Determinants of Overnight Stay in Health Centres and Length of Admission: A Study of Canadian Seniors*

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RÉSUMÉ

Cette étude examine l'influence des maladies chroniques et du statut socioéconomique sur les admissions nocturnes et la durée du séjour à l'hôpital chez les aînés canadiens. Des modèles de régression logistique multivariée incrémentielle et de régression binomiale négative avec excès de zéros ont permis d'évaluer les relations entre les facteurs prédictifs sélectionnés, les admissions nocturnes et la durée d'hospitalisation. Les résultats montrent que toutes les maladies chroniques et les facteurs socioéconomiques examinés étaient significativement associés aux admissions nocturnes à l'hôpital. Cependant, les personnes âgées ayant des problèmes de santé cardiovasculaire, les personnes très âgées et les personnes vivant dans des ménages à faible revenu étaient plus à risque d'hospitalisations de plus longue durée. Les Canadiens âgés ayant reçu un diagnostic d'hypertension, de cancer, de diabète et d'AVC étaient plus à risque d'hospitalisations nocturnes de plus longue durée. Les personnes âgées de 75-79 ans, de 80 ans ou plus et celles faisant partie de ménages à faible revenu (≤ 39 999 $) étaient plus sujettes à des hospitalisations nocturnes de plus longue durée. Les résultats suggèrent que l'amélioration de la santé et du statut socioéconomique des personnes âgées peut réduire le risque d'admissions nocturnes à l'hôpital et celui des longues durées d'hospitalisation.

ABSTRACT

This study examines the influence of chronic health conditions and socio-economic status on overnight admission and length of stay among Canadian seniors. Incremental multivariate logistic and zero-inflated negative binomial regression models assessed the relationship between selected predictors, overnight admission, and duration of stay. The findings show that all chronic health conditions and socio-economic factors examined were significantly associated with overnight hospital admission. However, seniors with cardiovascular health conditions, the very old, and seniors living in lower-income households had a greater risk of longer stays. Canadian seniors diagnosed with hypertension, cancer, diabetes, and stroke had greater risk of longer overnight hospital stays. Seniors aged 75 to 79 years, 80 years or older, and those living in lower-income households (≤ $39,999) were more likely to have a longer overnight hospital stay. Findings suggest that improving seniors' health and socio-economic status may reduce the risk of overnight admission and longer stays of hospitalisation.

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Introduction

Cases of emergency hospital admissions and overnight hospitalisation are increasing significantly in developed countries, including Canada (Galenkamp, Deeg, de Jongh, Kardaun, & Huisman, 2016; Hallgren et al., 2016; McCusker et al., 2007). Increased life expectancy and reduced birth rates have contributed to the rise in the proportion of seniors (persons aged 65 years and older) in Canada, as well as in other developed countries (Moore & Rosenberg, 2001; Rosenberg & Moore, 1997). Canada's ageing population comes with vital health, social, and economic consequences. Moore, Rosenberg, and Fitzgibbon (1999) noted that the growth in the older population comes with a change in health services and support. Advanced ageing is associated with susceptibility to degenerative chronic health conditions such as hypertension, diabetes, cancer, and musculoskeletal disorder (Bähler, Huber, Brüngger, & Reich, 2015; Šteinmiller, Routasalo, & Suominen, 2015).

Research suggests that about 20 per cent of Canadian seniors have been diagnosed with hypertension while another 20 per cent are at risk of developing hypertension (Campbell et al., 2012). A recent report indicates almost half of Canada's population will develop cancer in their lifetime, and a quarter will die of the disease (Canadian Cancer Society's Advisory Committee on Cancer Statistics, 2017). Economically, the rise in the number of chronic health conditions is also associated with high medical care expenditures (Bähler et al., 2015; Bail et al., 2015; Lehnert et al., 2011; McCabe et al., 2017). In 2010, hypertension-associated medical care in Canada was estimated to be $13.9 billion – accounting for 10.2 per cent of the country's total health care expenditure; this cost is expected to increase to $20 billion by 2020 (Weaver et al., 2015).

Community-dwelling seniors constitute a significant proportion of persons who use emergency care services (Lyon, Lancaster, Taylor, Dowrick, & Chellaswamy, 2007; McCusker et al., 2007). Comparatively, seniors have a higher rate of unplanned hospital admission than younger persons. Although seniors in developed countries constitute a relatively smaller proportion of the population, they often tend to have higher acute bed occupancy and emergency admissions (Ennis et al., 2014; Lyon et al., 2007). They are also more likely to have a return visit for treatment after their initial visit (Galvin et al., 2017; Lee et al., 2008; Lyon et al., 2007). Seniors using emergency health care facilities for unplanned visits are also highly vulnerable to hospital-acquired infections (Cookson & Laudicella, 2011; Wallace et al., 2014). Studies show that chronic health conditions together with the burden of multimorbidity among seniors increase their risk of overnight hospital admission and the duration of hospitalisation (Bähler et al., 2015; Galenkamp et al., 2016). Despite seniors' vulnerability and risk of hospital-acquired infections, existing data shows that older persons in Canada have longer wait times at emergency departments (36.3 hours) compared to their younger counterparts (31.4 hours) (Canadian Institute for Health Information, n.d.).

The literature also indicates that socio-economically vulnerable persons have higher rates of hospitalisation (Clay, Roth, Safford, Sawyer, & Allman, 2011; Landi et al., 2004). Some researchers are of the view that, beyond medical conditions, socio-economic factors are vital determinants of the rate of hospitalisation or emergency visits. Evidence in the literature suggests that socio-economically vulnerable persons often lack the resources to make better health and health care decisions (Buckles, Hagemann, Malamud, Morrill, & Wozniak, 2016; Clarke & Latham, 2014). Socio-economically vulnerable persons may not take required treatment or seek diagnosis necessary for early detection of possible hospitalisation conditions (Landi et al., 2004). Although there are considerable differences among the older population, seniors are relatively considered socio-economically vulnerable compared to younger people. Their socio-economic vulnerability stems from the loss of wage income and work-related health benefits due to retirement. For instance, in Canada, a significant proportion of seniors do not have adequate access to preventive oral health compared to the younger population (Amegbor & Rosenberg, 2018; McNally, 2005; Thompson, Cooney, Lawrence, Ravaghi, & Quiñonez, 2014). Age, gender, and place of residence have been identified as social factors that significantly predict the risk of hospitalisation among the population (Hallgren et al., 2016; Neufeld, Viau, Hirdes, & Warry, 2016).

Notwithstanding this prevailing knowledge, there are limited studies on the effect chronic health conditions and socio-economic factors have on overnight admission and length of stay among Canadian seniors. Existing studies focused on specific aspects of the country's older adult population: rural residents in Ontario (Neufeld et al., 2016), residents in Hamilton receiving home care (Smith et al., 2005), and users of emergency care services in Quebec (McCusker et al., 2007). The target population of these three studies differ considerably; consequently, it is difficult to appreciate the effect of chronic health conditions and socio-economic status on overnight hospital stay among Canadian seniors from these existing studies. In view of the gap in research, we undertook this study to examine the influence of age-associated chronic health conditions and socio-economic factors on the risk of hospitalisation and longer hospital stays among community-dwelling Canadian seniors. The findings will further current

discourse on ageing in the community, chronic morbidity, and risk of hospitalisation in Canada. Insights from the findings can inform health care policies and programmes for seniors, as well as improve community-based support and hospital-based services for the country's senior population.

Data and Methods

The study used data from the 2014 Canadian Community Health Survey (CCHS) annual component. The CCHS is a statistically representative cross-sectional survey of residents in Canada aged 12 years and older. The survey excludes persons living on reserves and other Aboriginal settlements; full-time members of the Canadian Forces, institutionalised persons, and persons living in the Quebec health regions of Région du Nunavik and Région des Terres-Cries-de-la-Baie-James. The excluded population represent 3 per cent of the Canadian population aged 12 years and older. The CCHS, which collects a sample of 65,000 respondents annually, uses a multi-stage sampling of dwellings selected from an area frame or clusters stratified by the 110 health regions (HR). A sample is allocated to each province according to their population size and the number of HRs in the province. The survey collects information related to health status, health care utilisation, health determinants, and socio-demographic details. The sample we used in the study includes all CCHS respondents aged 65 years or older. Statistics Canada, government policy documents, and existing studies (McNally, 2005; Rosenberg & Moore, 1997; Yao & MacEntee, 2014) classify persons in the selected age group as seniors – that is, elderly persons aged 65 years or older.

Measures

We used two variables from the CCHS as outcomes or dependent variables in our study. The first dependent variable was derived from the CCHS question, "In the past 12 months, have you been a patient overnight in a hospital, nursing home or convalescent home?", with the following response categories, coded and labelled as "1 = Yes" and "0 = No". The second dependent variable was a total count of the number of nights a respondent stayed as a patient in a hospital, nursing home, or convalescent home. It was derived from the follow-up question "For how many nights in the past 12 months?" The minimum count was zero corresponding to the number of respondents who were not patients overnight in a hospital, nursing home, or convalescent home, as well as patients who were discharged the same day after receiving emergency care.

Our study adopted the Andersen (1995) behavioural model of health utilisation as a conceptual framework. We used two sets of independent variables as predictors

of overnight hospital admission. The first group of predictors were measures of chronic conditions, which the CCHS collects as self-reported data. These chronic health conditions are conceptualised as need factors, which necessitate the use of health care services. We used eight chronic medical conditions in our study analysis as determinants of overnight admission and length of stay. The chronic conditions we used were hypertension, cancer, fibromyalgia, chronic obstructive pulmonary disease, diabetes, heart diseases, stroke, and bowel disorder. These conditions are not peculiar only to older persons; however, they are generally considered as senescent-associated conditions (Divo, Martinez, & Mannino, 2014).

The second set of predictor variables were age, sex, the highest level of education, and total household income per annum. Age, sex, and education are conceived as predisposing factors, whereas household income is conceptualised as an enabling factor. Age was categorised into four groups: 65–69 years, 70–74 years, 75–79 years, and 80 years or older. Education had four response categories: less than secondary, secondary school, some post-secondary, and post-secondary level. Existing studies point to the influence of socio-economic factors such as age, sex, education, and income on health and health behaviours (Andersen, 1995; Hallgren et al., 2016; Lehnert et al., 2011). For instance, education is hypothesised as promoting good health through its influence on health behaviours (Dupre, 2007; Lynch & von Hippel, 2016). Income, on the other hand, can foster better health through its enabling influence on access and use of preventive health care services (Marmot, Friel, Bell, Houweling, & Taylor, 2008; Prag, Mills, & Wittek, 2013).

Analysis

We performed univariate analysis to examine the proportional distribution of the study variables. The descriptive statistics report calculated percentages for categorical variables such as chronic conditions, socio-economic factors, and overnight hospital stay. Also, the mean length of overnight hospital stay was calculated for the second dependent which, as noted, is a count variable. Multivariate regression analyses were used to examine the relationship between the study's predictor variables, overnight admission and length of overnight hospital stay; using an incremental approach. The first level examines the relationship between chronic conditions (need factors) and the outcomes (overnight hospital stay and length of stay); the second level included socio-economic (predisposing and enabling) factors in the list of predictors.

The study's first dependent variable was dichotomous, and results of the descriptive statistics show that it is not

evenly distributed. Considering this, the complementary log-log function was employed in the logistic analysis instead of logit or probit analysis. Like the logit and the probit functions, the complementary log-log function fits maximum likelihood models with dichotomous dependent variables coded as "0" and "not 0" (Martuzzi & Elliott, 1998; StataCorp, 2013). However, the complementary log-log function relaxes symmetrical distribution assumption of both logit and probit models (Hedeker, 2008; StataCorp, 2013). That is, it relates to the Gompertz distribution in which the distribution is flexible and can be skewed to the right and to the left (StataCorp, 2013). This logistic function is ideal because the probability of an outcome occurring is very small or very large (Davies, Cifaldi, Segurado, & Weisman, 2009) as observed in the first dependent variable.

The second dependent variable was a count of days stayed at the hospital. A scan of the second dependent variable shows that the variable does not have a normal distribution; thus, an ordinary least square (OLS) regression is inappropriate for analysis. Generally, a Poisson regression is used in such situations; however, a summary test of the variables shows our count outcome suffers from over-dispersion created by an excess zero. The variable's variance is almost 18 times its mean (1.134). Ignoring the excess zero may lead to bias in the estimated parameters and standard error in the regression model (Zuur, Leno, Walker, Saveliev, & Smith, 2009). A zero-inflated negative binomial (ZINB) regression analysis was employed to examine the length of overnight hospital stay. ZINB generates two separate models. The first model is a negative binomial model that predicts respondents in "not certain zeros" – that is, respondents who are not always certain to have zero days' overnight hospital stay.

The second model is a logistic model that predicts respondents in "certain zeros", or respondents who will always have zero days' overnight hospital stay. The negative binomial part is a model of the number of days of overnight hospital stay, whereas the logit part models a probability of not having an overnight hospital stay. In both parts of the ZINB model, the study reports the exponentiated coefficients. The exponentiated coefficients of the negative binomial part are synonymous to the incidence-rate ratio (IRR) and that of the logit part of the model is the odds ratio (OR). Cases with missing information for our study variables were generally low (between 0.06% for household income and 2.13% for educational level). Thus, cases with missing values for the study variables were excluded. The multivariate analyses were weighted using the master weight provided by Statistics Canada in the CCHS. This weight was adjusted to account for the use of a subsample: that is, respondents aged 65 years and older. The data were prepared and analysed using IBM SPSS

Statistics (version 24) and STATA (version 14.2MP) by StataCorp (College Station, TX).

Results

Table 1 presents the descriptive summary of the characteristics of the study participants. A clear majority

Table 1: Descriptive summary of study variables ($n = 18,491$)

Dependent Variables	Frequency (%)
Overnight Admission (12 months)	
No	16,041 (86.75)
Yes	2,450 (13.25)
Length of stay (in days)	1.103[a]
Need Factors (Chronic Conditions)	
Hypertension	
No case of hypertension (ref)	7,895 (42.70)
Has hypertension	9,003 (48.69)
Had hypertension	1,593 (8.62)
Cancer	
No case of cancer (ref)	14,464 (78.22)
Has cancer	1,066 (5.76)
Had cancer	2,961 (16.01)
Fibromyalgia	
No (ref)	17,945 (97.05)
Yes	546 (2.95)
Arthritis	
No (ref)	10,049 (54.35)
Yes	8,442 (45.65)
Diabetes	
No (ref)	15,149 (81.93)
Yes	3,342 (18.07)
Heart disease	
No (ref)	15,375 (83.15)
Yes	3,116 (16.85)
Stroke	
No (ref)	17,849 (96.53)
Yes	642 (3.47)
Bowel disorder	
No (ref)	17,254 (93.31)
Yes	1,231 (6.69)
Predisposing & Enabling Factors	
Age	
65 – 69 years (ref)	6,040 (32.66)
70 –74 years	4,582 (24.78)
75 – 79 years	3,415 (18.47)
80 years or more	4,454 (24.09)
Sex	
Male (ref)	7,679 (41.53)
Female	10,812 (58.47)
Education	
Post-secondary level (ref)	8,408 (45.47)
Some post-secondary	574 (3.10)
Secondary school	3,486 (18.85)
< Secondary school	6,023 (32.57)
Household Income	
$80,000 or more (ref)	2,645 (14.30)
$60,000 – $79,999	2,239 (12.11)
$40,000 – $59,999	4,058 (21.95)
$20,000 – $39,999	6,697 (36.22)
< $20,000	2,852 (15.42)

[a] **Mean number of days of hospitalisation**

(86.75%) of Canadian seniors did not experience overnight hospital admission. The average length of stay for overnight admission among those admitted was 1.103 days while the range for overnight admission stay was 0 days to 31 days. Hypertension (48.69%) and arthritis (45.65%) were relatively common chronic health conditions among seniors surveyed. With respect to hypertension and cancer, 8.62 per cent and 16.01 per cent of sampled seniors indicated they had previously been diagnosed with hypertension and cancer respectively; however, they did not indicate they had these conditions currently. Approximately, a third (32.66%) of sampled seniors were between the ages of 65 and 69. Most sampled seniors were females (58.47%), had a post-secondary level of education (45.47%), and had an annual household income of $20,000 to $39,999 (36.22%).

Determinants of OHA – Multivariate Results

Table 2 presents the findings of the first multivariate analysis. Need variables defined in this study as chronic health conditions (Model 1) had statistically significant relationships with overnight admission among community-dwelling Canadian seniors. Seniors with chronic health conditions or with a history of having had chronic health issues were more likely to have had overnight hospital stays compared to seniors who did not have or never had chronic health conditions. Seniors who indicated they have hypertension and those who had previously been diagnosed with hypertension were 1.188 times and 1.244 times ($p < .01$) more likely to have had overnight admissions compared to their counterparts who did not have cases or a history of hypertension. Similarly, seniors with cancer and those previously diagnosed with cancer were 2.109 times and 1.404 times ($p < .01$) more likely to have had an overnight admission compared to those without cancer or no history of a cancer diagnosis. These observed relationships were still statistically significant after controlling for socio-economic status (Model 2). There were no significant changes in the odds ratios of seniors with chronic health conditions or with a previous history of chronic health reporting overnight admission compared to their healthier counterparts. For instance, the odds ratio of seniors with hypertension and those with a previous history of hypertension reporting overnight admission were 2.060 times (compared to 2.109 times in Model 1) and 1.193 times (compared to 1.244 times in Model 1).

With respect to predisposing and enabling factors, the findings demonstrate that socio-economically vulnerable seniors were more likely to have had overnight admissions compared to seniors of higher socio-economic status. Age-wise, the result shows an increase in the odds ratio of reporting overnight admission with an increase in age group. Seniors in the age groups 70 to 74 years, 75 to 79 years, and 80 years or more were 1.101 times ($p < .1$), 1.220 times ($p < .01$), and 1.396 times ($p < .01$) more likely to have had an overnight stay respectively, compared to seniors in the 65-to-69-year-old age group. Female seniors were less likely to have had overnight admission compared to their male counterparts (OR = 0.906, $p < .05$). Canadian seniors with an educational status below secondary education were more likely to have had overnight admission compared to those with a post-secondary level of education (OR = 1.086, $p < .1$). Seniors living in lower income–earning households were more likely to have had an overnight admission compared to those living in a household with annual income of $80,000 or more.

The odds ratio of overnight admissions increased with a decrease in annual household income; the size of the beta coefficient estimate increased by ~30 per cent (Model 2, Table 2). The results of the model statistics show that both Model 1 and Model 2 fit well for determining overnight admission among seniors in Canada as indicated by the Wald's statistics. The pseudo R-squared estimates indicate that in Model 1 the chronic health conditions explain approximately seven per cent of the variance in overnight admission. In Model 2, chronic health conditions and socio-economic factors explained about eight per cent of the variance in overnight admission. The Akaike's Information Criterion (AIC) and Bayesian Information Criterion (BIC) estimates of the models indicate that Model 2 is statistically preferable to Model 1.

Determinants of Length of Overnight Hospital Stay – Multivariate Results

Table 3 shows the result of the ZINB analysis. The first component displays the result of the negative binomial model that determines the frequency of overnight admission stay. An incidence-rate ratio above 1 indicates a factor increase in the number of days a senior spent as an overnight patient whereas an incidence-rate ratio below 1 indicates a factor decrease in the number of days a senior spent as an overnight patient. The second component (the logistic model) shows the likelihood of not having overnight hospital admission. An OR of above 1 indicates a greater likelihood of not having overnight admission whereas an OR below 1 shows a lesser likelihood of not having an overnight admission.

In the negative binomial part, the results show that hypertension, cancer, diabetes, stroke, and bowel disorder – as need factors – were significantly associated with the risk of longer overnight hospital stays. Canadian seniors who had a previously diagnosed case of

Table 2: Overnight stay at hospital

	Model 1	Model 2
Need Factors (Chronic Conditions)		
Hypertension		
No case of hypertension (ref)		
Has hypertension	1.188 (0.055)***	1.160 (0.054)***
Had hypertension	1.244 (0.092)***	1.193 (0.088)***
Cancer		
No case of cancer (ref)		
Has cancer	2.109 (0.143)***	2.060 (0.142)***
Had cancer	1.404 (0.073)***	1.377 (0.072)***
Fibromyalgia		
No (ref)		
Yes	1.305 (0.130)***	1.365 (0.138)***
Arthritis		
No (ref)		
Yes	1.276 (0.054)***	1.231 (0.053)***
Diabetes		
No (ref)		
Yes	1.183 (0.058)***	1.168 (0.058)***
Heart disease		
No (ref)		
Yes	2.271 (0.102)***	2.160 (0.100)***
Stroke		
No (ref)		
Yes	1.914 (0.152)***	1.848 (0.146)***
Bowel disorder		
No (ref)		
Yes	1.250 (0.089)***	1.250 (0.090)***
Predisposing & Enabling Factors		
Age		
65 – 69 years (ref)		
70 –74 years		1.101 (0.065)*
75 – 79 years		1.220 (0.076)***
80 years or more		1.396 (0.081)***
Sex		
Male (ref)		
Female		0.906 (0.040)**
Education		
Post-secondary level (ref)		
Some post-secondary		0.944 (0.121)
Secondary school		1.095 (0.062)
< Secondary school		1.086 (0.054)*
Household Income		
$80,000 or more (ref)		
$60,000 – $79,999		0.969 (0.087)
$40,000 – $59,999		1.155 (0.088)**
$20,000 – $39,999		1.152 (0.084)**
< $20,000		1.457 (0.119)***
Pseudo R-square	0.074	0.084
Wald chi-square	918.41***	1044.66***

Note. Robust standard error in parentheses; ***p < .01.
**p < .05. *p < .1.

hypertension compared to those without (or with no history of) hypertension were 1.250 times (p < .05) more likely to have a longer overnight hospital stay. Seniors with cancer compared to those without cancer or with no history of cancer were 1.153 times (p < .1) more likely to have a longer overnight hospital stay. Canadian seniors with diabetes, stroke, and bowel disorder were

1.143 times (p < .05), 1.424 times (p < .01), and 1.170 times (p < .1) more likely to have longer overnight hospital stays respectively, compared to their counterparts who did not have these chronic conditions. In the logistic regression part of Model 1, the findings indicate that all chronic health conditions examined in this study were significantly associated with the probability of having zero days overnight hospital stay. In other words, these seniors are more likely to be hospitalised for a day or more. Canadian seniors with chronic health conditions and previously diagnosed cases of chronic health were less likely to have zero days of overnight hospital stay. For instance, the OR of seniors with stroke and diabetes having no overnight admission stay after visiting the hospital were 0.415 times (p < .01) and 0.853 times (p < .05) less.

In Model 2, the observed relationships did not change when socio-economic factors were introduced as co-variates (Table 3). The only notable change was fibromyalgia which became significantly associated with a greater risk of longer overnight hospital stays (IRR = 1.251, p < .1). Similar to the observed relationship in Model 1 (the logistic part), seniors with chronic health conditions and those with previous history of chronic health were less likely to have zero days of overnight hospital stay compared to their healthier counterparts. The findings in Model 2 also show that age as a predisposing factor and household income as an enabling factor were significantly associated with frequency of overnight hospital stay (negative binomial part). Seniors in the age groups of 75 to 79 years and 80 years or older were 1.317 times (p < .01) and 1.556 times (p < .01) greater to have longer overnight hospital stays. With respect to household income, seniors living in households with annual income of $20,000 to $39,999 and less than $20,000 were 1.266 times (p < .05) and 1.340 times (p < .01) greater to have longer overnight hospital stays compared to those living in households with an annual income of $80,000 or more.

The logistics part shows that age, sex, and income were significantly associated with the likelihood of having zero days of overnight hospital stay. Female seniors compared to males were 1.115 times (p < .1) more likely to have zero days of overnight hospital stay, given that the other variables in the model held constant. Seniors living in households with annual income less than $20,000 were 0.687 times (p < .01) less likely to have zero days of overnight hospital stay, given that the other variables in the model held constant (Table 3). The results of Wald statistics show that both Model 1 and Model 2 fit well for determining the length of overnight stay among seniors in Canada; however, the AIC estimates of the models indicate that Model 2 is statistically preferable to Model 1, given the former's low AIC value.

Table 3: Days of overnight stay at hospital

	Model 1		Model 2	
	NB Model (IRR)	Logit Model (OR)	NB Model (IRR)	Logit Model (OR)
Need Factors (Chronic Conditions)				
Hypertension				
No case of hypertension (ref)				
Has hypertension	1.016 (0.067)	0.816 (0.058)***	1.001 (0.066)	0.837 (0.059)***
Had hypertension	1.250(0.121)**	0.809 (0.097)**	1.205 (0.115)**	0.844 (0.096)*
Cancer				
No case of cancer (ref)				
Has cancer	1.153 (0.099)*	0.363 (0.108)***	1.175 (0.103)*	0.376 (0.108)***
Had cancer	0.983 (0.068)	0.638 (0.070)***	0.958 (0.066)	0.654 (0.070)***
Fibromyalgia				
No (ref)				
Yes	1.160 (0.150)	0.739 (0.141)**	1.251 (0.163)*	0.708 (0.141)***
Arthritis				
No (ref)				
Yes	1.002 (0.058)	0.726 (0.055)***	0.974 (0.058)	0.757 (0.055)***
Diabetes				
No (ref)				
Yes	1.143 (0.076)**	0.853 (0.067)**	1.166 (0.079)**	0.871 (0.66)**
Heart disease				
No (ref)				
Yes	1.041 (0.062)	0.341 (0.069)***	1.025 (0.062)	0.367 (0.067)***
Stroke				
No (ref)				
Yes	1.424 (0.132)***	0.415 (0.0133)***	1.387 (0.133)***	0.446 (0.129)***
Bowel disorder				
No (ref)				
Yes	1.170 (0.106)*	0.763 (0.100)***	1.149 (0.103)	0.756 (0.100)***
Predisposing & Enabling Factors				
Age				
65 – 69 years (ref)				
70 – 74 years			1.057 (0.095)	0.897 (0.075)
75 – 79 years			1.317 (0.117)***	0.837 (0.079)**
80 years or more			1.556 (0.123)***	0.725 (0.074)***
Sex				
Male (ref)				
Female			0.976 (0.060)	1.115 (0.057)*
Education				
Post-secondary level (ref)				
Some post-secondary			1.310 (0.235)	1.151 (0.160)
Secondary school			0.999 (0.083)	0.901 (0.074)
< Secondary school			1.002 (0.069)	0.902 (0.065)
Household Income				
$80,000 or more (ref)				
$60,000 – $79,999			1.112 (0.147)	1.085 (0.114)
$40,000 – $59,999			1.105 (0.124)	0.887 (0.097)
$20,000 – $39,999			1.266 (0.134)**	0.905 (0.093)
< $20,000			1.340 (0.157)***	0.687 (0.105)***
/lnalpha	1.027 (0.090)***		0.948 (0.089)***	
alpha	2.791 (0.264)***		2.580 (0.231)***	
Wald chi-square	34.85***		93.68***	
Log pseudo-likelihood	−14,185.74		−14,108.52	

Note. IRR = incidence rate-ratio, NB = negative binomial, OR = odds ratio; Robust standard error in parentheses; ***$p < .01$. **$p < .05$. *$p < .1$.

Discussion

This study sought to examine the effect of chronic health conditions and socio-economic status on overnight admission and length of stay. The prevalence of overnight admission among community-dwelling Canadian seniors was 13.25 per cent. The average length of stay was approximately a day (1.103 days). As previously noted, the research on hospitalisation and the risk

of longer hospital stay among community-dwelling seniors is limited; thus, relating these figures to existing evidence is nearly impossible. Smith et al. (2005) in their study reported that, of seniors receiving home care in Hamilton, Ontario, 70 per cent and 50 per cent were likely to have been hospitalised and to visit the emergency department respectively. The higher proportion of hospitalisation and emergency department visit in their study can be attributed to its focus on seniors receiving home care services. This group of seniors are usually frail, increasing their risk of hospitalisation. Thus, it is difficult to compare the findings of the two studies to due to the difference in the target population.

The findings of our study show that chronic health conditions as need factors are significantly associated with the likelihood of community-dwelling seniors being admitted overnight in a hospital. All chronic health conditions examined in this study remained significantly associated with overnight admission after adjustment for socio-economic factors. This finding is consistent with evidence in existing studies on chronic health conditions and the hospitalisation. The findings of these studies show that the incidence of overnight or unplanned hospital admission is higher among seniors with chronic health conditions (Gibson, Segal, & McDermott, 2013; Takahashi et al., 2016). Age-associated chronic health conditions – such as hypertension, cancer, stroke, and other cognitive impairments – are associated with both higher health care utilisation and the risk of unplanned hospital admission. Evidence in studies in the United Kingdom and Canada suggests that seniors with chronic health conditions have a higher likelihood of hospital admission than their peers without such health problems (Lyon et al., 2007; Neufeld et al., 2016; Smith et al., 2005). Smith et al. (2005) in their study observed that community-dwelling seniors with congestive heart failure and cancer receiving home care were 6.38 times and 4.17 times, respectively, more likely to be hospitalised compared to those who did not have such conditions. In a more general senior population study in the United Kingdom, the odds ratio for hospitalisation among seniors with heart problems was 1.440 times (Lyon et al., 2007).

Although all forms of chronic health conditions increase the likelihood of overnight hospital admission, the risk of longer hospital stays is not significantly associated with all chronic conditions, which is a major strength of our study. Cardiovascular conditions, such as hypertension, cancer, diabetes, and stroke are consistently associated with the risk of longer hospital stays. Other chronic conditions, such as bowel disorder and fibromyalgia, only became significantly associated with longer hospital stays by controlling or not controlling for socio-economic factors. The evidence suggests that promoting a healthy lifestyle and active ageing that minimises the risk of cardiovascular disease can lead to reducing the risk of longer hospital stay among community-dwelling Canadians.

Another interesting finding in this study was that older persons previously diagnosed with hypertension had a greater risk of longer hospital stay. However, the risk for those currently diagnosed with hypertension was not statistically significant (Table 3). The increased risk of longer hospital stay may be attributed to non-adherence by seniors either to treatment or to prescribed lifestyle for those previously diagnosed with hypertension. Evidence in existing studies shows that compliance with anti-hypertensive treatment is generally high among patients newly diagnosed although adherence wanes over time (Mazzaglia et al., 2005; Van Wijk, Klungel, Heerdink, & de Boer, 2005).

Socio-economic factors are important predictors of health and health outcomes. Persons of lower socio-economic status have an increased risk of poor health outcomes and increased likelihood of hospital admission (Clay et al., 2011; Landi et al., 2004). The study shows that socio-economically vulnerable persons such as the very old (persons aged 80 years and above), less educated, and seniors in lower income households have a higher odds ratio of overnight hospital stay (Table 2). This finding is consistent with previous studies in overnight admission and health care utilisation. Socio-economic challenges create poor health and health-care-seeking behaviour. Studies in the United Kingdom and Ireland report variations in hospital admission across places due to differences in local socio-economic status (Cournane et al., 2017; O'Cathain et al., 2013).

Limited financial resources and health insurance coverage can significantly impede the ability of seniors to seek timely care, thus increasing their risk to being admitted to emergency care or unplanned overnight admission (Marmot et al., 2008; Prag et al., 2013). Formal education influences the ability to adopt new information, promote healthy behaviour, increase wealth level, and individual economic returns (Dupre, 2007; Lynch & von Hippel, 2016). Insight from existing studies show that persons with higher education engage in healthier behaviour, including less smoking and a more-active lifestyle (exercising), reducing their mortality and morbidity risk significantly compared to less-educated individuals (Buckles et al., 2016; Cutler & Lleras-Muney, 2010; Jürges, Reinhold, & Salm, 2011). Thus, we postulate that less-educated Canadian seniors may not have the socio-economic and behavioural benefits of formal education, thereby contributing to their risk of ill health (both physical and psychosocial), which would invariably increase their odds ratio of incurring overnight admission.

The results, however, of multivariate ZINB analysis demonstrate that only age and income are associated

with an increased risk of longer hospital stay. The risk of longer of hospital stays was significant among seniors aged 75 years and older and those living in lower-income households (Table 3). Our study shows that among community-dwelling seniors in Canada, ageing and economic deprivation may significantly contribute to longer periods of hospitalisation. Although Canada's universal health care coverage program provides non-fee-paying access to physician and hospital-based services, the evidence suggests persons of lower income households have less contact with general practitioners (Asada & Kephart, 2007). Less-frequent visits to a general practitioner means that early signs of chronic conditions could go undetected, thus raising the risk of complications and leading to a prolonged hospital admission or stay. The results of this study and others on health care utilisation in Canada suggest improving the socio-economic status of community-dwelling seniors can significantly reduce the risk of hospital admission and prolonged hospital stays.

Study Strengths and Limitations

To the best of our knowledge, this study is the first to investigate the effect of chronic health and socio-economic status on overnight hospitalisation among seniors in Canada nationwide. Unlike previous studies in the country that focused on a specific location (city, rural, or a province), and a smaller subsample of seniors, our study uses a national database, Canadian Community Health Survey (CCHS), to examine a population-wide effect of chronic health and socio-economic status on overnight hospitalisation. It also offers insight into the effect of specific age-associated chronic health conditions on overnight hospitalisation among seniors in Canada.

The findings of this study should be considered in the context of its methodological and analytical limitations. First, causal inferences cannot be made about the effect of chronic health conditions and socio-economic factors on overnight admission and length of overnight hospital stay. As noted previously, the CCHS is a cross-sectional survey; accordingly, we can only infer an association between the study's predictor variables (chronic health conditions and socio-economic status) and overnight hospital admission. Future research on this topic using longitudinal data could improve additional insight on the causative effect of chronic health conditions and socio-economic status on overnight hospital admission, as well as length of stay.

A second limitation of this study is that measures of chronic health and socio-economic status were self-reported accounts. Consequently, there might be an issue of reported status and inaccurate recall of past events. Self-reported health surveys such as the CCHS provide standard data on socio-economic and health status; also, they are reported to be reliable in large-scale surveys and for health research. Also, the outcome variable is defined broadly in this study, given that the data for the study are secondary data from the CCHS. It is difficult to determine whether there will be differences in the predictors depending on what type of overnight hospitalisation occurred – in-patient acute hospital stay or nursing and convalescent stays.

Conclusion

The findings of this study show that both chronic health conditions and socio-economic status influence the overnight admission among Canadian seniors. The study demonstrates that cardiovascular diseases, age, and lower levels of household income are both predisposing and enabling factors respectively, and can increase the susceptibility of community-dwelling seniors to longer periods of hospital stay. To reduce unplanned hospital admission and the risk of longer hospital stay among community-dwelling seniors, effort must be directed towards promoting active and healthy ageing, as well as improving socio-economic well-being. Inevitably, such health and socio-economic interventions will significantly reduce the government expenditure on health-care-associated prolonged hospital stays and contribute to the well-being of Canadian seniors ageing in the community.

References

Amegbor, P. M., & Rosenberg, M. W. (2018). The use of dental care services in Alberta, Manitoba, and Newfoundland and Labrador: A comparative analysis. *The Canadian Geographer / Le Géographe Canadien*, *62*(3), 414–426. https://doi.org/10.1111/cag.12435

Andersen, R. M. (1995). Revisiting the behavioral model and access to medical care: Does it matter ? *Journal of Health and Social Behavior*, *36*(1), 1–10. https://doi.org/2137284

Asada, Y., & Kephart, G. (2007). Equity in health services use and intensity of use in Canada. *BMC Health Services Research*, 7, Article no. 41, 1–12. https://doi.org/10.1186/1472-6963-7-41

Bähler, C., Huber, C. A., Brüngger, B., & Reich, O. (2015). Multimorbidity, health care utilization and costs in an elderly community-dwelling population: A claims data based observational study. *BMC Health Services Research*, *15*(1), 1–12. https://doi.org/10.1186/s12913-015-0698-2

Bail, K., Goss, J., Draper, B., Berry, H., Karmel, R., & Gibson, D. (2015). The cost of hospital-acquired complications for older people with and without dementia; A retrospective cohort study. *BMC Health Services Research*, *15*(1), Article no. 91. https://doi.org/10.1186/s12913-015-0743-1

Buckles, K., Hagemann, A., Malamud, O., Morrill, M., & Wozniak, A. (2016). The effect of college education on

mortality. *Journal of Health Economics*, *50*, 99–114. https://doi.org/10.1016/j.jhealeco.2016.08.002

Campbell, N., Young, E. R., Drouin, D., Legowski, B., Adams, M. A., Farrell, J., … Tobe, S. (2012). A framework for discussion on how to improve prevention, management, and control of hypertension in Canada. *Canadian Journal of Cardiology*, *28*(3), 262–269. https://doi.org/10.1016/j.cjca.2011.11.008

Canadian Cancer Society's Advisory Committee on Cancer Statistics. (2017). *Canadian Cancer Statistics 2017. Canadian Cancer Society*. Toronto, ON: Author. https://doi.org/0835-2976

Canadian Institute for Health Information. (n.d.). Emergency department wait times in Canada continuing to rise. Retrieved from https://www.cihi.ca/en/emergency-department-wait-times-in-canada-continuing-to-rise

Clarke, P., & Latham, K. (2014). Life course health and socioeconomic profiles of Americans aging with disability. *Disability and Health Journal*, *7*(1 Supple), S15–S23. https://doi.org/10.1016/j.dhjo.2013.08.008

Clay, O. J., Roth, D. L., Safford, M. M., Sawyer, P. L., & Allman, R. M. (2011). Predictors of overnight hospital admission in older African American and Caucasian medicare beneficiaries. *The Journals of Gerontology Series A: Biological Sciences and Medical Sciences*, *66A*(8), 910–916. https://doi.org/10.1093/gerona/glr082

Cookson, R., & Laudicella, M. (2011). Do the poor cost much more? The relationship between small area income deprivation and length of stay for elective hip replacement in the English NHS from 2001 to 2008. *Social Science and Medicine*, *72*(2), 173–184. https://doi.org/10.1016/j.socscimed.2010.11.001

Cournane, S., Conway, R., Byrne, D., O'Riordan, D., Coveney, S., & Silke, B. (2017). Social factors determine the emergency medical admission workload. *Journal of Clinical Medicine*, *6*(6), 59. https://doi.org/10.3390/jcm6060059

Cutler, D. M., & Lleras-Muney, A. (2010). Understanding differences in health behaviors by education. *Journal of Health Economics*, *29*(1), 1–28. https://doi.org/10.1016/j.jhealeco.2009.10.003

Davies, A., Cifaldi, M. A., Segurado, O. G., & Weisman, M. H. (2009). Cost-effectiveness of sequential therapy with tumor necrosis factor antagonists in early rheumatoid arthritis. *Journal of Rheumatology*, *36*(1), 16–25. https://doi.org/10.3899/jrheum.080257

Divo, M. J., Martinez, C. H., & Mannino, D. M. (2014). Ageing and the epidemiology of multimorbidity. *European Respiratory Journal*, *44*(4), 1055–1068. https://doi.org/10.1183/09031936.00059814

Dupre, M. E. (2007). Educational differences in age-related patterns of disease: reconsidering the cumulative disadvantage and age-as-leveler hypotheses. *Journal of*

Health and Social Behavior, *48*(1), 1–15. https://doi.org/10.1177/002214650704800101

Ennis, S. K., Larson, E. B., Grothaus, L., Helfrich, C. D., Balch, S., & Phelan, E. A. (2014). Association of living alone and hospitalization Among community-dwelling elders with and without dementia. *Journal of General Internal Medicine*, *29*(11), 1451–1459. https://doi.org/10.1007/s11606-014-2904-z

Galenkamp, H., Deeg, D. J. H., de Jongh, R. T., Kardaun, J. W. P. F., & Huisman, M. (2016). Trend study on the association between hospital admissions and the health of Dutch older adults (1995–2009). *BMJ Open*, *6*(8), e011967. https://doi.org/10.1136/bmjopen-2016-011967

Galvin, R., Gilleit, Y., Wallace, E., Cousins, G., Bolmer, M., Rainer, T., … Fahey, T. (2017). Editor's choice: Adverse outcomes in older adults attending emergency departments: A systematic review and meta-analysis of the Identification of Seniors At Risk (ISAR) screening tool. *Age and Ageing*, *46*(2), 179–186. https://doi.org/10.1093/ageing/afw233

Gibson, O., Segal, L., & McDermott, R. (2013). A systematic review of evidence on the association between hospitalisation for chronic disease related ambulatory care sensitive conditions and primary health care resourcing. *BMC Health Services Research*, *13*(1), 336. https://doi.org/doi: 10.1186/1472-6963-13-336

Hallgren, J., Fransson, E. I., Kåreholt, I., Reynolds, C. A., Pedersen, N. L., & Dahl Aslan, A. K. (2016). Factors associated with hospitalization risk among community living middle aged and older persons: Results from the Swedish Adoption/Twin Study of Aging (SATSA). *Archives of Gerontology and Geriatrics*, *66*, 102–108. https://doi.org/10.1016/j.archger.2016.05.005

Hedeker, D. (2008). Multilevel models for ordinal and nominal variables. In J. de Leeuw & Meijer Erik (Eds.), *Handbook of Multilevel Analysis* (1st ed., pp. 237–274). New York, NY: Springer-Verlag.

Jürges, H., Reinhold, S., & Salm, M. (2011). Does schooling affect health behavior? Evidence from the educational expansion in Western Germany. *Economics of Education Review*, *30*(5), 862–872. https://doi.org/10.1016/j.econedurev.2011.04.002

Landi, F., Onder, G., Cesari, M., Barillaro, C., Lattanzio, F., Carbonin, P. U., & Bernabei, R. (2004). Comorbidity and social factors predicted hospitalization in frail elderly patients. *Journal of Clinical Epidemiology*, *57*(8), 832–836. https://doi.org/10.1016/j.jclinepi.2004.01.013

Lee, J. S., Schwindt, G., Langevin, M., Moghabghab, R., Alibhai, S. M. H., Kiss, A., & Naglie, G. (2008). Validation of the triage risk stratification tool to identify older persons at risk for hospital admission and returning to the emergency department. *Journal of the American Geriatrics Society*, *56*(11), 2112–2117. https://doi.org/10.1111/j.1532-5415.2008.01959.x

Lehnert, T., Heider, D., Leicht, H., Heinrich, S., Corrieri, S., Luppa, M., … König, H. H. (2011). Review: Health care utilization and costs of elderly persons with multiple chronic conditions. *Medical Care Research and Review*, *68* (4), 387–420. https://doi.org/10.1177/1077558711399580

Lynch, J. L., & von Hippel, P. T. (2016). An education gradient in health, a health gradient in education, or a confounded gradient in both? *Social Science and Medicine*, *154*, 18–27. https://doi.org/10.1016/j.socscimed.2016.02.029

Lyon, D., Lancaster, G. A., Taylor, S., Dowrick, C., & Chellaswamy, H. (2007). Predicting the likelihood of emergency admission to hospital of older people: Development and validation of the Emergency Admission Risk Likelihood Index (EARLI). *Family Practice*, *24*(2), 158–167. https://doi.org/10.1093/fampra/cml069

Marmot, M., Friel, S., Bell, R., Houweling, T. A., & Taylor, S. (2008). Closing the gap in a generation: Health equity through action on the social determinants of health. *The Lancet*, *372*(9650), 1661–1669. https://doi.org/10.1016/S0140-6736(08)61690-6

Martuzzi, M., & Elliott, P. (1998). Estimating the incidence rate ratio in cross-sectional studies using a simple alternative to logistic regression. *Annals of Epidemiology*, *8*(1), 52–55. https://doi.org/10.1016/S1047-2797(97)00106-3

Mazzaglia, G., Mantovani, L. G., Sturkenboom, M. C. J. M., Filippi, A., Trifirò, G., Cricelli, C., … Caputi, A. P. (2005). Patterns of persistence with antihypertensive medications in newly diagnosed hypertensive patients in Italy: A retrospective cohort study in primary care. *Journal of Hypertension*, *23*(11), 2093–2100. https://doi.org/10.1097/01.hjh.0000186832.41125.8a

McCabe, J. J., McElroy, K., Cournane, S., Byrne, D., O'Riordan, D., Fitzgerald, B., & Silke, B. (2017). Deprivation status and the hospital costs of an emergency medical admission. *European Journal of Internal Medicine*, *46*, 30–34. https://doi.org/10.1016/j.ejim.2017.09.017

McCusker, J., Ionescu-Ittu, R., Ciampi, A., Vadeboncoeur, A., Roberge, D., Larouche, D., … Pineault, R. (2007). Hospital characteristics and emergency department care of older patients are associated with return visits. *Academic Emergency Medicine*, *14*(5), 426–433. https://doi.org/10.1197/j.aem.2006.11.020

McNally, M. (2005). Oral health matters: What will it take to leave no senior behind? *Journal of the Canadian Dental Association*, *71*(7), 465–467.

Moore, E. G., & Rosenberg, M. W. (2001). Canada's elderly population : The challenges of diversity. *The Canadian Geographer*, *45*(1), 145–150. https://doi.org/10.1111/j.1541-0064.2001.tb01179.x

Moore, E. G., Rosenberg, M. W., & Fitzgibbon, S. H. (1999). Activity limitation and chronic conditions in Canada's elderly, 1986 2011. *Disability and Rehabilitation*, *21*(5/6), 196–210. https://doi.org/10.1080/096382899297620

Neufeld, E., Viau, K. A., Hirdes, J. P., & Warry, W. (2016). Predictors of frequent emergency department visits among rural older adults in Ontario using the Resident Assessment Instrument-Home Care. *Australian Journal of Rural Health*, *24*(2), 115–122. https://doi.org/10.1111/ajr.12213

O'Cathain, A., Knowles, E., Maheswaran, R., Pearson, T., Turner, J., Hirst, E., … Nicholl, J. (2013). Hospital characteristics affecting potentially avoidable emergency admissions: National ecological study. *Health Services Management Research*, *26*(4), 110–118. https://doi.org/10.1177/0951484814525357

Prag, P., Mills, M., & Wittek, R. (2013). Income and income inequality as social determinants of health: Do social comparisons play a role? *European Sociological Review*, *30*(2), 218–229. https://doi.org/10.1093/esr/jct035

Rosenberg, M. W., & Moore, E. G. (1997). The health of Canada's elderly population: current status and future implications. *Canadian Medical Association Journal*, *157*(8), 1025–1032. Retrieved from http://www.ecmaj.ca/content/157/8/1025.short

Smith, A. A., Chan Carusone, S. B., Willison, K., Babineau, T. J., Smith, S. D., Abernathy, T., … Loeb, M. (2005). Hospitalization and emergency department visits among seniors receiving homecare: A pilot study. *BMC Geriatrics*, *5*, 9. https://doi.org/10.1186/1471-2318-5-9

StataCorp. (2013). cloglog — Complementary log-log regression. College Station, TX: Stata Press. Retrieved from https://www.stata.com/manuals13/rcloglog.pdf

Šteinmiller, J., Routasalo, P., & Suominen, T. (2015). Older people in the emergency department: A literature review. *International Journal of Older People Nursing*, *10*(4), 284–305. https://doi.org/10.1111/opn.12090

Takahashi, P. Y., Ryu, E., Hathcock, M. A., Olson, J. E., Bielinski, S. J., Cerhan, J. R., … Juhn, Y. J. (2016). A novel housing-based socioeconomic measure predicts hospitalisation and multiple chronic conditions in a community population. *Journal of Epidemiology and Community Health*, *70*(3), 286–291. https://doi.org/10.1136/jech-2015-205925

Thompson, B., Cooney, P., Lawrence, H., Ravaghi, V., & Quiñonez, C. (2014). Cost as a barrier to accessing dental care: Findings from a Canadian population-based study. *Journal of Public Health Dentistry*, *74*(3), 210–218. https://doi.org/10.1111/jphd.12048

Van Wijk, B. L. G., Klungel, O. H., Heerdink, E. R., & de Boer, A. (2005). Rate and determinants of 10-year persistence with antihypertensive drugs. *Journal of Hypertension*, *23*(11), 2101–2107. https://doi.org/10.1097/01.hjh.0000187261.40190.2e

Wallace, E., Stuart, E., Vaughan, N., Bennett, K., Fahey, T., & Smith, S. M. (2014). Risk prediction models to predict emergency hospital admission in community-dwelling

adults: A systematic review. *Medical Care*, *52*(8), 751–765. https://doi.org/10.1097/MLR.0000000000000171

Weaver, C. G., Clement, F. M., Campbell, N. R. C., James, M. T., Klarenbach, S. W., Hemmelgarn, B. R., … McBrien, K. A. (2015). Healthcare costs attributable to hypertension: Canadian population-based cohort study. *Hypertension*, *66*(3), 502–508. https://doi.org/10.1161/HYPERTENSIONAHA.115.05702

Yao, C. S., & MacEntee, M. I. (2014). Inequity in oral health care for elderly Canadians: Part 1. Oral health status. *Journal (Canadian Dental Association)*, *79*, d114. Retrieved from http://www.ncbi.nlm.nih.gov/entrez/query.fcgi?holding=inleurlib_fft&cmd=Retrieve&db=PubMed&dopt=Citation&list_uids=24598318%5Cnhttp://ovidsp.ovid.com/ovidweb.cgi?T=JS&CSC=Y&NEWS=N&PAGE=fulltext&D=medl&AN=24598318

Zuur, A. F., Leno, E. N., Walker, N. J., Saveliev, A. A., & Smith, G. M. (2009). *Mixed Effects Models and Extensions in Ecology with R*. New York, NY: Springer. https://www.springer.com/us/book/9780387874579?gclid=EAIaIQobChMImNTa9uOB5wIViaDsCh0-Cg29EAQYAiABEgIxKPD_BwE#otherversion=9781441927644