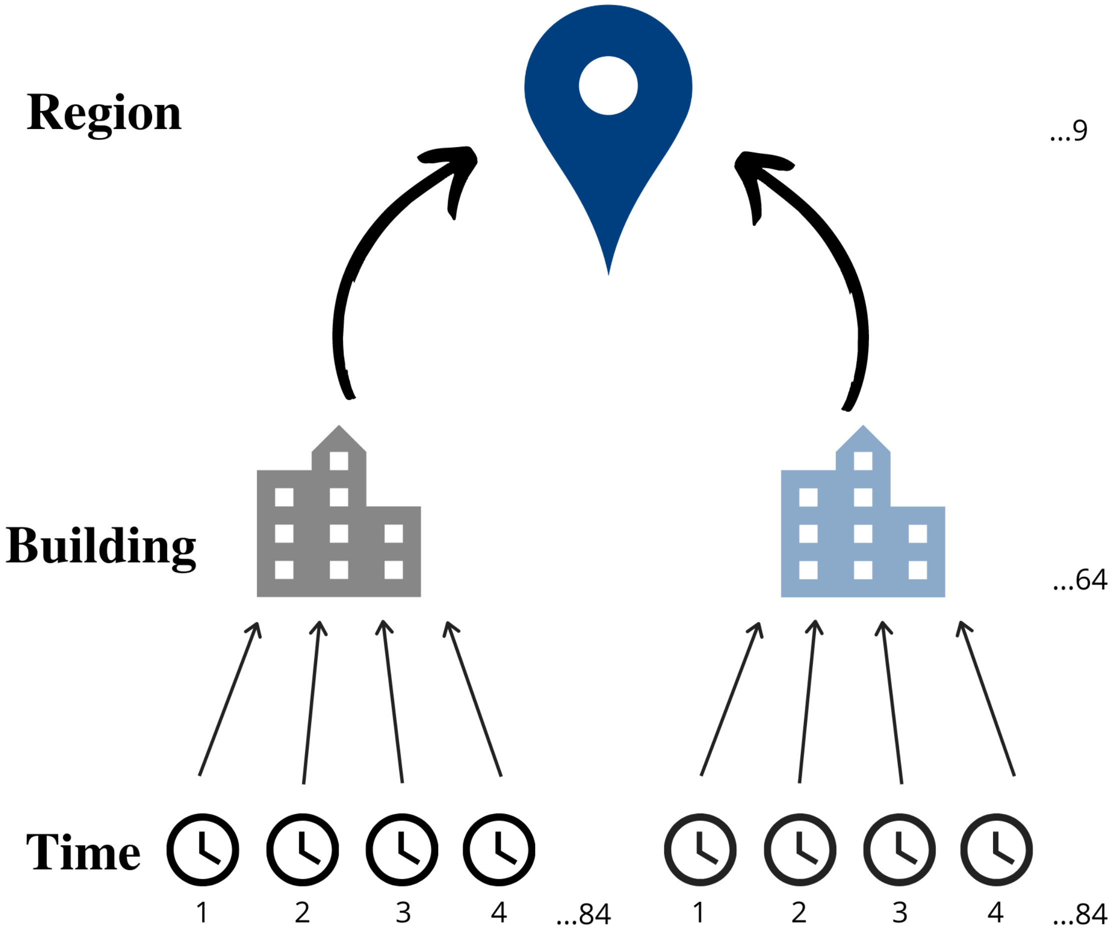

Figure 3: Multilevel data structure

data structure to be taken into account when measurements within and between groups are highly correlated, such as in repeated measures designs (46). Clusters are hierarchical in the sense that each cluster is placed at a different level, where the outcome is measured at the lowest level and is nested within higher levels (e.g., students within classes within schools).

Multilevel models are mixed effects models, meaning both random and fixed effects are measured. Conversely, fixed effects models, such as simple linear regression, only measure fixed effects. The random portion of the multilevel model is what allows different levels within the data and includes both random intercepts, to allow for varying starting points, and random slopes, to allow for different trajectories between groups. Random intercepts and slopes can be defined where clusters are allowed to have different intercepts and/or relationships with the dependent variable.

The negative binomial distribution was selected as the optimal distribution to fit the outcome data, as the data were positively skewed. A Poisson distribution was initially investigated, but upon comparisons (visualization of distribution fit, likelihood ratio test) the negative binomial distribution was better suited due to overdispersion, and poorer model fit in the Poisson model.

To assess the degree to which clustering was present, two null negative binomial mixed models were compared. The first model, with no independent variables, was a two-level model including clustering only at the building-level, the outcome number of EMS calls, and apartment units as an offset. The second model was a three-level negative binomial multilevel model, accounting for clustering at the building level and region level. The equations for the null two-level multilevel model (with negative binomial distribution) are written in Raudenbush and Byrk (2002) format as (47):

Level 1: (1.1)

$$\log(Y_{ij}) = \pi_{ij} + \varepsilon_{ij}$$

In equation 1.1, I modelled the rate of EMS calls per apartment unit as a function of building mean and random error. Here, Y_{tij} represents the rate of monthly EMS calls at time (adjusted for building size) i and building j, π_{0ij} is the average monthly rate of EMS calls for building i, and ε_{ij} is the random effect of time, or the deviation any repeated measure from the building mean. The building-level equation is presented as:

Level 2: (1.2)

$$\log(\pi_{ij}) = \beta_{0j} + r_{ij}$$

In equation 1.2, I modelled the rate of monthly EMS calls per apartment unit as randomly varying around a building average. Here, π_{ij} represents each building (level 2) mean, β_{0j} is the mean monthly rate of EMS calls (adjusted for building size) in building j, and r_{ij} is the random building effect, or the deviation of any building's mean from the overall mean.

Through substitution, the full equation for the two-level null model can be written as:

$$\log(Y_{ij}) = \beta_{0j} + r_{ij} + \varepsilon_{ij} \tag{1.3}$$

The equations for the null three-level multilevel model (with a negative binomial distribution) are written in Raudenbush and Byrk (2002) format as (47):

Level 1: (2.1)

$$\log(Y_{tij}) = \pi_{0ij} + \varepsilon_{tij}$$

In equation 2.1, I modelled monthly EMS calls per apartment unit as a function of building mean and random error. Here, Y_{tij} represents the rate of monthly EMS calls at time t in building i and region j, π_{0ij} is the average rate of monthly EMS calls (adjusted for building size) of building i and region j, and ε_{tij} is the random effect of time, or the deviation any repeated measure from the building mean. The building-level equation is presented as:

Level 2: (2.2)

$$\log(\pi_{0ij}) = \beta_{00j} + r_{0ij}$$

In equation 2.2, I modelled the buildings individual means as randomly varying around a region average. Here, π_{0ij} represents each building (level 2) mean, β_{00j} is the mean monthly rate of EMS calls (adjusted for building size) in region j (the intercept), and r_{0ij} is the random building effect, or the deviation of any building's mean from the region mean. The region level equation is presented as:

Level 3: (2.3)

$$\log(\beta_{00j}) = \gamma_{000} + u_{00j}$$

In equation 2.3, the region-level variability is measured. Here, β_{00j} is the region means which varies randomly around an overall mean, γ_{000} is the overall mean, and u_{00j} is the random region effect, or the deviation from any region's mean from the overall mean. Through substitution, the full equation for the three-level null model can be written as:

(2.4)

$$\log(Y_{tij}) = \gamma_{000} + u_{00j} + r_{0ij} + \varepsilon_{tij}$$

To assess the degree to which clustering was present, the intraclass correlation coefficient of both models was assessed to understand how much each level contributed to the variation in 9-1-1 calls, adjusted for building size. I also conducted a likelihood ratio test to compare goodness-of-fit for both null models.

2.3.1 Model Specification

Since the research question is focused on the association of the number of CP@clinic sessions held per month and the number of EMS calls per apartment unit, a primary model to address the question was constructed. I applied the hypothesized optimal clustering structure to the primary model, the negative binomial distribution. A sensitivity analyses was conducted to understand the impact of adjusting for confounders and different clustering structures on the estimate for the impact of the number of sessions per month on EMS calls per unit. Adjusting for staff allowed us to account for potential confounding with the key independent variable of interest and omitting the third-level allowed me to see any differences with the primary model. A random slope model was considered, as both building and region-level variation was present (Appendix A, Figure 6 & 7), however due to inadequate power the model was singular and had convergence issues, potentially leading to untrustworthy coefficients and standard errors (48). Subsequently, the random slope model was omitted from the analysis. A comparison of the goodness-of-fit statistics (AIC, -loglik, and deviance) between the primary model and all models from the sensitivity analyses was also conducted through a likelihood ratio test.

To address the secondary research question, a secondary model was generated where the number of sessions held per month was a categorical variable. This allowed for the individual associations of the number of sessions held per month on monthly EMS calls, adjusted for building size, to be elucidated. The reference category was zero CP@clinic sessions per month. The same sensitivity analysis was conducted for the secondary model. Regression coefficients are presented as incident rate ratios and interpreted as percent rate increases.

All analyses were conducted in R 4.0.4 (49).

2.4 Ethical Considerations

The current project employed de-identified, building-level data and is a quality improvement study. This project falls under the ethics approval (approval number 11078) for the national scale-up for CP@clinic. Several ethics considerations exist, mostly in the interpretation of results. CP@clinic has been shown to improve the health outcomes of older adults living in subsidized housing, while also reducing the burden on EMS through the reduction of EMS calls (5,41,42). The results of the following analysis will be relayed back to stakeholders to help inform CP@clinic programme delivery. As a result, inferences made in the analysis will inform the number of CP@clinic sessions that each paramedic service offers. Should incorrect inferences be drawn, a sub-optimal recommendation could be offered to paramedic services, creating discrepancy in the benefits the older adult population could be experiencing from the programme.

CHAPTER 3 - RESULTS

Initially, repeated measures for 76 buildings within 10 regions were obtained from each paramedic service. However, 12 buildings were excluded from the analysis due to cessation of CP@clinic programme directly after their RCT period (i.e., no unstructured programme delivery occurred). This led to the exclusion of one region as the programme delivery stopped directly after the RCT. In total, 64 buildings across 9 regions in Ontario were included in the analyses. Guelph had 13 buildings, 7 were in Hamilton, 4 were in Sudbury, 4 were in York, 4 were in Peel, 7 were in Halton, 4 were in Grey, 8 were in Timmins, and 5 were in Essex-Windsor. In total, there were 2349 repeated measures. Three repeated measures were missing or 0.12% of total outcome data. Due to only a very small proportion of data being missing, complete case analysis was followed.

The number of observations in each building was important to consider in this multilevel analysis. If each building had a small number of repeated measures, then the overall estimate may weigh towards the overall average, and lead to a minimized estimate of the between-building and building-region variance (50). Of the 64 buildings included, 100% had at least 10 repeated measures, and 64% had at least 30 repeated measures.

3.1 Descriptive Statistics

The average EMS calls per unit was 0.051 calls per month, while the average of the number of sessions held per month was 1.96 (Table 2). Buildings had 116.6 units, on average, and one staff operated the programme on average. Figure 4 shows the distribution of the key independent variable of interest, number of sessions held per month. There were several time points where no sessions took place because

Table 2: Descriptive Statistics of the outcome, key variable of interest, and potential confounders.

Variable	**Number of repeated measures**	**Mean**	**Standard Deviation**	**Minimum**	**Maximum**
EMS calls	2346	0.051	0.54	0	0.7
Number of sessions per month	2349	1.96	2.09	0	10
Staff	2349	1	0.97	0	4
Time (Months)	2349	63.8	13.26	26	84
	Number of observations	**Mean**	**Standard Deviation**	**Minimum**	**Maximum**
Building size (# units)	64 buildings	116.58	103.67	22	536
Region	9 regions	-	-	-	-

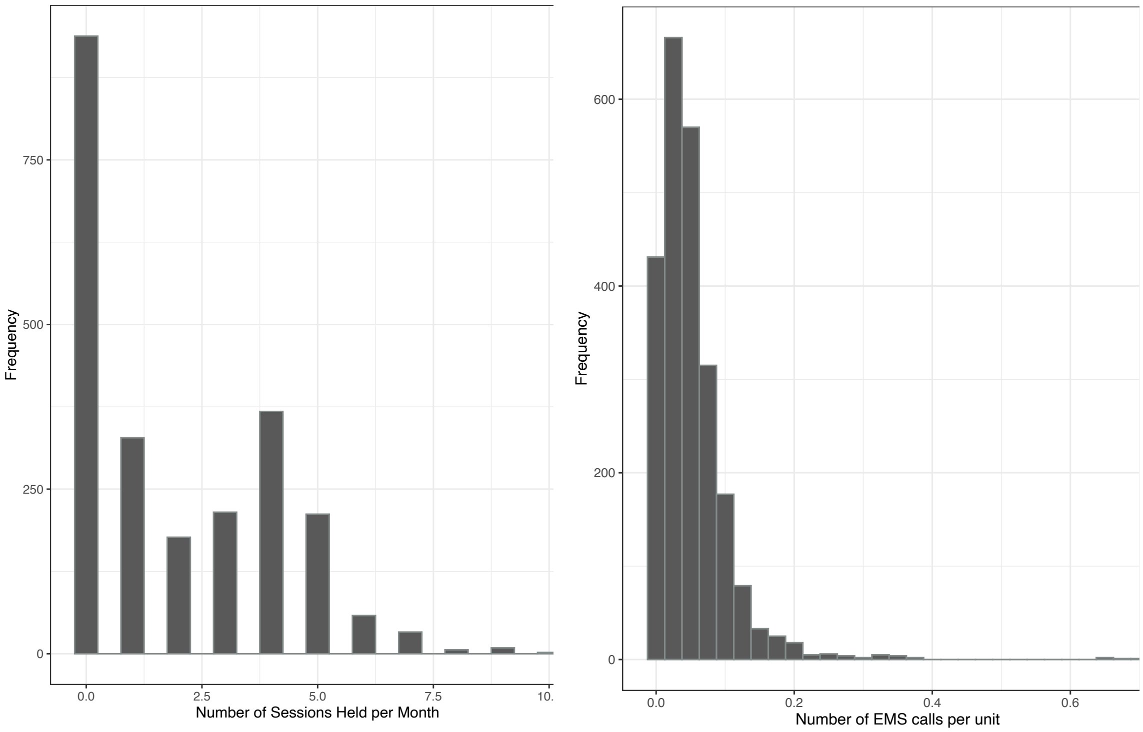

Figure 4: Distribution of key independent variable, Number of Sessions held per Month (left) and outcome, EMS calls per unit (right)

Note: Staff variable was displayed due to minimal variation.

of the inclusion of post-implementation data. Despite this, there is variation in the frequency of CP@clinic sessions held per month (Figure 4).

3.2 Clustering Structure

To construct the primary multilevel model, I first investigated whether applying a multilevel structure to account for clustering was appropriate. For the two-level null model, where level 1 = repeated measures and level 2 = building, the ICC value, or the proportion of total variance in monthly EMS calls per unit accounted for by clustering in buildings, was 0.210. For the three-level null model, where level 1 = repeated measures, level 2 = building, and level 3 = region, the proportion of total variance accounted for by clustering within buildings increased to 0.634 and the proportion of total variance accounted for by clustering within regions was 0.156. I conducted a likelihood ratio test to compare the goodness-of-fit statistics of both null models and found that the three-level null model had a significantly improved fit when compared to the two-level null model ($p<0.05$). Since correlation between regions existed, although modestly, and the three-level null model had significantly improved fit, I allowed both region and building to have random intercepts in the primary model through a three-level model.

3.3 Results of Primary Analysis

The primary model used to answer the research question was a three-level negative binomial mixed effects model. The dependent variable was monthly EMS calls, adjusted for number of apartment units, and the independent variable was the number of CP@clinic sessions held per month. The multilevel regression results for the primary model are presented in table 3 and estimates are visually displayed in figure 5.

Table 3: Primary research question: Results of multilevel regression analysis

Parameter	**Primary Model**		**Adjusted for Staff**		**Two level model**	
Offset: Number of apartment units	*Estimate* [95% CI]	*p-value*	*Estimate* [95% CI]	*p-value*	*Estimate* [95% CI]	*p-value*
Fixed						
Intercept	0.046 [0.036-0.060]	<0.01*	0.043 [0.035-0.053]	<0.01*	0.044 [0.038-0.051]	<0.01*
Number of sessions per month	1.024 [1.0063-1.042]	0.0078*	1.0013 [0.97-1.024]	0.90	1.026 [1.0083-1.044]	0.0038*
Staff	-	-	1.098 [1.040-1.16]	0.0021*	-	-
Random						
Intercept variance (Buildings)	1.28 [1.22-1.36]		1.28 [1.21-1.34]		1.36 [1.25-1.40]	
Intercept variance (Location)	1.069 [1.00-1.32]		1.056 [1.00-1.21]		-	-

*Indicates significance (p<0.01)

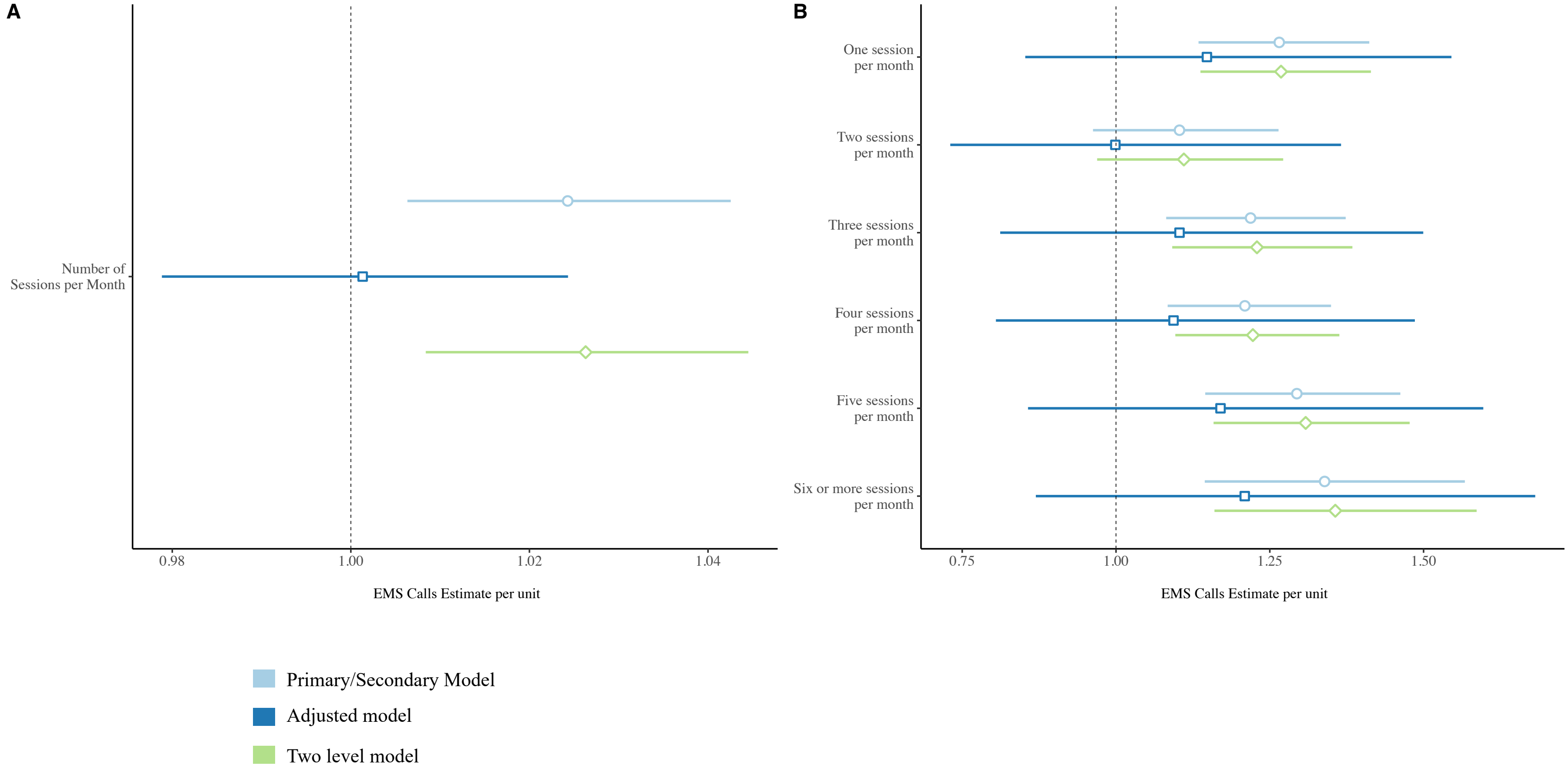

Figure 5: Estimated effect of the number of sessions per month on monthly EMS calls, adjusted for building size

Figure A: Estimates for primary model & sensitivity analysis. Figure B: Estimates from secondary model & sensitivity analysis.

The fixed effects portion of the regression model estimated that every one-session increase in the number of CP@clinic sessions held per month was associated with an average 2.4% higher incident rate of EMS calls, adjusted for building size [95%CI 0.63-4.2%, p =0.0078]. There was between-building variation in the rate of EMS calls per unit (1.28) and between-region variation in the number of EMS calls per 100 units (1.0069). The AIC value was 11197.5, the negative log-likelihood value was -5593.8, and the deviance was 11187.5.

3.4 Results of Sensitivity Analysis

The multilevel regression results for the sensitivity analyses are presented in table 3 and all estimates visually displayed in figure 5.

3.4.1 Adjusted Model

The first model in the sensitivity analysis was adjusted for a potential confounder: number of staff operating the programme. After adjusting for the number of staff operating the programme, every one-session increase in the number of CP@clinic sessions held per month was associated with an average 0.13% higher incident rate of EMS calls, adjusted for building size [95%CI -3.0-2.4%, p=0.90]. This was a smaller estimate of association when compared to the primary model. The between-building variation in the rate of EMS calls was 1.28, and the between-region variation in the rate of EMS calls was 1.056. A likelihood ratio test found that the adjusted model had significantly improved goodness-of-fit when compared to the primary model (p<0.01).

3.4.2 Ignoring the third level

The second model in the sensitivity analysis was a two-level negative binomial generalized model, omitting the third region level. Here, a one-session increase in the number of CP@clinic sessions was associated with an average 2.5% higher incident rate of EMS calls, adjusted for building size [95%CI 0.83-4.4%, p=0.0038]. A likelihood ratio test found no significant difference in goodness-of-fit between the two-level generalized mixed model and the initial primary model.

3.5 Results of Secondary Research Question

Regression results for the secondary research question, what is the association between each number of CP@clinic sessions per month and monthly rate of EMS calls, are presented in table 4. Figure 5B presents a plot of the estimates for the number of sessions held per month for each model. One CP@clinic session per month was associated with an average 25% higher incident rate of EMS calls, adjusted for building size [95% CI 2, p<0.01]. Two CP@clinic sessions per month was associated with an average 7.5% higher incident rate of EMS calls, adjusted for building size [95% CI -6-21%, p = 0.28]. Three CP@clinic sessions per month was associated with an average 17% higher incident rate of EMS calls per unit [95% CI 4.3-32%, p <0.0060]. Four CP@clinic sessions per month was associated with an average 15% higher incident rate of EMS calls, adjusted for building size [95% CI 4.0-27%, p <0.0064]. Five CP@clinic sessions per month was associated with an average 23% higher incident rate of EMS calls, adjusted for building size [95% CI 11-37%, p<0.01]. Six or more CP@clinic sessions per month was associated with an average 27% higher incident rate of EMS calls, adjusted for building size [95% CI 9.3-48%, p=0.0018]. The variation in the rate ratio at the building level was 1.27 and 1.068 at the region level.

Table 4: Secondary research question: Results of multilevel regression analysis

Parameter	**Secondary Model**		**Adjusted for Staff**		**Two level model**	
Offset: Number of apartment units	*Estimate* [95% CI]	*p-value*	*Estimate* [95% CI]	*p-value*	*Estimate* [95% CI]	*p-value*
Fixed						
Intercept	0.043 [0.034-0.053]	<0.01*	0.043 [0.035-0.054]	<0.01*	0.041 [0.035-0.048]	<0.01*
One session	1.25 [1.12-1.38]	<0.01*	1.12 [0.90-1.41]	0.42	1.25 [1.12-1.39]	<0.01*
Two sessions	1.075 [0.94-1.21]	0.28	0.97 [0.77-1.23]	0.85	0.082 [0.94-1.22]	0.25
Three sessions	1.17 [1.043-1.32]	0.0060*	1.060 [0.84-1.31]	0.70	0.18 [1.061-1.31]	0.0039*
Four sessions	1.15 [1.040-1.27]	0.0064*	1.038 [0.84-1.31]	0.80	0.16 [1.044-1.28]	0.0036*
Five sessions	1.23 [1.11-1.37]	<0.01*	1.11 [0.89-1.41]	0.50	1.24 [1.10-1.40]	<0.01*

Six or more sessions	1.27 [1.093-1.48]	0.0018*	1.14 [0.88-1.48]	0.42	1.28 [1.10-1.48]	0.0011*
Staff	-	-	1.061 [0.93-1.18]	0.47	-	-
Random						
Intercept variance (Buildings)	1.27 [1.21-1.34]		1.27 [1.21-1.34]		1.34 [1.24-1.37]	
Intercept variance (Location)	1.068 [1.00-1.22]		1.060 [1.00-1.22]		-	

*Indicates significance (p<0.01)

3.5.1 Adjusted model

After adjusting for the number of staff operating the program, one CP@clinic session was associated with an average 12% higher incident rate of EMS calls, adjusted for building size [95% CI -10-41%, p=0.42]. Two CP@clinic sessions were associated with an average 3.0% higher incident rate of EMS calls, adjusted for building size [95%CI -23-23%, p=0.85]. Three CP@clinic sessions were associated with an average 6.0% higher incident rate of EMS calls, adjusted for building size [95%CI -15-32%, p=0.70]. Four CP@clinic sessions were associated with an average 3.8% higher incident rate of EMS calls, adjusted for building size [95% CI -16%-31%, p=0.80]. Five CP@clinic sessions were associated with an average 11% higher incident rate of EMS calls, adjusted for building size [95% CI -11-41%, p=0.50]. Six or more CP@clinic sessions was associated with an average 14% higher incident rate of EMS calls, after adjusting for building size [95% CI -12-48%, p=0.42]. The variation at the building level in rate ratio of EMS calls was 1.27 and the variation at the region level was 1.060. There was no significant difference in goodness-of-fit between the initial secondary model and the adjusted model.

3.5.2 Two-level model

The second model in the sensitivity analysis was a two-level generalized mixed model, omitting the third level of region. One CP@clinic session per month was associated with an average 25% higher incident rate of EMS calls, adjusted for building size [95% CI 12-39%, p<0.01]. Two CP@clinic sessions per month was associated with an average 8.2% higher incident rate of EMS calls, adjusted for building size [95% CI -6-

22%, p = 0.25]. Three CP@clinic sessions per month was associated with an average 18% higher rate of EMS calls, adjusted for building size [95% CI 6.1-31%, p <0.0039]. Four CP@clinic sessions per month was associated with an average 16% higher incident rate of EMS calls, adjusted for building size [95% CI 4.4-28%, p <0.0036]. Five CP@clinic sessions per month was associated with an average 24% higher incident rate of EMS calls, adjustefd for building size [95% CI 10-40%, p<0.01]. Six or more CP@clinic sessions per month was associated with an average 28% higher incident rate of EMS calls, adjusted for building size [95% CI 10-48%, p=0.0011]. The variation in the rate ratio at the building level was 1.34. There was no significant difference in goodness-of-fit between the initial secondary model and the two-level model.

Chapter 4 - Discussion

4.1 Interpretation of Results

The current study was a retrospective multilevel analysis of building-level EMS data during a period of unstructured CP@clinic implementation. I found that variation within buildings accounted for 63.4% of variation in the rate of monthly EMS calls (adjusted for building size), while regions accounted for 15.6% of variation in the rate of monthly EMS calls (adjusted for building size). A smaller ICC in regions indicates that repeated measures within buildings are more alike than repeated measures within regions. This is expected as residents within the same building may have similar characteristics, whereas more variation exists in resident characteristic at the region level. Most regions included in the analysis were in large, urban centers. However, some buildings may have been more rural than others, or further away from health care services. This may account for the lower correlation between observations at the region-level, as urban-rural living can have impacts on the health outcomes of older adults (51). Additionally, different subsidized housing buildings may have different admission policies. This can also contribute to residents within the same building being more alike, as the residents will share a variety of characteristics. Since there was apparent clustering at both the building and region level, a three-level primary model was employed to answer the primary research question. Overall, there was no consistent association between the number of CP@clinic sessions and EMS calls across models, which evident in table 3.

4.1.1 Primary Model

The primary model revealed that the number of sessions held per month was associated with an average 2.4% higher incident rate of EMS calls, adjusted for building size. As previously stated, Ontario is experiencing a trend of rising EMS calls (13). The current study did not account for time, making any inferences cross-sectional in nature rather than longitudinal. As such, the increase in EMS calls seen in the primary model reflects an overall increase in EMS calls across buildings and regions, associated with the number of sessions per month, rather than a growth over time. This increase may be contributed to by the trend of rising EMS calls in Ontario, but also by the fact that paramedic services were not implementing the programme per RCT protocol. Each paramedic service implemented the programme in an unstructured manner. In this way, there may have been several months where CP@clinic was not offered, potentially diminishing the beneficial impacts on the outcome. Conversely, it is possible that the frequency of the programme could be associated with preventing a larger increase in the rate of EMS calls, given that we know CP@clinic can lead to improved EMS outcomes (42).

Additionally, the increase in EMS calls per unit associated with the frequency of CP@clinic sessions may be explained by more sessions being held in buildings with increased need (i.e., more apartment units). Out of all 64 buildings, 42% had 100 or more apartment units and 57% had less than 100 units. Upon visualization (Appendix B, Figure 8), buildings with 100 or more units had more sessions compared to smaller buildings. Specifically, buildings with 100 or more units had a mean session frequency of 2.88 while buildings with less than 100 units had a mean session frequency of 1.39. Further to this, larger buildings (>=100 units) had a higher average rate of EMS calls per unit (0.062) than smaller buildings (<100 units) at 0.044. Taken together, the finding that number of sessions is positively associated with EMS calls per unit may be in part explained by larger buildings hosting more sessions and having more EMS calls than smaller buildings.

After adjusting for the number of staff operating the programme, the estimate for the association between the number of sessions held per month and EMS calls decreased. Here, a one-session increase in CP@clinic per month was associated with an average, non-significant 0.13% higher incident rate of EMS calls, adjusted for building size. The number of staff operating the program is under the jurisdiction of each individual paramedic service and varies according to region. Several unmeasured factors may have influenced the decision of how many staff should operating the programme. Resources, including funding and infrastructure, may be a limiting factor for paramedic services in their ability to supply staff for programme operation. Organizational capacity, including number of paramedics employed and capacity for upper management to organize sessions, may lead to a smaller number of staff operating the programme. Paramedic services may deploy more staff to the buildings or regions with the most need, congruent with regions who are experiencing higher rates of EMS calls. This is reflected in results, as the model estimated that increasing the number of staff by 1, was associated with an average 9.8% higher incident rate of EMS calls, adjusted for building size.

The two-level generalized mixed model, without region as a third level, found that a one-session increase in the number of sessions held per month led to an average 2.6% in higher incident rate of EMS calls, adjusted for building size. This estimate was larger than that of the primary model and the model did offer improved goodness-of-fit. Notably, the variance across buildings intercepts rose to 1.36 from 1.28 in the primary model. This highlights the validity of capturing all clusters within the data. Omitting a level of clustering can lead to an increased risk of type I error, underestimating standard errors, and leading to narrow confidence intervals (52). Therefore, the smaller p-values obtained from this model could be explained by ignoring the correlation of repeated measures within regions.

4.1.2 Secondary Model

The secondary model, with the number of sessions per month as a categorical variable, was employed to understand the association of each individual number of sessions per month with the number of EMS calls, adjusted for building size. Two CP@clinic sessions per month was associated with the smallest increase in the number of EMS calls, at an average 7.5% higher incident rate of EMS calls, adjusted for building size. Conversely, six CP@clinic session per month was associated with the highest average rate of EMS calls, at 27%. Since there has been no previous studies regarding optimal dose of community paramedicine programmes, no comparisons to other programmes can be drawn. However, it was expected that a higher number of sessions per month would be associated with a smaller increase in the rate of monthly EMS calls. Unexpectedly, as the number of sessions per month increased, as did the number of EMS calls per unit. This finding ties back into the unstructured nature of CP@clinic delivery and the results of the primary analysis. As previously discussed, buildings and regions with increased need (i.e., high EMS user buildings and larger buildings) may deliver the programme on a more frequent basis, accounting for the increase in EMS calls per unit as sessions increase.

After adjusting for the number of staff operating the programme, the estimates of the association decreased. However, the findings remain consistent with the initial secondary model; two CP@clinic sessions per month leads to a lowered incident rate of EMS calls (-3.0%) while six session per month leads to the highest incident rate of EMS calls (14%), after adjusting for building size. As the number of sessions increase, the association begins to increase as well. These findings are also congruent with the primary analysis, as adjusting for staff led to a lowered rate of EMS calls. In both the adjusted and unadjusted version of the secondary analysis, two CP@clinic sessions per month is associated with the most optimal outcome: a lowered or only slightly higher incident rate of EMS calls. However, any frequency per month may be associated with lower EMS calls than would have previously been expected given the rising trend of EMS calls in Ontario (13).

4.2 Limitations

The current study is not without limitations. Since the data were collated from each paramedic service and their data practices are not known, the accuracy of the data cannot be elucidated. Also, since the number of staff operating each programme was an average based on each service's recollection, this data may not accurately reflect the actual staffing levels during the time frame. A more accurate estimate could be obtained if the data were more granular, and at the building level rather than the region level. However, such data were not available for the current project. The confounder of building size was adjusted for by including offsetting the model for building size, essentially turning the outcome into a rate. The number of building units does not reflect the flux in the number of residents within in building. As a result, the estimate for the association between number of sessions and monthly EMS calls may be confounded by a growth or decrease in the number of residents during the time frame of the study. Also, despite using data from the post-RCT period only (for buildings that participated in an earlier RCT period), there may residual influence from the RCT period in the programme delivery and monthly EMS calls, meaning that paramedic services may continue delivering the programme at the frequency recommended during the RCT period.

4.3 Future Directions

The current study spanned the timeframe of January 2013 to December 2019, just before the coronavirus disease 2019 (COVID-19) pandemic. During this time, CP@clinic was suspended for a period throughout the first lockdown. Future research could examine the impact of CP@clinic programme interruptions on EMS calls. As such, the current study may act as a baseline and may be useful as a "pre" period to compare call volumes during a time where CP@clinic was not in operation. Additionally, the same analysis could be undertaken after adjusting for urban vs. rural regions, or distance to the emergency department. This may provide insight into the association between geography and CP@clinic programme delivery. Additionally, including time into the multilevel model would allow repeated measures to be treated as separate time points, rather than cross-sectionally, and would be interesting for further investigations. Beyond quantitative research, further qualitative studies would also clarify the factors influencing paramedic services' ability to delivery CP@clinic.

4.4 Conclusions

The current association study was a retrospective multilevel analysis of de-identified EMS service data. I found that the number of CP@clinic sessions held per month was associated with an average 2.4% higher incident rate of EMS calls, adjusted for building size. However, after adjusting for the number of staff operating the programme, this estimate decreased. Two CP@clinic sessions per month was associated with a higher incident rate of EMS calls, but after adjusting for the number of staff operating the programme, was associated with a lowered incident rate of EMS calls, adjusted for building size. Six CP@clinic session was associated with the highest incident rate of EMS calls, adjusted for building size. Taken together, it is recommended to paramedic partners that, given resources are available to them, more than one CP@clinic session should be held per month in subsidized housing. One session per month was associated with the highest incident rate of EMS calls, adjusted for building size, that was over and above all other sessions frequencies except for six sessions. As such, more than one session held per month may be associated with lower EMS call rates and lead to reduced health system strain. However, since more CP@clinic sessions are associated with higher incident rate ratios, EMS may see higher EMS calls in certain buildings potentially due to factors outside of the CP@clinic programme. Taken together, further research is needed to understand paramedic service contexts and resources, so that recommendations may consider organizational capacity. The current thesis was a beginning of a long program evaluation process to be carried out in the future. Analyses are underway to ensure that the interpretation can be longitudinal in nature, rather than cross-sectional in order to draw more meaningful conclusions for the paramedic services.

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APPENDICES

APPENDIX A

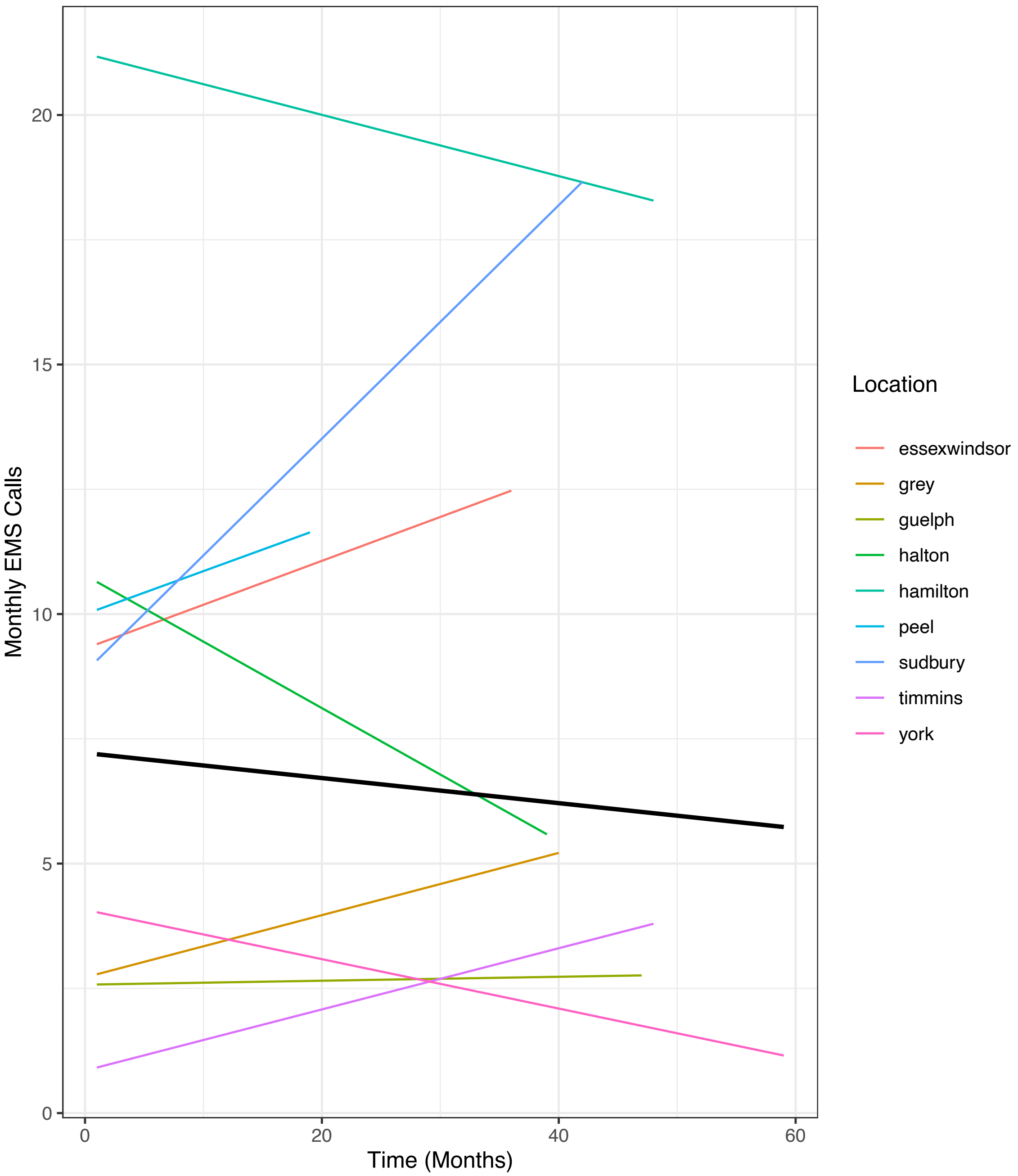

Figure 6: Trajectory of EMS calls over time, stratified by region

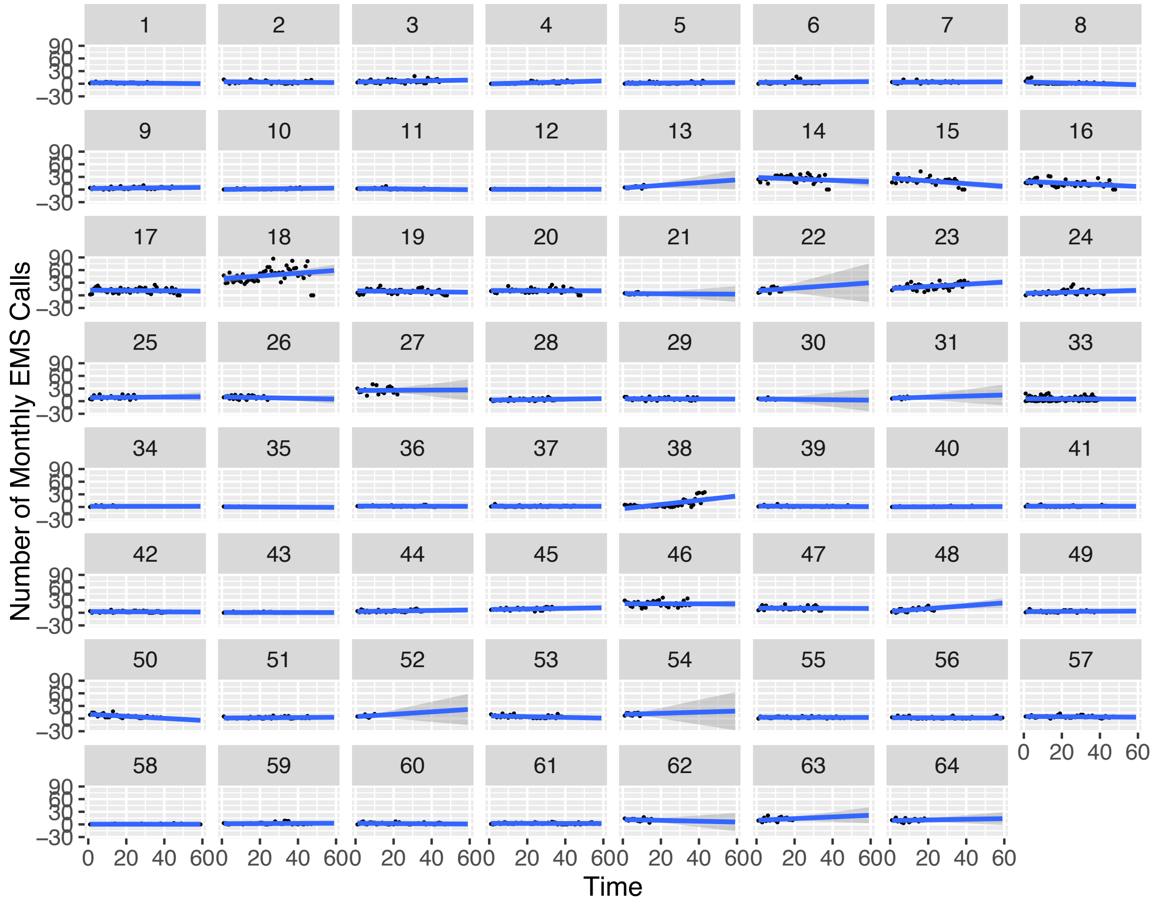

Figure 7: Trajectory of EMS calls over time, stratified by building

APPENDIX B

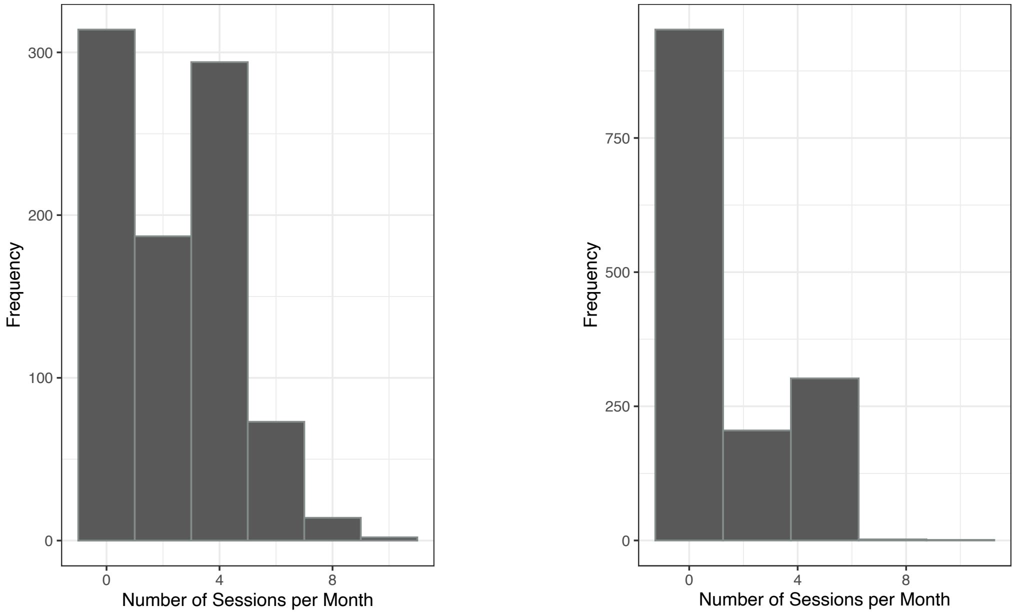

Figure 8: Distribution of number of sessions per month. Left: large buildings (>=100 units), right: small buildings (<100 units)