A Short Walk a Day Shortens the Hospital Stay: Physical Activity and the Demand for Hospital Services for Older Adults

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ABSTRACT

Objectives: To estimate the impact of increased physical activity on utilization of hospital services among older adults in Canada.

Methods: The paper uses the Canadian Community Health Survey Cycle 2.1, and count data regression models. The study sample includes 18,196 adults aged 65 and above. Specification tests are used in order to identify the appropriate count data model, and sensitivity analyses are conducted to check the robustness of the results.

Results: The paper shows that physical activity is negatively associated with the probability of staying in the hospital as well as the numbers of hospital stay among users. However, the potential gain decreases as current activity level increases. The results also imply that an additional 20-minute daily walk by inactive older Canadians would decrease total hospital stays by about 2% of the total annual inpatient days. This is equivalent to 1.2% of total hospital bed capacity in a given year.

Conclusions: Health promotion efforts to increase the level of activity among older adults may create significant savings for the health care system. The total potential gain from additional physical activity is substantial, especially for those who are inactive. However, these gains can be materialized if people stay active enough to derive positive health benefits of physical activity. These results, therefore, should be evaluated in the light of findings from related literature on health and physical activity.

Key words: Physical activity; hospital services; exercise; aging

La traduction du résumé se trouve à la fin de l'article.

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The proportion of people aged 65 and above is growing faster than other age groups, and inactivity is more prevalent among them.¹ Insufficient physical activity negatively affects their health and quality of life due to its association with several chronic diseases.^{2,3} Studies show a positive association between inactivity and additional health care utilizations, and health care costs,⁴⁻¹⁰ however, these studies do not specifically study older adults. Another research stream focuses on clinical trials of physical fitness and wellness programs and associated health and health care utilization. Studies for various fitness programs have used samples from Texaco employees,¹¹ Bank of America retirees,¹² employees of insurance companies,¹³⁻¹⁶ and employees of the University of Kentucky.¹⁷ However, the samples in these studies are small and mostly specific to the younger or working age groups. Therefore, their results cannot be generalized to older adults.

In order to fill this research gap, this study aims to estimate potential saving from an increase in physical activity among older adults in Canada. Using count data regression models, I estimate the reduction in hospital stays associated with an increase in physical activity. I then examine total reduction in hospital stays that can be achieved from an overall increase in physical activity among older adults.

METHODS

Data source and variables

I used the Canadian Community Health Survey (CCHS), Cycle 2.1, which includes individual level information on health determi-

nants, health status, health care utilization, and health behaviours as well as health conditions, socio-economic and demographic factors.¹ The study sample included 18,196 individuals aged 65 and above.

Physical Activity Variable

The CCHS includes information on individuals' leisure-time physical activities (LTPAs). In the survey, total daily energy expenditure (TEE) from all LTPAs is measured as kilocalories (kcal) per kilogram (kg) of body weight, and calculated using the duration and type of the exercise and the corresponding Metabolic Energy Expenditure (MET). These MET values correspond to low intensity value for each activity since survey participants were not asked to specify intensity of activities. This conservative approach has been adopted in the survey since individuals tend to overestimate the intensity, frequency and duration of activities.^{18,19}

It is, however, important to note that this instrument may underestimate older adults' LTPAs since their daily living and activity preferences can be different from the rest of the population,²⁰ and this instrument may not appropriately reflect more prevalent activities among older adults.

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Conflict of Interest: None to declare.

Table 1. Summary Statistics and Variable Description for Main Variables

Variable Name	Variable Description	Mean	S.D.
Hospital stays	Annual number of nights at a hospital as a patient	1.175	4.576
TEE	Total daily energy expenditure from LTPAs	1.628	1.654
Age65-69	Age group: 65-69 years	0.334	0.461
Age70-79	Age group: 70-79 years	0.494	0.500
Interaction terms for age and physical activity			
TEE*Age65-69	Total daily energy expenditure for those who are in age group 65-69	0.633	1.330
TEE*Age70-79	Total daily energy expenditure for those who are in age group 70-79	0.800	1.375

Note: S.D.=standard deviation
LTPA=leisure-time physical activity

Other Independent Variables

Other than physical activity, there are other factors influencing demand for hospital services. For instance, individuals' health status, social and economic environments, and other health behaviours affect the demand. There are systematic health inequalities among individuals from different socio-economic backgrounds, which cannot be solely explained by the differences in individual health behaviours. People with low income or education suffer more disease and premature mortality and their low socio-economic background also affects their health behaviour.^{21,22} To control for socio-economic differences and variations in health status, economic and social factors, household composition and size, smoke-free environment, work-related factors, mental and general health status, and number of chronic conditions are included in the analysis.

Individuals' behaviour related to LTPAs and health care use can also be affected by other health behaviours. To account for them, alcohol and tobacco consumption and diet are included. Active individuals may utilize more health care services due to sports-related injuries and they may stay inactive during the injuries.²³ To control for these factors, dummy variables for injuries related to exercise are included.

In this study, physical activity is measured using LTPAs. However, individuals can be active during work or other daily activities. To account for these factors, dummy variables for walking or biking to work or while doing errands, and physical effort required at work or daily activities are also included. Tables 1 and 2 present a complete list of all variables.

Count data regressions

Following the literature, I used count data models to estimate the demand for hospital services, measured by the number of hospital stays.^{24,25} A number of different count data models are developed to deal with potential problems that exist in count data sets. For instance, non-zero counts are typically observed for a small share of the population that increases skewness in the data, and the variance of the dependent variable can be higher than the mean (overdispersion problem). As opposed to other models, a *zero inflated negative binomial* (ZINB) model provides a solution to these problems.²⁶

The ZINB explicitly models the number of predicted zeros and allows for the variance to differ from the mean. This model implies that conditional mean of the dependent variable,, for an individual i with characteristics X is:

$$E(y_i|X) = \lambda_i(1 - p_i) \quad (1)$$

where λ_i stands for average utilization among users, and $(1 - p_i)$ denotes the probability of being a user. Using the ZINB, one can jointly estimate the probability of being a user with a logit, and average utilization among users with a negative binomial (NB) model.

Specification tests for model selection and sensitivity analysis

To compare various count data approaches, specification tests are performed (see Table 3). First, using an overdispersion test, I test whether the mean and variance of the dependent variable is equal. The test shows that they are not equal, implying that the ZINB or NB are preferable to others. Next, a Vuong test²⁷ is used to see if the overdispersion is due to excess zeros. The Vuong test suggests that the ZINB is preferable to the NB, implying that the appropriate approach is the ZINB.

In order to check the robustness of the results, the model is also estimated using alternative measures. For instance, income adequacy and ownership of dwellings are used as alternative income and wealth measures. Since the sample consists predominantly of retired seniors, it is also estimated without including active commuting terms. These analyses show that the results presented here are robust.

Partial effect estimations from the ZINB regression

While estimated coefficients show the direction of the association between physical activity and hospital stays, determining the size effect for an improvement in physical activity requires the estimation of partial effects. Partial effects, which are an impact of a one-unit change in TEE on hospital stays, are calculated using a partial derivative of $E(y|X)$ with respect to TEE for age group j as:

$$\frac{\partial E(y|X)}{\partial TEE} = \hat{\lambda}(1 - \hat{p})[(\hat{\beta}_{TEE} + \hat{\beta}_{TEE*j}) - \hat{p}(\hat{\gamma}_{TEE} + \hat{\gamma}_{TEE*j})] \quad (2)$$

where j stands for age groups 65-69 or 70-79. $\hat{\beta}_k$ and $\hat{\gamma}_k$ denote the estimated coefficients for variable k from the NB and logit results in Appendix 1. $\hat{\lambda}$ and $\hat{p}$ show the predicted numbers of hospital stays among users and the probability of being a non-user. The partial effect for age group 80+ can be calculated using Equation (2) after deleting $\hat{\beta}_{TEE*j}$ and $\hat{\gamma}_{TEE*j}$.

TEE is expressed as kcal burned per kg of body weight. One can also express it as total daily kcal burned by an individual with average body weight of 72.5 kg in this sample. In this case, a one-unit increase in TEE is equivalent to burning 72.5 kcal/day. This corresponds to walking the dog for 20 minutes, or a 20-minute walk for pleasure, or a 20-minute walk at 2.5 miles/hour on a firm surface.²⁸

Given the coefficient estimates and Equation (2), one can estimate the impact of a one-unit increase in TEE (20-minute daily walk) on numbers of hospital stays. However, the partial effects can only be calculated for known values of individual characteristics since $\hat{\lambda}$ and $\hat{p}$ are a function of independent variables. To do this, I divide each age group into three subgroups (inactive, moderately active, active) based on their current physical activity.

To calculate corresponding effects for all subgroups in each age group, I use all relevant values for TEE in each activity group (i.e.,

Table 2. Summary Statistics and Variable Description for Other Variables

Variable Name	Variable Description	Mean	S.D.
Alcohol	Average daily alcohol consumption	0.354	0.751
Alcohol2	Square of average daily alcohol consumption	0.724	3.468
Smoker	Daily smoker	0.092	0.301
Moderately Smoker	Occasional smoker	0.016	0.130
Former Smoker	Former daily smoker	0.417	0.492
Former Mod Smoker	Former occasional smoker	0.143	0.346
Fruit & Veggie	Daily consumption of fruit and vegetables (servings)	5.167	2.335
Handsmoker_home	Number of people who smoke inside home every day	0.127	0.382
Handsmoker_car	Exposed to second-hand smoke in private vehicle	0.037	0.182
Handsmoker_bldg	Exposed to second-hand smoke in public places	0.083	0.279
Minority	Visible minority	0.061	0.188
Immigrant	Immigrant	0.241	0.378
Recent Immigrant	Lived in Canada less than 10 years	0.007	0.050
Poor Health	Self-rated poor or fair health	0.236	0.435
Poor Mental Health	Self-rated poor or fair mental health	0.043	0.206
Stress	Self-perceived stress: extremely or quite a bit	0.094	0.290
Stress at Work	Self-perceived stress at work: extremely or quite a bit	0.012	0.101
Life Dissatisfaction	Dissatisfied from life	0.028	0.174
Chronic Conditions	Number of chronic conditions	2.947	2.194
Live Together	Married or common law partner	0.627	0.499
No Income	No household income	0.135	0.401
Low Income	Household income (\$15,000-\$29,999)	0.345	0.485
Medium Income	Household income (\$30,000-\$49,999)	0.275	0.432
Med-high Income	Household income (\$50,000-\$79,999)	0.165	0.329
Household Size	Household size	1.839	0.640
Bedrooms	Number of bedrooms at home	2.571	0.939
Education	Highest level of education (4 categories)	2.294	1.340
Has MD	Has regular medical doctor	0.958	0.221
BMI	Body Mass Index	25.95	4.34
Male	Sex of the respondents	0.456	0.491
Repetitive Injury	Had repetitive injury in the last 12 months	0.049	0.213
Repetitive (Sports)	Sports-related repetitive injury in the last 12 months	0.007	0.083
Other Injury	Had other injuries in the last 12 months	0.081	0.276
Other Injury (Sports)	Sports-related other injuries in the last 12 months	0.007	0.082
Occupation1	Occupations related to management, business, finance, natural, social and health sciences, education, religion, culture	0.047	0.189
Occupation2	Occupations related to sales and service	0.023	0.136
Occupation3	Occupations related to trades and transportation, processing, manufacturing and utilities	0.028	0.166
Walk_<1	Less than 1 hour/week walking to work or while doing errands	0.130	0.333
Walk_1-5	1-5 hours/week walking to work or while doing errands	0.343	0.470
Walk_6-10	6-10 hours/week walking to work or while doing errands	0.094	0.293
Walk_11-20	11-20 hours/week walking to work or while doing errands	0.042	0.205
Walk_>20	More than 20 hours/week walking to work or while doing errands	0.048	0.218
Bike_<1	Less than 1 hour/week biking to work or while doing errands	0.010	0.097
Bike_1-5	1-5 hours/week biking to work or while doing errands	0.011	0.108
Bike_6-10	6-10 hours/week biking to work or while doing errands	0.003	0.048
Bike_11-20	11-20 hours/week biking to work or while doing errands	0.001	0.031
Bike_>20	More than 20 hours/week biking to work or while doing errands	0.001	0.034
Work(stand walk)	Work habits (if relevant) and/or daily physical activities: stand or walk	0.526	0.500
Work(light load)	Work habits (if relevant) and/or daily physical activities: lift light loads	0.205	0.408
Work(heavy load)	Work habits (if relevant) and/or daily physical activities: lift heavy loads	0.011	0.113

Note: S.D.=standard deviation

Table 3. Summary Results From the ZINB Regression

Physical Activity Variables	NB		Logit	
	Coefficients	t-values	Coefficients	t-values
TEE	-0.098	-2.01	-0.105	-1.94
TEE*Age65-69	0.008	0.13	0.030	0.44
TEE*Age70-79	0.004	0.07	-0.005	-0.07
Specification Tests	Test Statistics	p-value		
Over-dispersion test	13.66	<0.01		
Vuong-test	16.50	<0.01		

Note: NB denotes the negative binomial regression model. The sign of the logit coefficients are reversed to reflect that the logit models predict the probability of being in the potential user group. Full results are presented in Appendix 1.

0 ≤ TEE < 1.5 for inactive) and subgroup mean values for all other variables. These results are presented in Table 4 for an individual in each subgroup at two different current LTPA levels.

RESULTS

Table 3 presents estimated coefficients for LTPAs. The NB model estimates the number of hospital stays among users, and the logit model predicts the probability of being a user. They imply that physical activity is negatively associated with any hospital stay and with the numbers of stays among users.

Table 4 shows that the impact of an additional 20-minute walk is higher for inactive people than for others. These results suggest that if an inactive 65-69 year old with a current activity level of 20 minutes per day walked an additional 20 minutes per day, his/her hospital stays would be decreased by 0.115 days/year (a 16% decrease). The effects for a similar individual aged 70-79 or 80+ would be 0.193 and 0.179 days per year, respectively (a 19% decrease). For an individual with higher current activity level (i.e., a 40-minute/day walk), the impact of an additional 20-minute/day walk on hospital stays is lower for all age groups. These results show

Table 4. Impacts of an Additional 20-minute Daily Walk on Hospital Stays

	Current Activity Level					
	Inactive* (less than a 30-min daily walk)		Moderately active (30-60 min daily walk)		Active* (60 min & more daily walk)	
	0 min	20 min	30 min	40 min	60 min	80 min
Age 65-69						
Per capita change						
Days/year	-0.134	-0.115	-0.086	-0.079	-0.059	-0.050
%	-16	-16	-16	-16	-16	-16
Total (days/year)		-65,614		-23,439		-13,693
Age 70-79						
Per capita change						
Days/year	-0.230	-0.193	-0.133	-0.121	-0.089	-0.074
%	-18	-19	-19	-19	-19	-20
Total (days/year)		-201,267		-56,332		-26,183
Age 80+						
Per capita change						
Days/year	-0.212	-0.179	-0.179	-0.163	-0.137	-0.144
%	-18	-19	-19	-19	-19	-19
Total (days/year)		-125,797		-29,042		-15,679

Note: * An active individual is one with a TEE of more than 3 kcal per kg of body weight. This corresponds to a low intensive 1-hour/day walk. An inactive individual, on the other hand, is one with a TEE of less than 1.5 kcal per kg of body weight. This corresponds to less than a 30-minute/day walk.¹⁷

that the gain from additional physical activity decreases as physical activity increases.

The partial effects show per capita gain from additional physical activity. One can estimate total number of fewer hospital stays using total number of people in each sub-group, and the per capita gain. To show the breakdown by age groups, I estimate the total gain as a result of an additional 20-minute/day walk for all age groups. To do this, I use conservative estimates (i.e., -0.115 rather than -0.134 for the 65-69 year inactive group) for each subgroup.

For inactive 65-69 year olds, these findings suggest that total hospital stays decrease by 65,614 days/year. Total impact is even higher for other age groups. For inactive older adults aged 70-79 and 80+, total gain is more than 201,000 and 125,000 days/year, respectively. This implies that an additional 20-minute/day walk by all inactive people aged 65+ decreases hospital stays by about 392,000 days/year. When compared to the 20.8 million inpatient days, or the total bed capacity in all hospitals,²⁹ potential gain from an additional 20-minute walk by inactive older Canadians accounts for about 2% of total annual inpatient days, or 1.2% of total hospital bed capacity.

However, these results imply that the potential gain from an additional 20-minute walk decreases as current physical activity increases. For instance, the total decrease in annual hospital stays for those who are at least moderately active would be less than 1% of total annual inpatient days.

DISCUSSION

This paper suggests that a small change in sedentary lifestyles for inactive older adults could translate into a substantial decrease in hospital stays: adding some activity for inactive older adults decreases hospital stays by 16% to 19%. In terms of total hospital days, the results suggest that an additional 20-minute/day walk by inactive older adults decreases total inpatient stays by about 2%. If all older adults increase their activity level by the equivalent of a 20-minute/day walk, total inpatient days decrease by about 2.7%, equivalent to 1.7% of annual bed capacity in Canadian hospitals.

These results should be evaluated in the light of findings from related literature on health and physical activity. Epidemiological research firmly established positive effects of physical activity on people's health due to its strong association in preventing chronic

diseases.^{3,30} As suggested in the literature, these benefits can be derived in a short period of time. For instance, the studies on physical fitness, diabetes and obesity show that changes in fitness level and their influence on risk factors may occur within about six months after individuals reach the appropriate activity level.¹⁰

This paper may have some limitations due to its cross-sectional design. It is likely that unobservable factors can create bias in cross-sectional studies. For instance, if exercisers are inherently different from sedentary people, these unmeasured differences can partly explain the differences in utilization. To account for the bias, I included a comprehensive set of control variables. However, any unobserved factors not controlled by the included variables would still create bias. Therefore, further research dealing with these methodological issues may extend our understanding and provide additional insights on this issue.

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Appendix 1. ZINB Regression Results

	NB		Logit	
	Coefficient	t-value	Coefficient	t-value
TEE	-0.098	-2.01	0.105	1.94
Age65-69	-0.074	-0.60	0.348	2.46
Age70-79	-0.084	-0.89	0.170	1.51
TEE*Age65-69	0.008	0.13	-0.030	-0.44
TEE*Age70-79	0.004	0.07	0.005	0.07
Alcohol	0.0002	0.0003	0.333	3.24
Alcohol2	0.001	0.04	-0.017	-0.81
Smoker	-0.152	-1.14	0.041	0.27
Moderately Smoker	-0.112	-0.59	-0.087	-0.36
Former Smoker	0.125	1.55	-0.138	-1.37
Former Mod Smoker	-0.106	-1.01	-0.273	-2.15
Fruit & Veggie	-0.017	-1.15	-0.019	-1.12
Handsmoker_home	0.016	0.17	-0.192	-1.99
Handsmoker_car	-0.096	-0.55	-0.088	-0.44
Handsmoker_bldg	0.051	0.39	0.075	0.45
Minority	0.227	1.15	0.612	3.09
Immigrant	-0.185	-2.16	-0.178	-1.55
Recent Immigrant	-1.348	-1.04	1.323	1.16
Poor Health	0.210	3.01	-0.584	-7.11
Poor Mental Health	-0.102	-0.84	0.605	3.37
Stress	0.164	1.62	-0.096	-0.80
Stress at Work	0.006	0.01	0.158	0.35
Life Dissatisfaction	-0.007	-0.06	-0.414	-2.38
Chronic Conditions	0.008	0.56	-0.148	-7.36
Live Together	-0.164	-1.75	-0.027	-0.27
No Income	0.134	0.69	0.091	0.42
Low Income	0.210	1.18	0.149	0.75
Medium Income	0.207	1.16	0.176	0.90
Med-high Income	0.106	0.58	0.070	0.32
Household Size	0.035	0.54	-0.009	-0.10
Bedrooms	-0.062	-1.59	0.017	0.42
Education	0.046	1.76	-0.004	-0.12
Has MD	0.056	0.30	-0.449	-2.60
BMI	-0.007	-0.92	0.011	1.24
Male	0.013	0.17	-0.555	-6.13
Repetitive Injury	-0.365	-2.04	-0.181	-0.90
Repetitive (Sports)	0.083	0.22	0.257	0.33
Other Injury	0.185	2.07	-0.597	-5.39
Other Injury (Sports)	-0.454	-1.45	0.248	0.43
Occupation1	-0.073	-0.37	0.027	0.08
Occupation2	0.652	1.43	0.535	1.59
Occupation3	-0.209	-0.82	0.133	0.56
Walk_<1	-0.307	-3.01	0.083	0.74
Walk_1-5	-0.103	-1.33	0.199	2.13
Walk_6-10	-0.201	-1.57	0.022	0.17
Walk_11-20	-0.152	-0.80	-0.163	-0.74
Walk_>20	-0.216	-1.29	0.052	0.29
Bike_<1	-0.701	-1.57	0.175	0.34
Bike_1-5	-0.129	-0.37	0.392	1.22
Bike_6-10	-0.046	-0.12	1.388	2.13
Bike_11-20	-2.407	-4.43	-2.949	-1.55
Bike_>20	-0.303	-0.88	-1.427	-1.47
Work(stand walk)	-0.346	-4.60	0.287	3.36
Work(light load)	-0.440	-3.75	0.425	3.80
Work(heavy load)	-0.227	-0.52	0.960	2.74
Constant	2.579	6.15	2.047	4.15

Note: Sample size in all models is 18,196 individuals, aged 65 and above. NB denotes the negative binomial regression model. The logit coefficients predict the probability of being in the non-user group. All models include provincial dummies.

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RÉSUMÉ

Objectifs : Estimer l'impact d'une hausse de l'activité physique sur l'utilisation des services hospitaliers par les personnes âgées au Canada.

Méthode : Nous avons utilisé le cycle 2.1 de l'Enquête sur la santé dans les collectivités canadiennes et des modèles de régression avec données chiffrées. L'échantillon comprend 18 196 adultes de 65 ans et plus. Nous avons mené des essais de spécification pour trouver le modèle approprié et des analyses de sensibilité pour vérifier la robustesse des résultats.

Résultats : L'activité physique est associée négativement à la probabilité d'un séjour à l'hôpital et au nombre de séjours à l'hôpital chez les utilisateurs. Toutefois, le gain potentiel diminue avec la hausse du niveau d'activité actuel. On déduit que 20 minutes de marche de plus par jour chez les Canadiens âgés sédentaires diminueraient d'environ 2 % le nombre de séjours à l'hôpital. C'est l'équivalent de 1,2 % de la capacité totale en lits d'hôpitaux pour une année donnée.

Conclusion : Les efforts de promotion de la santé qui visent à augmenter le niveau d'activité des personnes âgées pourraient générer des économies importantes pour le système de santé. Les gains potentiels totaux d'une hausse de l'activité physique sont considérables, surtout chez les sédentaires. Ces gains peuvent se concrétiser si les gens restent suffisamment actifs pour améliorer leur santé. Ces résultats devraient donc être évalués à la lumière des constatations des travaux connexes publiés sur la santé et l'activité physique.

Mots clés : activité physique; service hospitalier; exercice physique; vieillissement