BMJ Open

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Journal:	*BMJ Open*
Manuscript ID	bmjopen-2019-032837
Article Type:	Research
Date Submitted by the Author:	08-Aug-2019
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Keywords:	Abulatory care sensitive conditions, Life Satisfaction, Avoidable hospitalization

The relationship between life satisfaction and preventable hospitalizations: a population-based cohort study

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WORD COUNT: 3,417

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Abstract

Objective: To examine if low life satisfaction is associated with an increased risk of being hospitalized for an ambulatory care sensitive condition (ACSC), in comparison to high life satisfaction

Design and setting: Population-based cohort study of adults from Ontario, Canada. Baseline data was captured through the Canadian Community Health Survey (CCHS) and linked to health administrative data for follow-up information.

Participants: 129,467 men and women between the ages of 18 to 74.

Main outcome measures: Time to avoidable hospitalizations defined by ACSCs.

Results: Life satisfaction was measured at baseline through the CCHS and follow-up information on ACSC hospitalizations were captured by linking participant respondents to hospitalization records covered under a single payer health system. Within the study timeframe (maximum of 14 years), 3037 individuals were hospitalized. Older men in the lowest household income quintile were more likely to be hospitalized with an ACSC. After controlling for age, sex, socioeconomic (SES), and other behavioural factors, low life satisfaction at baseline had a strong relationship with future hospitalizations for ACSCs (hazard ratio 2.71; 95% CI, 1.87-3.93). The hazards were highest for those who jointly had the lowest levels of life satisfaction and low household income (hazard ratio 3.80; 95% CI, 2.13-6.73). Results did not meaningful change after running a competing risk survival analysis.

Conclusions: This study demonstrates that poor life satisfaction is associated with hospitalizations for ACSCs after adjustment for several confounders. Furthermore, this relationship is experienced more severely for those who are more socioeconomically disadvantaged. This study adds to the existing literature around the significance of life satisfaction on health and the health system by documenting its impact on a health system, particularly for avoidable hospitalizations.

Article Summary

Strengths and limitations of the study

- Few studies have addressed hospitalizations for ambulatory care sensitive conditions (ACSC) as an outcome and those that do have often done so with diseased baseline cohorts.
- In the present study, poor life satisfaction was associated with an increased risk of future hospitalizations for an ACSC, a finding that persisted after controlling for socioeconomic status, behaviour risk factors, multi-morbidity and mental health factors.
- The influence of poor life satisfaction was stronger for those who were more socioeconomically disadvantaged compared to those with poor life satisfaction but not socioeconomically disadvantaged.
- Research on life satisfaction has shown it to be consistent over time; however, it is possible that life satisfaction could have changed during the study period, which was not captured in our study.
- This study did not directly address mechanisms by which life satisfaction can influence avoidable hospitalizations.

Introduction

There has been broad recognition that upstream determinants have an influence on a range of health outcomes, including social determinants and risky health behaviours. However, subjective well-being, specifically life satisfaction is increasingly being recognized as playing an important role.(1-3) Many ambulatory care sensitive conditions (ACSC) are preventable resulting in potentially high amounts of healthcare resources if left unmanaged.(4, 5) Hospitalizations for these conditions (e.g., diabetes) are regarded as avoidable due to the relationship of timely access to primary care preventing complications and acute episodes.(5-7) In many countries, hospitalizations for these conditions are used as an indicator to measure the effectiveness of the healthcare system. (8)

Positive affect, which is the degree to which an individual experiences positive emotions (9), has been shown to be independently associated with reduced risk of coronary heart disease, even after adjustment for depressive symptoms. (10) Similarly, life satisfaction is associated with a reduced risk of various chronic conditions. (2, 11) Evidence from a recent prospective cohort study concluded lower life satisfaction was associated with a higher incidence of cancer, stroke, and type-2 diabetes. (11)

Research on life satisfaction has also recently shown to impact future high-health care use.(13) Specifically that individuals with lower life satisfaction had three times the odds of being in the top 5% of healthcare resource utilization.(13) However, another important system indicator that is absent from the current life satisfaction literature is avoidable hospitalizations, such as those caused by ACSCs. Given the evidence around the interrelationships between emotional factors and chronic-disease self -management (14) and in particular how emotional and psychological distress can influence the ability of a patient to manage their chronic condition (15, 16), more research is needed that quantitatively measures the impact of subjective well-being on the healthcare system.

Upon a recent search, only eight studies have were identified that fit the criteria of a similar exposure to life satisfaction and hospitalizations for one or more ACSC as an outcome. Previous studies mostly focused on singular conditions, with small sample sizes, limited follow-up time and clinical or convenience-based samples (17)(18). Regarding the length of follow-up, these ranged from six months (19) to four years (20). Considering many of the conditions regarded as ACSCs are also chronic diseases (e.g., diabetes) studies that accommodate a longer follow-up time necessary to allow for outcomes to be observed. Furthermore, hospitalizations for ACSCs are a relatively rare event in Canada where people with an ACSC hospitalization constitutes only 0.4% of the population aged 12 to 74 (21), and therefore, the limited sample sizes in previous studies may not be sufficient to observe an effect. We address these limitations by conducting the largest large population-based cohort study to date, to improve our understanding of this relationship.

The primary objective of this study was to determine if poor life satisfaction increased the risk of being hospitalized for an ACSC in a relatively healthy baseline cohort among an adult population.

Methods

Participants

The study was a longitudinal population-based cohort study of adult Ontario participants of the Canadian Community Health Survey (CCHS) pooled across five cycles: Cycle 2.1 (2003-2004), Cycle 3.1 (2005-2006), Cycle (2007-2008), Cycle (2009-2010), and Cycle (2011-2012). Furthermore, the data was linked to population-based health administrative data held at ICES. These data sources capture all hospitalization records for every person living in the province of Ontario covered under the single-payer health system. The CCHS is a cross-sectional survey administered by Statistics Canada, representative of 98% of the Canadian population aged ≥12 years living in private dwellings with response rates >75%.(22) Detailed survey methodology is available elsewhere. (23)

Eighty percent of the CCHS survey respondents consented to have their data linked to the single-payer health insurance data, referred to as the Ontario Health Insurance Plan (OHIP), which captures all related healthcare encounters. All survey respondents were linked to Ontario's population registry, the Registered Persons Database (RPDB), which captures core demographic and clinical information as well as death, in addition to the Discharge Abstract Database (DAD). The analytic sample included adults (aged 18 to 74) who reported on life satisfaction and did not have an ACSC-related hospitalization in the two years before their CCHS interview date (**Figure 1**).

Measures

Self-reported life satisfaction, the primary exposure variable, is captured from CCHS. The question that respondents answered regarding life satisfaction was, "*How satisfied are you with your life in general?"* With response options being: *very satisfied, satisfied, neither satisfied nor dissatisfied, dissatisfied, or very dissatisfied.* Due to small sample sizes within each category, we collapsed the categories of dissatisfied and very dissatisfied. Furthermore, we did not hypothesize significant conceptual differences between these two categories related to hospitalizations for ACSCs.

The primary outcome variable was hospitalizations for an ACSC, which we used as a composite outcome. The ACSCs that we chose to report on are grand mal status and other epileptic convulsions, chronic obstructive pulmonary disease, asthma, diabetes, heart failure and pulmonary edema, hypertension, and angina. These conditions are in accordance with the Canadian Institute for Health Information's (CIHI) methodology (24) were chosen as our primary focus. See **Supplement Table 1** for the list of included conditions and their corresponding ICD-10 codes.

Aggregate diagnosis groups (ADGs®)(25) were captured through administrative data as a summary measure of comorbidity and are based on the Johns Hopkins ACG® System, which is a person-focused, diagnosis-based method of categorizing subjects' illnesses [22]. ADGs have previously been used and validated as a reliable method of comorbidity adjustment in the Ontario population (26), and we used Version 10.0.1 in this analysis. Additionally, we used the Ontario Marginalization Index (ON-Marg) as a measure of socioeconomic status. The ON-Marg is a census-based, geographically derived index that was used to calculate area-level material deprivation.(27) Specifically, the material deprivation dimension measures the proportion of the population within a geographic region that is low income, without high school diploma, lone parent families, receiving government transfer payments, unemployed, and living in dwellings in need of repair. All other important covariates were captured through self-report from the CCHS interview questions.

CCHS Variables

Household income quintile categorizes individuals based on their total household income in addition to the number of individuals living in the household. Individuals are then ranked from the lowest levels of household income (*Q1*) to the highest (*Q5*). Body Mass Index (BMI) was categorized into five categories ranging from "underweight" (BMI less than 18.5) to "severely obese" (BMI greater than 34.9). Physical activity was based on an individual's daily energy expenditure and further categorized into three levels: active, moderately active and inactive. Smoking status measured an individuals' past and present smoking habits by considering both the total amount of cigarettes smoked and the type of smoker they are (e.g., daily vs. occasional). This variable was categorized into three levels: current smoker, former smoker, never smoker. Alcohol consumption was based on the participant's sex and the quantity of alcohol consumed each day. This variable was then categorized into four levels: heavy drinker, moderate drinker, light drinker and never drinker. Mood disease was captured through the CCHS interview question "have you ever been diagnosed by a health professional for depression, bipolar disorder, mania or dysthymia?" This variable was used to control for depression. Anxiety disorder, which was captured through the question: "have you ever been diagnosed by a health professional for an anxiety disorder such as a phobia, obsessive-compulsive disorder, or panic disorder?" Education level is a derived variable which indicates the highest level of education acquired by the participant; this variable was explored as a potential indicator for SES.

Statistical Analysis

We calculated the distribution of demographic, socioeconomic, health status and behaviour characteristics according to ACSCs and life satisfaction. Excluding those with an ACSC in the year prior allowed for the investigation of the upstream determinants (i.e. the factors associated with future development of an ACSC hospitalization in a cohort who were without a recent hospitalization for one of these conditions).

Cox proportional hazards models were used to estimate the hazards associated with baseline life satisfaction on the risk of being hospitalized for an ACSC. Time is defined as survey date until disease or censoring for study endpoint (max follow up until March 31, 2017) or death. We calculated unadjusted, age-sex-adjusted, minimally adjusted and fully adjusted models. The minimally adjusted model controlled for age, sex and household income while the fully adjusted model included age, sex, household income, smoking status, alcohol consumption, physical activity and BMI. We ran three additional models which controlled for ADG score, mood disease, and anxiety separately in order to quantify their independent effects on the fully adjusted model. The models were used to quantify the association between life satisfaction and the hazard of being hospitalized for an ACSC using "very satisfied" as the referent category.

A joint-effects model was used to test if the relationship between life satisfaction and avoidable hospitalizations varied by SES. A joint-effects variable, which contains each combination of life satisfaction and household income, was included in the model while controlling for age, sex, smoking status, alcohol consumption, physical activity and BMI.

We ran sensitivity analyses by re-running the fully adjusted model with a consistent survival time of five years. Additionally, models for individuals who did not have an event in the first two years of the study were run to control for undocumented comorbidity. Finally, the subdistribution hazards model, which was initially developed by Fine and Gray (28), was run to test the possibility of death behaving as a competing risk.

Survey and bootstrap sampling weights provided by Statistics Canada were applied to the analyses to account for the complex survey design of the CCHS.(29) The bootstrap sampling weights were applied using balanced repeated replication, in order to properly calculate confidence intervals. Additionally, this project received ethics approval from the Health Sciences Research Ethics Board at the University of Toronto (Ref # 36123, 15 August 2018). Finally, all statistical analyses were performed in 2018 and 2019 using SAS version 9.4.

Patient Involvement

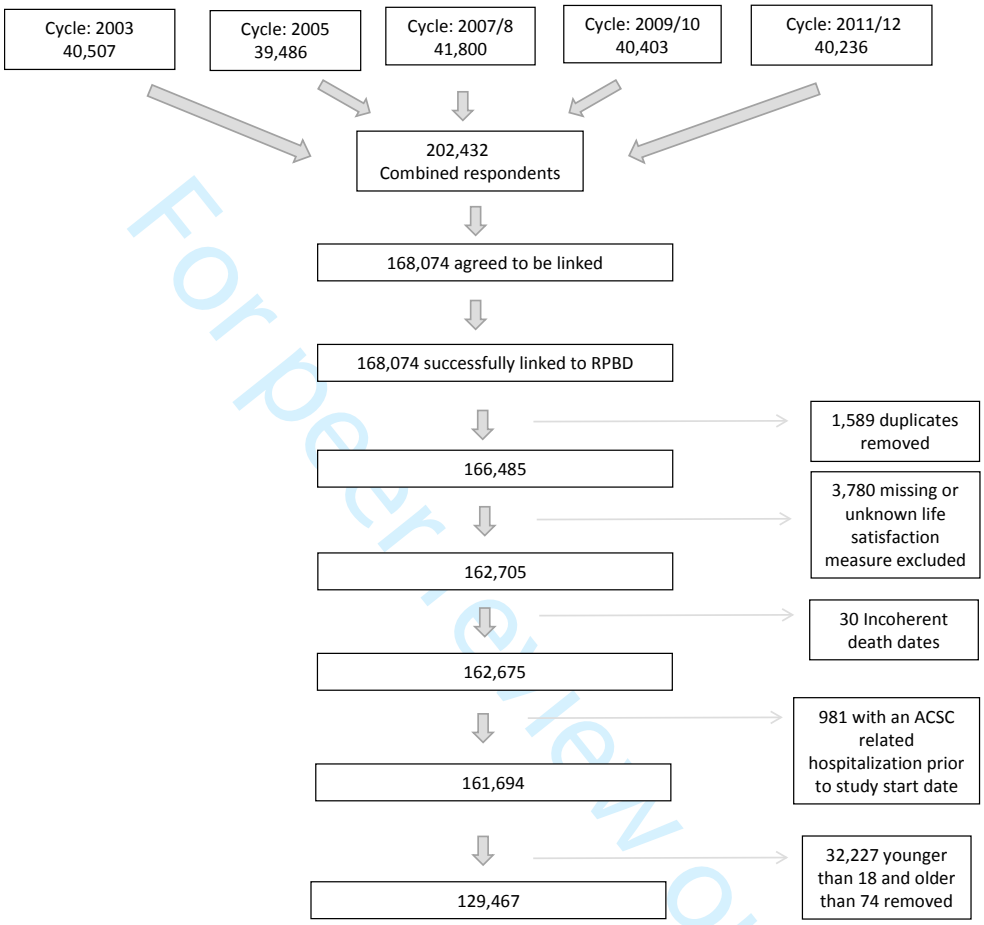
Patients were not involved in the development of the research question, outcome measures, recruitment, design or the implementation of the study objectives. Furthermore, no patients were consulted on the interpretation of results, and there are no plans to disseminate the results of this study to the relevant participants or their communities.

Results

After combining the five cycles of data linked to the Registered Persons Database and excluding those less than 18, older than 74, in multiple survey cycles, missing life satisfaction, had an ACSC related hospitalization in the two years before the start of the study resulted in 129,467 individuals remaining. Those who experienced an ACSC-related hospitalization two years before their survey interview date were removed to examine the impact of life satisfaction on future hospitalizations for an ACSC and reduce the possibility of reverse causality (**Figure 1**). In the

case of people in multiple survey cycles (n=1,589), we used the earliest survey response. Each respondent was followed for a maximum of 14 years or until the study end date, after which we determined that 3,037 individuals had experienced an ACSC-related hospitalization.

Figure 1: Flow chart of study participants



Older men in the lowest household income quintile were more likely to be hospitalized with an ACSC. Also, individuals with a higher degree of comorbidity as measured by a higher ADG score and the presence of behavioural risk factors such as smoking and physical inactivity were associated with being hospitalized for an ACSC (**Table 1**). Poor life satisfaction was associated with being older, less education, lower household income, higher ADG score, and higher disease-related risk factors such as smoking and physical inactivity (**Table 2**).

Life satisfaction had a strong unadjusted relationship with hospitalization for ACSC. **Table 3** presents the unadjusted and adjusted hazard ratios for the relationship between life satisfaction and ACSC-related hospitalizations, which include models that adjusted for age and sex, and then further adjusted for socioeconomic and lifestyle factors. Although full adjustment does reduce

the size of the effect, the hazard ratio of an individual with the lowest levels of life satisfaction (dissatisfied and very dissatisfied combined) compared to those who were very satisfied is 2.71 (95% confidence interval 1.87 to 3.93). Interestingly, the observed relationship follows a dose-response pattern, or in other words, the hazard ratios increase in size for each decreasing level of life satisfaction. For example, in the fully adjusted model, the hazard ratio for the middle life satisfaction category (neither satisfied nor dissatisfied) was 1.71 (95% confidence interval 1.36 to 2.14) while the satisfied category produced a hazard ratio of 1.32 (95% confidence interval 1.15 to 1.50). Furthermore, the additional analyses (**Table 4**) that controlled for ADG score, mood disease and anxiety separately did not substantially reduce the observed effect sizes with the added adjusted of ADG score having the largest impact (hazard ratio of 2.42, 95% confidence interval of 1.68 to 3.51).

Regarding the joint effects model (**Table 6**), individuals who identified as having both low life satisfaction and low household income produced a fully adjusted hazard ratio of 3.80 (95% confidence interval 2.13 to 6.73). Therefore, in comparison to the fully adjusted model presented above (hazard ratio of 2.71), poor SES individuals are at an increased risk of being hospitalized when they are not satisfied with their lives.

A range of sensitivity analyses were conducted to test the robustness of the study findings. Both the five-year survival model and the model which excluded individuals who had an event within the first two years did not change the effect sizes to a significant degree. The hazard ratios for the lowest levels of life satisfaction compared to those who were very satisfied were 2.74 and 2.77, respectively (**Supplement Table 2**). In the competing risk analysis (**Supplement Table 3**), the unadjusted hazard ratios produced in the subdistribution hazard model were similar to those produced in the final model (4.38 vs 4.51 respectively). Finally, we exmined the impact of alternate measures of SES (**Supplement Table 4**), showing similar results, with the largest effect seen with household income, which was used in our primary analysis.

Discussion

Life satisfaction was shown to be associated with a range of health outcomes. However, little is known about how life satisfaction can impact health system indicators such as avoidable hospitalizations in a general population cohort. We investigated this relationship and accounted for a wide variety of clinical and behavioral risk factors. We saw robust findings that poor life satisfaction was shown to have strong independent relationship with future ACSC hospitalizations with the lowest levels of life satisfaction (dissatisfied and very dissatisfied) being associated with almost a three times higher hazard of an avoidable hospitalization compared to those who were very satisfied after accounting for numerous confounders.

Previous studies have linked life satisfaction and similar exposures (e.g. positive affect) to health outcomes such as stroke (11) and heart disease (10). Life satisfaction has also been shown to be associated with a wide variety of health behaviours. (30, 31) For instance, one study found that

those who exercised more were generally happier. (32) Furthermore, life satisfaction has also been shown to be experienced differently across categories of socioeconomic status. (33) Due to the detailed survey variables available from the survey data and the linkage of these data to complete hospitalization outcomes form from health administrative databases, these confounders in addition to objective measures of comorbidity were adjusted for in the analyses.

This study addresses an important gap in the literature by providing a robust population sample size and examining how life satisfaction related to a meaningful health system outcome. There are few studies that addresses life satisfaction or other forms of subjective well being as they relate to hospitalizations for ACSCs. Furthermore, the existing research is limited by small sample sizes and insufficient follow-up times. This study also has more direct implications for the health system given ACSCs are defined as conditions for which hospitalizations should be prevented, given timely and effective access to primary care. (7) Considering the preventable nature of these conditions, hospitalizations for ACSCs are an ineffective use of healthcare resources and insight into the risk factors for these conditions can help improve health system functioning.

Unlike previous studies, we measured baseline life satisfaction on a sample who did not have an ACSC hospitalization in the two years prior while also presenting analyses that controlled for comorbidity and therefore overcomes the criticism of other studies that that poor life satisfaction could have been the result of the bidirectional relationship between poor health and life satisfaction. A possible explanation for the observed results is that individuals who experience poor life satisfaction tend to have higher rates of depression, given its observed relationship with poor health outcomes. (34, 35) To address this, we further adjusted for mood disease and found that this has little effect on attenuated the observed association.

Limitations

We acknowledge that there are some limitations and interpretive cautions in this study. First, this study was an observational study, although we controlled for several potential confounders and excluded those with a recent history of ACSC at baseline through linkage, we cannot rule out the possibility of unmeasured or residual confounding. We note however that the effect sizes are large, and this study did control for many more confounders than previous studies through a combination of survey data in addition to health administrative variables to capture comorbidity. Second, we measured life satisfaction at one point in time (survey interview date). Research on life satisfaction has shown it to be consistent over time (36); however, it is possible that life satisfaction could have changed during the study period. Therefore, we only capture the effect from that initial time point and cannot account for the influence of changes in life satisfaction that happen following the baseline assessment. Furthermore, there are other instruments that can be used to assess life satisfaction that were not available in this study. Finally, life satisfaction is a subjective measure. It has been shown to be an accurate and robust measure of happiness, it is still up to the individuals to judge and reflect on their life satisfaction. This means that its

meaning can differ based on the individual resulting in variation in the exposure. Despite these limitations, this study has still provided an essential contribution to the literature by being one of the first assessments of life satisfaction on avoidable hospitalization that utilizes a longitudinal population-based study design while measuring this exposure before the disease outcome.

Mechanisms

This study did not directly address mechanisms by which life satisfaction can influence avoidable hospitalizations; however, these have been studied by others. Out of the existing literature, there seem to be three main mechanisms that could help explain the observed relationship between life satisfaction and health: behavioural, health service use, and biological. Subjective well-being has been shown to impact a variety of health behaviours, such as increased physical activity (37-40) and reduced smoking habits (40). However, many of these studies lacked proper adjustment of confounding variables such as SES and psychological distress.(40) Regarding health service use, a study from 2014 found that participants who were identified as having a greater purpose in life were more likely to receive preventative health services such as mammograms or colonoscopies.(41) What remains to be seen regarding this mechanism is whether the use of these services reflects access to primary care, or the decisions made by the individuals themselves to seek these services. However, a recent population-based cohort study noted how hospitalizations for ACSCs could not be explained by a lack of access to primary care (42), and therefore we could perhaps interpret the impacts of this mechanism as a result of individual decisions that are influenced by their satisfaction with life. Finally, biological mechanisms could also play a contributing role. A recent meta-analysis noted how individuals who were identified as having greater psychological well-being experienced favourable lipid profiles.(43) However, these associations were largely mitigated once behavioural characteristics were taken into account.(43)

Conclusions

This study demonstrates that life satisfaction is associated with hospitalizations for ACSCs, even after controlling for socioeconomic characteristics, health behaviours, comorbidities and mental health factors. Furthermore, more socioeconomically deprived individuals were shown to be at an increased risk. While governments plan to improve the sustainability and functioning of their health systems, understanding the factors that contribute to costly and preventable conditions such as ACSCs is vital. The findings of this study suggest that broader considerations, such as self-perception of happiness and satisfaction, can impact potentially avoidable hospitalizations, which represent a burden to the individual and healthcare systems. Further research in this area may contribute to the development of broader approaches to reduce potentially avoidable burden on the health system.

Tables

Table 1: Weighted[a] distributions of baseline characteristics across five levels of life satisfaction (N= 129,467)

	Very Satisfied (N= 49,502)	Satisfied (N= 67,978)	Neither Satisfied or Dissatisfied (N= 7,312)	Dissatisfied (N= 3,779)	Very Dissatisfied (N= 896)	Unweighted N's
ACSC Hospitalization						
Yes	1.12	1.61	2.51	4.81	5.39	3,037
No	98.88	98.39	97.49	95.19	94.61	126,430
Sex						
Male	47.5	50.53	47.34	49.93	47.32	59,292
Female	52.5	49.47	52.66	50.07	52.68	70,175
Age group						
18-34	30.64	33.09	30.78	23.91	14.53	35,255
35-49	31.9	33.21	31.14	36.12	33.6	35,063
50-64	26.31	24.97	27.37	31.04	41.39	38,662
65-74	11.15	8.72	10.7	8.93	10.49	20,487
BMI						
Underweight < 18.5	2.22	2.79	3.79	4.08	3.35	2,674
Normal weight, 18.5-24.9	46.83	46.02	43.31	39.31	37.18	53,327
Overweight, 25-29.9	35.48	33.55	32.37	31.78	32.34	43,915
Moderately obese, 30-34.9	11.72	12.44	13.15	15.62	16.57	17,840
Severely obese, > 34.9	3.75	5.2	7.38	9.22	10.57	7,815
ADG® Score [b]						
Mean (95% CI)	3.42 (3.31 - 3.54)	3.95 (3.84 - 4.06)	5.76 (5.35 - 6.18)	7.29 (6.712 - 7.88)	10.13 (8.76 - 11.49)	-
Physical Activity Status						
Active	32.24	24.09	18.2	16.94	14.95	35,482
Moderate	27.08	24.73	19.25	18.8	14.5	33,791
Inactive	40.65	51.14	62.22	64.2	70.55	60,149
On-Marg Deprivation						
1 (Least Marginalized)	24.86	20.76	12.81	15.84	15.43	23,405
2	22.03	20.22	18.21	15.72	13.13	25,427
3	19.84	19.72	18.93	19.23	17.55	26,391
4	16.74	18.99	22.71	20.01	21.85	26,386
5 (Most Marginalized)	15.57	19.29	26.2	28.04	31.52	26,073
Education Level						
< secondary	4.62	6.52	9.87	12.4	12.91	12,302
Secondary grad	10.79	12.25	13.65	12.78	16.24	18,047
> secondary	79.93	75.6	69.26	68.55	61.28	94,084

Unknown	4.66	5.63	7.22	6.28	9.57	5,034
Alcohol Consumption						
Heavy Drinker	7.94	8.62	8.08	9.11	11.6	11,502
Moderate Drinker	24.62	20.19	15.43	12.57	7.58	17,934
Light Drinker	15.37	13.61	11.42	9.26	7.44	28,413
Never Drinker	50.79	56.33	63.66	67.55	71.93	69,785
Smoking Status						
Current Smoker	17.38	22.71	31.65	36.52	43.75	30,875
Former Smoker	22.92	20.53	17.48	19.76	19.43	32,623
Never Smoked	56.06	53.48	48.15	40.86	34.91	61,357
Immigrant Status						
Yes	26.22	33.84	40.73	36.21	29.25	25,228
No	72.5	64.24	57.2	61.64	67.89	102,911
Household Income Quintile						
Q1 (Lowest Income)	9.5	14.16	23.52	32.29	38.88	17,369
Q2	12.19	15.72	18.68	16.97	15.92	18,687
Q3	16.34	17.68	16.93	15.25	15.41	24,063
Q4	22.29	21.61	16.05	13.11	12.73	29,029
Q5 (Highest Income)	30.74	20.71	12.36	11.18	7.92	31,515
Unknown	8.94	10.12	12.47	11.2	9.13	8,804

[a] Weighted through surveysampling weights provided by Statistics Canada.
[b] ADG® Score is a weighted score based on an individual's ADGs. This method has been validated elsewhere.(26)

Table 2: Weighted[a] distributions of baseline characteristics according to hospitalization for an ACSC (N= 129,467)

	ACSC Hospitalization Yes (N= 3,037)	ACSC Hospitalization No (N= 126,430)	Unweighted N's	Standardized Difference
Sex				
Male	56.12	49.09	59,292	0.06
Female	43.88	50.91	70,175	0.14
Age group				
18-34	9.35	32.07	35,255	0.58
35-49	20.5	32.89	35,063	0.28
50-64	48.6	25.49	38,662	0.49
65-74	21.56	9.55	20,487	0.34
BMI				
Underweight <18.5	2.19	2.68	2,674	0.03
Normal Weight, 18.5 – 24.9	29.19	46.2	53,327	0.36
Overweight, 25-29.9	33.96	34.13	43,915	0.00
Moderately obese, 30-34.9	21.39	12.18	17,840	0.25
Severely obese, >34.9	13.27	4.8	7,815	0.30

ADG® Score [b]				
Mean (95% CI)	11.8 (11.04 -12.56)	3.86 (3.77 -3.95)	-	0.35
Physical Activity Status				
Active	17.33	26.64	35,482	0.23
Moderate	21.27	25.12	33,791	0.09
Inactive	61.41	48.2	60,149	0.27
On-Marg Deprivation				
(Least Deprived) 1	14.91	21.74	23,405	0.18
2	19.67	20.62	25,427	0.02
3	16.62	19.74	26,391	0.08
(Most Deprived) 4	21.42	18.38	26,386	0.08
Education Level				
Less than secondary	19.16	6.01	12,302	0.40
Secondary graduate	15.18	11.78	18,047	0.10
More than secondary	60.1	76.81	94,084	0.37
Unknown	5.57	5.4	5,034	0.01
Alcohol Consumption				
Heavy Drinker	6.95	8.39	11,502	0.05
Moderate Drinker	16.37	21.34	17,934	0.13
Light Drinker	9.67	14.05	28,413	0.14
Never Drinker	65.23	54.95	69,785	0.21
Smoking Status				
Current Smoker	36.7	21.53	30,875	0.34
Former Smoker	29.26	21.07	32,623	0.19
Never Smoked	31.09	54.04	61,357	0.48
Immigrant Status				
Yes	25.03	31.59	25,228	0.15
No	72.45	66.71	102,911	0.13
Household Income				
Q1 (Lowest Income)	20.72	13.51	17,369	0.19
Q2	16.09	14.61	18,687	0.04
Q3	16.56	17.07	24,063	0.01
Q4	17.57	21.31	29,029	0.09
Q5 (Highest Income)	18.58	23.65	31,515	0.12
Unknown	10.48	9.84	8,804	0.02

[a] Weighted through survey sampling weights provided by Statistics Canada.
[b] ADG® Score is a weighted score based on an individual's ADGs. This method has been validated elsewhere.(26)

Table 3: Multivariable AHRs and 95% CIs From Proportional Hazards Regression (N= 129,467)

	Unadjusted		Age-Sex Adjusted	
	HR (95% CI)	p-value	HR (95% CI)	p-value
Life Satisfaction				
Very Satisfied	(ref)	ref	(ref)	ref

Satisfied	1.44 (1.27 - 1.64)	P < 0.0001	1.56 (1.37 - 1.77)	P < 0.0001
Neither Satisfied or Dissatisfied	2.22 (1.79 - 2.76)	P < 0.0001	2.37 (1.91 - 2.95)	P < 0.0001
Dissatisfied and Very Dissatisfied	4.51 (3.17 - 6.41)	P < 0.0001	4.48 (3.16 - 6.34)	P < 0.0001
	Minimally Adjusted [a]		Fully Adjusted [b]	
	HR (95% CI)	p-value	HR (95% CI)	p-value
Life Satisfaction				
Very Satisfied	(ref)	ref	(ref)	ref
Satisfied	1.48 (1.30 - 1.69)	P < 0.0001	1.32 (1.15 - 1.50)	P < 0.0001
Neither Satisfied or Dissatisfied	2.11 (1.69 -2.65)	P < 0.0001	1.71 (1.36 - 2.14)	P < 0.0001
Dissatisfied and Very Dissatisfied	3.79 (2.66 - 5.41)	P < 0.0001	2.71 (1.87 - 3.93)	P < 0.0001

HR – hazard ratio, AHR – adjusted hazard ratio, CI – confidence interval

[a] Minimally adjusted models controlled for age, sex and household income

[b] Fully adjusted models controlled for age, sex, household income, physical activity, BMI, alcohol consumption and smoking status.

Table 4: Multivariable AHRs[a] and 95% CIs From Proportional Hazards Regression While Additionally Adjusting for ADG® score, Mood Disease and Anxiety (N= 129,467)

	Fully Adjusted with ADG® Score		Fully Adjusted with Mood Disease		Fully Adjusted with Anxiety	
	HR (95% CI)	p-value	HR (95% CI)	p-value	HR (95% CI)	p-value
Life Satisfaction						
Very Satisfied	(ref)	(ref)	(ref)	(ref)	(ref)	(ref)
Satisfied	1.28 (1.12 - 1.46)	0.0004	1.30 (1.13 - 1.50)	0.0002	1.31 (1.14 - 1.49)	0.0001
Neither Satisfied or Dissatisfied	1.56 (1.25 - 1.96)	0.0001	1.62 (1.29 - 2.05)	P < 0.0001	1.65 (1.31 - 2.08)	P < 0.0001
Dissatisfied and Very Dissatisfied	2.42 (1.68 - 3.51)	P < 0.0001	2.45 (1.68 - 3.55)	P < 0.0001	2.52 (1.76 - 3.61)	P < 0.0001

HR – hazard ratio, CI – confidence interval

[a] Both models controlled for age, sex, household income, physical activity, BMI, alcohol consumption, smoking status in addition to the variable specified.

Table 5: Multivariable AHRs and 95% CIs From Joint Effects Models (N= 129,467)

	Unadjusted		Fully Adjusted [a]	
Joint Effects	**HR (95% CI)**	**p-value**	**HR (95% CI)**	**p-value**
High Life Satisfaction and High Income	1.00	(ref)	1.00	(ref)
High Life Satisfaction and Middle Income	1.40 (1.18 – 1.65)	P < 0.0001	1.18 (0.99 – 1.40)	0.0581
High Life Satisfaction and Low Income	2.00 (1.66 – 2.42)	P < 0.0001	1.63 (1.35 – 1.99)	P < 0.0001
Neither Satisfied Nor Dissatisfied and High Income	1.84 (1.16 – 2.93)	0.0099	1.55 (0.98 – 2.46)	0.0614
Neither Satisfied Nor Dissatisfied and Middle Income	2.46 (1.84 – 3.29)	P < 0.0001	1.92 (1.42 – 2.60)	P < 0.0001
Neither Satisfied Nor Dissatisfied and Low Income	2.44 (1.7 – 3.53)	P < 0.0001	1.68 (1.16 – 2.45)	0.0067
Low Life Satisfaction and High Income	3.71 (1.08 – 12.78)	0.0377	2.81 (0.80 – 9.91)	0.1068
Low Life Satisfaction and Middle Income	3.67 (2.67 – 5.03)	P < 0.0001	2.30 (1.66 – 3.18)	P < 0.0001
Low Life Satisfaction and Low Income	6.95 (3.91 – 12.38)	P < 0.0001	3.80 (2.13 – 6.73)	P < 0.0001

HR – hazard ratio, CI – confidence interval

[a] Fully adjusted models controlled for age, sex, physical activity, BMI, alcohol consumption, smoking status

Contributors: LCR and VG conceptualized the study, TW created the database and ED planned the analysis, analyzed the data, and drafted and revised the paper. LR is the guarantor. All authors contributed to the manuscript and revised the draft paper. All have approved the final version for publication.

Funding: This research was supported by a Canada Research Chair held by LCR (CRC-950-23072).

Disclaimer: This study was supported by ICES, which is funded by an annual grant from the Ontario Ministry of Health and Long-Term Care. The opinions, results and conclusions reported in this paper are those of the authors and are independent from the funding sources.

Competing interests: None declared

Data sharing statement: The data set from this study is held securely in coded form at ICES. While data sharing agreements prohibit ICES from making the data set publicly available, access may be granted to those who meet prespecified criteria for confidential access (available at www.ices.on.ca/DAS). The full data set creation plan and underlying analytic code are available from the authors upon request, understanding that the programs may rely upon coding templates or macros that are unique to ICES.

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Supplement Table 1:

ICD-10-CA/ CCI codes for ACSC hospitalizations[1]

Condition	ICD-10-CA Code(s)
Grand mal status and other epileptic convulsions	G40, G41
Chronic obstructive pulmonary disease (COPD)	J41, J42, J43, J44, J47 (only when a secondary diagnosis of J44 is also present) J10.0, J11.0, J12–J16, J18, J20, J21, J22
Asthma	J45
Diabetes	E10.0, E10.1, E10.63, E10.64, E10.9 E11.0, E11.1, E11.63, E11.64, E11.9 E13.0, E13.1, E13.63, E13.64, E13.9 E14.0, E14.1, E14.63, E14.64, E14.9
Hypertension*	I10.0, I10.1, I11
Heart Failure and pulmonary edema	I50, J81
Angina*	I20, I23.82, I24.0, I24.8, I24.9

*Excluding cases with cardiac procedures, CCI codes for exclusion:

1.HA.58.^^, 1.HA.80.^^, 1.HA.87.^^, 1.HB.53.^^, 1.HB.54.^^, 1.HB.55.^^, 1.HB.87.^^, 1.HD.53.^^, 1.HD.54.^^, 1.HD.55.^^, 1.HH.59.^^, 1.HH.71.^^, 1.HJ.76.^^, 1.HJ.82.^^, 1.HM.57.^^, 1.HM.78.^^, 1.HM.80.^^, 1.HN.71.^^, 1.HN.80.^^, 1.HN.87.^^, 1.HP.76.^^, 1.HP.78.^^, 1.HP.80.^^, 1.HP.82.^^, 1.HP.83.^^, 1.HP.87.^^, 1.HR.71.^^, 1.HR.80.^^, 1.HR.84.^^, 1.HR.87.^^, 1.HS.80.^^, 1.HS.90.^^, 1.HT.80.^^, 1.HT.89.^^, 1.HT.90.^^, 1.HU.80.^^, 1.HU.90.^^, 1.HV.80.^^, 1.HV.90.^^, 1.HW.78.^^, 1.HW.79.^^, 1.HX.71.^^, 1.HX.78.^^, 1.HX.79.^^, 1.HX.80.^^, 1.HX.83.^^, 1.HX.86.^^, 1.HX.87.^^, 1.HY.85.^^, 1.HZ.53 rubric (except 1.HZ.53.LA-KP), 1.HZ.54.^^, 1.HZ.55 rubric (except 1.HZ.55.LA-KP), 1.HZ.56.^^, 1.HZ.57.^^, 1.HZ.59.^^, 1.HZ.80.^^, 1.HZ.85.^^, 1.HZ.87.^^, 1.IF.83.^^, 1.IJ.50.^^, 1.IJ.54.GQ-AZ, 1.IJ.55.^^, 1.IJ.57.^^, 1.IJ.76.^^, 1.IJ.80.^^, 1.IJ.86.^^, 1.IK.50.^^, 1.IK.57.^^, 1.IK.80.^^, 1.IK.87.^^, 1.IN.84.^^, 1.LA.84.^^, 1.LC.84.^^, 1.LD.84.^^, 1.YY.54.LA-NJ, 1.YY.54.LA-FS, 1.YY.54.LA-NM

[1] More information on CIHI methodology: http://indicatorlibrary.cihi.ca/display/HSPIL/Ambulatory+Care+Sensitive+Conditions

Supplement Table 2: Multivariable AHRs [a] and 95% CIs Across Sensitivity Analyses

	Five-year survival [b] (N= 129,467)		Excluding events from first two years [c] (N= 128,638)	
	HR (95% CI)	p-value	HR (95% CI)	p-value
Life Satisfaction				
Very Satisfied	(ref)	(ref)	(ref)	(ref)
Satisfied	1.32 (1.16 – 1.51)	P < 0.0001	1.38 (1.17 – 1.62)	P < 0.0001
Neither Satisfied or Dissatisfied	1.71 (1.36 – 2.14)	P < 0.0001	1.74 (1.33 – 2.28)	P < 0.0001
Dissatisfied and Very Dissatisfied	2.74 (1.89 – 3.98)	P < 0.0001	2.77 (1.69 – 4.55)	P < 0.0001

[a] All models were fully adjusted models which controlled for age, sex, physical activity, BMI, alcohol consumption, smoking status.
[b] Five-year survival models were run with a consistent survival time of five years.
[c] Models were run without individuals who had an event within the first two years of follow-up.

Supplement Table 3: Unadjusted HRs from The Subdistribution Hazard Model [a]

	HR (95% CI)	p-value
Life Satisfaction		
Very Satisfied	(ref)	(ref)
Satisfied	1.44 (1.30 - 1.60)	P < 0.0001
Neither Satisfied or Dissatisfied	2.20 (1.86 - 2.60)	P < 0.0001
Dissatisfied and Very Dissatisfied	4.38 (3.73 - 5.14)	P < 0.0001

[a] Subdistribution hazard model considered death as a competing risk.

Supplement Table 4: Multivariable AHRs [a] and 95% CIs Across Different Measures of Socioeconomic Status

	On-Marg Deprivation Quintile		Household Income Quintile		Education Level	
	HR (95% CI)	p-value	HR (95% CI)	p-value	HR (95% CI)	p-value
Life Satisfaction						
Very Satisfied	(ref)	(ref)	(ref)	(ref)	(ref)	(ref)
Satisfied	1.33 (1.17 - 1.52)	P < 0.0001	1.32 (1.15 - 1.50)	P < 0.0001	1.32 (1.15 - 1.51)	P < 0.0001
Neither Satisfied or Dissatisfied	1.75 (1.40 - 2.19)	P < 0.0001	1.71 (1.36 - 2.14)	P < 0.0001	1.75 (1.40 - 2.19)	P < 0.0001
Dissatisfied and Very Dissatisfied	2.89 (2.01 - 4.15)	P < 0.0001	2.71 (1.87 - 3.93)	P < 0.0001	2.86 (2.00 - 4.08)	P < 0.0001

HR – hazard ratio, CI – confidence interval

[a] Models are adjusted for age, sex, physical activity, BMI, alcohol consumption, smoking status in addition to the variable specified.

Table 1: Multivariable AHRs [a] and 95% CIs Across Different Measures of Socioeconomic Status (N= 129,467)

	On-Marg Deprivation Quintile		Household Income Quintile		Education Level	
	HR (95% CI)	p-value	HR (95% CI)	p-value	HR (95% CI)	p-value
Life Satisfaction						
Very Satisfied	(ref)	(ref)	(ref)	(ref)	(ref)	(ref)
Satisfied	1.33 (1.17 - 1.52)	P < 0.0001	1.32 (1.15 - 1.50)	P < 0.0001	1.32 (1.15 - 1.51)	P < 0.0001
Neither Satisfied or Dissatisfied	1.75 (1.40 - 2.19)	P < 0.0001	1.71 (1.36 - 2.14)	P < 0.0001	1.75 (1.40 - 2.19)	P < 0.0001
Dissatisfied and Very Dissatisfied	2.89 (2.01 - 4.15)	P < 0.0001	2.71 (1.87 - 3.93)	P < 0.0001	2.86 (2.00 - 4.08)	P < 0.0001

HR – hazard ratio, CI – confidence interval

[a] Models are adjusted for age, sex, physical activity, BMI, alcohol consumption, smoking status in addition to the variable specified.

STROBE Checklist – Location of Specific Items for "The relationship between life satisfaction and preventable hospitalizations: a longitudinal population-based cohort study"

	Item No	Page Number
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		(*b*) Abstract: 1
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Outcome data	15	5
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Discussion		
Key results	18	3 to 8
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Interpretation	20	7 to 9
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Other information		
Funding	22	10

Commented [EDP1]: Update with correct funding statement!

BMJ Open

The relationship between life satisfaction and preventable hospitalizations: a population-based cohort study in Ontario, Canada

Journal:	*BMJ Open*
Manuscript ID	bmjopen-2019-032837.R1
Article Type:	Original research
Date Submitted by the Author:	04-Jan-2020
Complete List of Authors:	De Prophetis, Eric; University of Toronto, Dalla Lana School of Public Health Goel, Vivek; University of Toronto, Dalla Lana School of Public Health; University of Toronto, Institute of Health Policy, Management and Evaluation Watson, Tristan; Institute for Clinical Evaluative Sciences Rosella, Laura; University of Toronto, Dalla Lana School of Public Health
Primary Subject Heading:	Epidemiology
Secondary Subject Heading:	Health services research, Health policy
Keywords:	Life Satisfaction, Avoidable hospitalization, EPIDEMIOLOGY

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The relationship between life satisfaction and preventable hospitalizations: a population-based cohort study in Ontario, Canada

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WORD COUNT: 3,390

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Abstract

Objective: To examine if low life satisfaction is associated with an increased risk of being hospitalized for an ambulatory care sensitive condition (ACSC), in comparison to high life satisfaction

Design and setting: Population-based cohort study of adults from Ontario, Canada. Baseline data was captured through the Canadian Community Health Survey (CCHS) and linked to health administrative data for follow-up information.

Participants: 129,467 men and women between the ages of 18 to 74.

Main outcome measures: Time to avoidable hospitalizations defined by ACSCs.

Results: Life satisfaction was measured at baseline through the CCHS and follow-up information on ACSC hospitalizations were captured by linking participant respondents to hospitalization records covered under a single payer health system. Within the study timeframe (maximum of 14 years), 3037 individuals were hospitalized. Older men in the lowest household income quintile were more likely to be hospitalized with an ACSC. After controlling for age, sex, socioeconomic (SES), and other behavioural factors, low life satisfaction at baseline had a strong relationship with future hospitalizations for ACSCs (hazard ratio 2.71; 95% CI, 1.87-3.93). The hazards were highest for those who jointly had the lowest levels of life satisfaction and low household income (hazard ratio 3.80; 95% CI, 2.13-6.73). Results did not meaningful change after running a competing risk survival analysis.

Conclusions: This study demonstrates that poor life satisfaction is associated with hospitalizations for ACSCs after adjustment for several confounders. Furthermore, the magnitude of this relationship was greater for those who were more socioeconomically disadvantaged. This study adds to the existing literature on the impact of life satisfaction on health system outcomes by documenting its impact on avoidable hospitalizations in a universal health system.

Strengths and Limitations

- This is the largest study to combine detailed survey variables linked to complete hospitalization outcomes form from health administrative databases to study the impact of life satisfaction on ambulatory care sensitive conditions (ACSCs).
- The linkage of various databases allowed for control of a wide range of confounders in addition to objective measures of comorbidity.
- The linkage and study design allowed measurement of baseline life satisfaction on a sample of individuals who did not have an ACSCs in the two years prior, which overcomes a limitation of previous studies that may have been influenced by the bidirectional relationship between poor health and life satisfaction.
- Life satisfaction was measured at one point in time and thus we were unable to capture changes in life satisfaction over the study period.
- This study did not directly address mechanisms by which life satisfaction could influence ACSCs.

Transparency Statement

The lead author affirms that the manuscript is an honest, accurate, and transparent account of the study being reported; that no important aspects of the study have been omitted; and that any discrepancies from the study as planned (and, if relevant, registered) have been explained.

What is already known about the topic

Poor life satisfaction has been associated with an increased risk of death, chronic disease and future high healthcare use. In this context, few studies have addressed hospitalizations for ambulatory care sensitive conditions (ACSC) as an outcome and those that do have often done so with diseased baseline cohorts.

What this study adds

In the present study, poor life satisfaction was associated with an increased risk of future hospitalizations for an ACSC. These effects remained significant even after controlling for socioeconomic status, behaviour risk factors, multi-morbidity and mood disease. These effects were also shown to be stronger for those who were more socioeconomically disadvantaged.

Introduction

There has been broad recognition that upstream determinants have an influence on a range of health outcomes, including social determinants and risky health behaviours. In addition, subjective well-being, specifically life satisfaction is increasingly being recognized as playing an important role.(1-3) Shifting from health outcomes to a health system perspective, many ambulatory care sensitive conditions (ACSC) are preventable and result in high amounts of healthcare resources if left unmanaged.(4, 5) Hospitalizations for these conditions (e.g., diabetes) are regarded as avoidable due to the relationship of timely access to primary care preventing complications and acute episodes.(5-7) In many countries, hospitalizations for these conditions are used as an indicator to measure the effectiveness of the healthcare system. (8)

Positive affect (i.e. positive emotions, happiness), is the degree to which an individual experiences positive emotion (9), has been shown to be independently associated with reduced risk of coronary heart disease, even after adjustment for depressive symptoms. (10) Similarly, life satisfaction is associated with a reduced risk of various chronic conditions. (2, 11) Evidence from a recent prospective cohort study concluded lower life satisfaction was associated with a higher incidence of cancer, stroke, and type-2 diabetes (11) and others have shown its relationship with health behaviours. (12) Positive affect is distinct from life satisfaction in that it is an emotional response describing positive emotions or happiness, which can be transitory. This is conceptually distinct from the more stable and complex measure of being satisfied with life, which is based on an individual's self-judgments of several factors that they feel are valuable to their life.

Research on life satisfaction has also recently shown to impact future high-health care use.(13) Individuals with lower life satisfaction had three times the odds of being in the top 5% of healthcare resource utilization.(13) However, another important system indicator that is absent from the current life satisfaction literature is avoidable hospitalizations, such as those caused by ACSCs. Given the evidence around the interrelationships between emotional factors and chronic-disease self -management (14) and in particular how emotional and psychological distress can influence the ability of a patient to manage their chronic condition (15, 16), more research is needed that quantitatively measures the impact of subjective well-being on important healthcare system outcomes.

Upon a recent search, only eight studies were identified that fit the criteria of a similar exposure to life satisfaction and hospitalizations for one or more ACSCs as an outcome. Previous studies mostly focused on singular conditions, with small sample sizes, limited follow-up time and clinical or convenience-based samples (17, 18). Regarding the length of follow-up, these ranged from six months (19) to four years (20). Studies with shorter follow-up times can be limited because many of the conditions regarded as ACSCs are also chronic diseases (e.g., diabetes) require a longer follow-up time necessary to allow for outcomes to be observed. Furthermore, hospitalizations for ACSCs are a relatively rare event in Canada where people with an ACSC hospitalization constitutes only 0.4% of the population aged 12 to 74 (21), and therefore, the

limited sample sizes in previous studies may not be sufficient to observe an effect. We address these limitations by conducting the largest population-based cohort study to date. The low rate of ACSCs is typical of similar health systems in Europe, the UK and Australia.

The primary objective of this study was to determine if poor life satisfaction increased the risk of being hospitalized for an ACSC in a relatively healthy baseline cohort among an adult population using linked survey and complete hospitalization records. Our secondary objective was to determine if this association was stronger among those with lower socioeconomic status.

Methods

Participants

The study was a longitudinal population-based cohort study of adult Ontario participants of the Canadian Community Health Survey (CCHS) pooled across five cycles: Cycle 2.1 (2003-2004), Cycle 3.1 (2005-2006), Cycle (2007-2008), Cycle (2009-2010), and Cycle (2011-2012). The CCHS conducted surveys on a 2-year collection cycle (i.e., 2003, 2005) therefore no cycle existed for 2004 and 2006 and cycle naming conventions changed after 2005 to remove cycle numbers. The CCHS is a cross-sectional survey administered by Statistics Canada, representative of 98% of the Canadian population aged ≥12 years living in private dwellings with response rates >75%. (22,23) The respondents in the CCHS survey consented to participate in the survey and have their data linked to administrative data for research purposes. Where the CCHS is a cross-sectional survey, the longitudinal aspect of this study is achieved by retrieving the outcome measure from hospital administrative databases. The data was linked to population-based health administrative data held at ICES. These data sources capture all hospitalization records for every person living in the province of Ontario covered under the single-payer health system.

Eighty percent of the CCHS survey respondents consented to have their data linked to the single-payer health insurance data, referred to as the Ontario Health Insurance Plan (OHIP), which captures all related healthcare encounters. All survey respondents were linked to Ontario's population registry, the Registered Persons Database (RPDB), which captures core demographic and clinical information as well as death, in addition to the Discharge Abstract Database (DAD). The analytic sample included adults (aged 18 to 74) who reported on life satisfaction and did not have an ACSC-related hospitalization in the two years before their CCHS interview date (**Figure 1**).

Measures

Self-reported life satisfaction, the primary exposure variable, is captured from CCHS. The question that respondents answered regarding life satisfaction was, "*How satisfied are you with your life in general?"* With response options being: *very satisfied, satisfied, neither satisfied nor dissatisfied, dissatisfied, or very dissatisfied.* Due to small sample sizes within each category, we collapsed the categories of dissatisfied and very dissatisfied. Furthermore, we did not hypothesize significant conceptual differences between these two categories related to hospitalizations for ACSCs.

The primary outcome variable was hospitalizations for an ACSC, which we used as a composite outcome. The ACSCs that we chose to report on are grand mal status and other epileptic convulsions, chronic obstructive pulmonary disease, asthma, diabetes, heart failure and pulmonary edema, hypertension, and angina. These conditions are in accordance with the Canadian Institute for Health Information's (CIHI) methodology (24) and this composite outcome is an established health system indicator in Canada. The CIHI indicator applies only to individuals under the age of 75 as the hospitalizations in those above the age of 75 are not as clearly avoidable through timely and effective primary care. See **Supplement Table 1** for the list of included conditions and their corresponding ICD-10 codes.

Aggregate diagnosis groups (ADGs®)(25) were captured through administrative data as a summary measure of comorbidity and are based on the Johns Hopkins ACG® System, which is a person-focused, diagnosis-based method of categorizing subjects' illnesses [22]. ADGs have previously been used and validated as a reliable method of comorbidity adjustment in the Ontario population (26), and we used Version 10.0.1 in this analysis. Additionally, we used the Ontario Marginalization Index (ON-Marg) as a measure of socioeconomic status. The ON-Marg is a census-based, geographically derived index that was used to calculate area-level material deprivation.(27) Specifically, the material deprivation dimension measures the proportion of the population within a geographic region that is low income, without high school diploma, lone parent families, receiving government transfer payments, unemployed, and living in dwellings in need of repair. All other covariates were captured through self-report from the CCHS interview questions.

CCHS Variables

Household income quintile categorizes individuals based on their total household income in addition to the number of individuals living in the household. Individuals are then ranked from the lowest levels of household income (*Q1*) to the highest (*Q5*). Body Mass Index (BMI) was categorized into five categories ranging from "underweight" (BMI less than 18.5) to "severely obese" (BMI greater than 34.9). Physical activity was based on an individual's self-reported daily energy expenditure and further categorized into three levels: active, moderately active and inactive. Smoking status measured an individuals' self-reported past and present smoking habits by considering both the total amount of cigarettes smoked and the type of smoker they are (e.g., daily vs. occasional). This variable was categorized into three levels: current smoker, former smoker, never smoker. Alcohol consumption was based on the participant's sex and the quantity of alcohol consumed each day. This variable was then categorized into four levels: heavy drinker, moderate drinker, light drinker and never drinker. Mood disease was captured through the CCHS interview question "have you ever been diagnosed by a health professional for depression, bipolar disorder, mania or dysthymia?" This variable was used to control for depression. Anxiety disorder, which was captured through the question: "have you ever been diagnosed by a health professional for an anxiety disorder such as a phobia, obsessive-compulsive disorder, or panic disorder?" Education level is a derived variable which indicates

the highest level of education acquired by the participant; this variable was explored as a potential indicator for SES.

Statistical Analysis

We calculated the distribution of demographic, socioeconomic, health status and behaviour characteristics according to ACSCs and life satisfaction. Excluding those with an ACSC in the year prior allowed for the investigation of the upstream determinants (i.e. the factors associated with future development of an ACSC hospitalization in a cohort who were without a recent hospitalization for one of these conditions).

Cox proportional hazards models were used to estimate the hazards associated with baseline life satisfaction on the risk of being hospitalized for an ACSC. Time is defined as survey date until disease or censoring for study endpoint (max follow up until March 31, 2017) or death. The models were used to quantify the association between life satisfaction and the hazard of being hospitalized for an ACSC using "very satisfied" as the referent category. We calculated unadjusted, age-sex-adjusted, minimally adjusted and fully adjusted models to transparently demonstrate the impact of adjustment. The minimally adjusted model controlled for age, sex and household income while the fully adjusted model included age, sex, household income, smoking status, alcohol consumption, physical activity and BMI. In order to show the fully adjusted results were not meaningfully affected by over comorbidity, mood disorders and anxiety, we ran three additional models, which controlled for ADG score, mood disease, and anxiety separately. We ran these models separately in order to quantify their impact on the life satisfaction hazards in the fully adjusted model that controlled for sociodemographic and behavioural factors that we conceptualized as confounders (i.e. age, sex, household income, smoking status, alcohol consumption, physical activity and BMI).

To evaluate the proportional hazards assumption for life satisfaction, a plot of log(-log (survival)) versus the logarithm of follow-up time in days was run. With this method, the proportional hazards assumption is met if the plot produces parallel curves.

A joint-effects model was used to test if the relationship between life satisfaction and avoidable hospitalizations varied by SES. A joint-effects variable, which contains each combination of life satisfaction and household income, was included in the model while controlling for age, sex, smoking status, alcohol consumption, physical activity and BMI.

We ran sensitivity analyses by re-running the fully adjusted model with a consistent survival time of five years. Additionally, models for individuals who did not have an event in the first two years of the study were run to control for undocumented comorbidity. The subdistribution hazards model, which was initially developed by Fine and Gray (28), was run to test the possibility of death behaving as a competing risk.

Survey and bootstrap sampling weights provided by Statistics Canada were applied in all descriptive and survival regression analyses to account for the complex survey design and to maintain population representativeness. (29) The bootstrap sampling weights were applied using balanced repeated replication, in order to properly calculate confidence intervals. Additionally, this project received ethics approval from the Health Sciences Research Ethics Board at the University of Toronto (Ref # 36123, 15 August 2018). Finally, all statistical analyses were performed in 2018 and 2019 using SAS version 9.4.

Patient Involvement

Patients were not involved in the development of the research question, outcome measures, recruitment, design or the implementation of the study objectives. Furthermore, no patients were consulted on the interpretation of results, and there are no plans to disseminate the results of this study to the relevant participants or their communities.

Results

After combining the five cycles of data linked to the Registered Persons Database and excluding those less than 18, older than 74, in multiple survey cycles, missing life satisfaction, had an ACSC related hospitalization in the two years before the start of the study resulted in 129,467 individuals remaining. Those who experienced an ACSC-related hospitalization two years before their survey interview date were removed to examine the impact of life satisfaction on future hospitalizations for an ACSC and reduce the possibility of reverse causality (**Figure 1**). In the case of people in multiple survey cycles (n=1,589), we used the earliest survey response. Each respondent was followed for a maximum of 14 years or until the study end date, after which we determined that 3,037 individuals had experienced an ACSC-related hospitalization.

The distribution of baseline characteristics according to life satisfaction categories are shown in Table 1. Those with the lowest levels of life satisfaction (very dissatisfied) compared to the highest level of life satisfaction (very satisfied) had a lower proportion in the youngest (18-34 years) age group (14.5% versus 30.6%), more likely to have less than secondary education (12.9% versus 4.62%), had a greater proportion in the lowest income quintile (38.9% versus 9.5%), higher comorbidity levels (ADG score 10.1 versus 3.42) , and higher disease-related risk factors such as smoking (43.8% versus 17.4%) and physical inactivity (70.6% versus 40.7%) . (**Table 1**).

The distribution of all the cohort characteristics according to ACSC status are show in Table 2. Those that had an ACSC during the follow-up compared to those that did not were more likely to be in the older age group (65-74 years) (21.6% versus 9.55%), more likely to have less than secondary education (19.2% versus 6.01%), had a greater proportion in the lowest income quintile (20.7% versus 13.5%), higher comorbidity levels (ADG score 11.8 versus 3.86), and higher disease-related risk factors such as smoking (36.7% versus 21.5%) and physical inactivity (61.4% versus 48.2%). (**Table 2**).

Life satisfaction had a strong unadjusted relationship with hospitalization for ACSC (unadjusted Kaplan Meir curves are shown in Supplement Figure 1). **Table 3** presents the unadjusted and adjusted hazard ratios for the relationship between life satisfaction and ACSC-related hospitalizations, which include models that adjusted for age and sex, and then further adjusted for socioeconomic and lifestyle factors. Although full adjustment does reduce the size of the effect, the hazard ratio of an individual with the lowest levels of life satisfaction (dissatisfied and very dissatisfied combined) compared to those who were very satisfied is 2.71 (95% confidence interval 1.87 to 3.93). The observed relationship follows a dose-response pattern, or in other words, the hazard ratios increase in size for each decreasing level of life satisfaction. For example, in the fully adjusted model, the hazard ratio for the middle life satisfaction category (neither satisfied nor dissatisfied) was 1.71 (95% confidence interval 1.36 to 2.14) while the satisfied category produced a hazard ratio of 1.32 (95% confidence interval 1.15 to 1.50). Furthermore, the additional analyses (**Table 4**) that controlled for ADG score, mood disease and anxiety separately did not substantially reduce the observed effect sizes with the added adjustment of ADG score having the largest impact (hazard ratio of 2.42, 95% confidence interval of 1.68 to 3.51). Finally, as the plot of survival by time according to life satisfaction produced parallel curves, the proportional hazards assumption was satisfied.

Regarding the joint effects model (**Table 5**), individuals who identified as having both low life satisfaction and low household income produced a fully adjusted hazard ratio of 3.80 (95% confidence interval 2.13 to 6.73). Therefore, in comparison to the fully adjusted model presented in Table 3 (hazard ratio of 2.71), poor SES individuals are at an increased risk of being hospitalized when reporting low life satisfaction.

A range of sensitivity analyses were conducted to test the robustness of the study findings. Both the five-year survival model (where everyone was limited to a 5-year follow-up) and the model which excluded individuals who had an event within the first two years did not change the effect sizes to a significant degree. The hazard ratios for the lowest levels of life satisfaction compared to those who were very satisfied were 2.74 and 2.77, respectively (**Supplement Table 2**). In the competing risk analysis (**Supplement Table 3**), the unadjusted hazard ratios produced in the subdistribution hazard model were similar to those produced in the final model (4.38 vs 4.51 respectively).

Discussion

This study focuses on how life satisfaction can impact health system indicators such as avoidable hospitalizations in a general population cohort without a recent ACSC. We investigated this relationship and accounted for a wide variety of sociodemographic and behavioral risk factors. We saw a robust association that poor life satisfaction had a strong independent relationship with future ACSC hospitalizations. The lowest levels of life satisfaction (dissatisfied and very dissatisfied) being associated with almost a three times higher hazard of an avoidable

hospitalization compared to those who were very satisfied after accounting for several sociodemographic and behavioural confounders.

Previous studies have linked life satisfaction and related exposures (e.g. positive affect or happiness) to health outcomes such as stroke (11) and heart disease. (10) Life satisfaction has also been shown to be associated with a wide variety of health behaviours. (30, 31) For instance, one study found that those who exercised more were generally happier.(32) Furthermore, life satisfaction has also been shown to be experienced differently across categories of socioeconomic status.(33) Due to the detailed survey variables available from the survey data and the linkage of these data to complete hospitalization outcomes from health administrative databases, were able to adjust for these health behaviours and measures of socioeconomic status in our analysis as well as examine how the influence of life satisfaction is strengthen or lessened across levels of socioeconomic status.

This study addresses an important gap in the literature by providing a robust population sample size and examining how life satisfaction related to a meaningful health system outcome. There are few studies that addresses life satisfaction or other forms of subjective well being and their relationship to hospitalizations for ACSCs. Furthermore, the existing research is limited by small sample sizes and limited follow-up times to capture the relatively rare ACSC event. This study also has more direct implications for the health system given ACSCs are defined as conditions for which hospitalizations should be prevented, given timely and effective access to primary care. (7) Considering the preventable nature of these conditions, hospitalizations for ACSCs are an ineffective use of healthcare resources and insight into the risk factors for these conditions can help improve health system functioning.

Unlike previous studies, we measured baseline life satisfaction on a sample who did not have an ACSC hospitalization in the two years prior while also presenting analyses that additionally controlled for comorbidity. These aspects of the study help mitigate the possibility that that poor life satisfaction could have been the result of the bidirectional relationship between poor health and life satisfaction. A possible explanation for the observed results is that individuals who experience poor life satisfaction tend to have higher rates of depression, given its observed relationship with poor health outcomes. (34, 35) To address this, we further adjusted for mood disease and found that this has little effect on attenuated the observed association. The survey did not include continuous measures that could capture sub-threshold levels or undiagnosed anxiety or depression.

Limitations

We acknowledge that this study has some limitations and interpretive cautions. First, this study was an observational study and although we controlled for several potential confounders and excluded those with a recent history of ACSC at baseline through linkage, we cannot rule out the possibility of unmeasured or residual confounding. We note however that the effect sizes are large, and this study did control for many more confounders than previous studies through a

combination of survey data in addition to health administrative variables to capture comorbidity. Second, we measured life satisfaction at one point in time (survey interview date). Research on life satisfaction has shown it to be consistent over time (36); however, it is possible that life satisfaction could have changed during the study period. Therefore, we only capture the effect from that initial time point and cannot account for the influence of changes in life satisfaction that happen following the baseline assessment. Furthermore, there are other instruments that can be used to assess life satisfaction that were not available in this survey. Finally, life satisfaction is a subjective measure. It has been shown to be an accurate and robust measure, it is still up to the individuals to judge and reflect on their life satisfaction. This means that its meaning can differ based on the individual, which can result in variation in the exposure. Despite these limitations, this study has still provided an essential contribution to the literature by being one of the first assessments of life satisfaction on avoidable hospitalization that utilizes a longitudinal population-based study design while measuring this exposure before the hospitalization outcome.

Mechanisms

This study did not directly address mechanisms by which life satisfaction can influence avoidable hospitalizations; however, these have been studied by others. Out of the existing literature, there are three main mechanisms that could help explain the observed relationship: behavioural, health service use, and biological. Subjective well-being has been shown to impact a variety of health behaviours, such as increased physical activity (37-40) and reduced smoking habits (40). However, many of these studies lacked proper adjustment of confounding variables such as SES and psychological distress.(40) Regarding health service use, a study from 2014 found that participants who were identified as having a greater purpose in life were more likely to receive preventative health services such as mammograms or colonoscopies.(41) What remains to be seen regarding this mechanism is whether the use of these services reflects access to primary care, or the decisions made by the individuals themselves to seek these services. However, a recent population-based cohort study noted how hospitalizations for ACSCs could not be explained by a lack of access to primary care (42), and therefore it is possible that this phenomenon is a result of individual decisions that are influenced by their satisfaction with life. Finally, biological mechanisms could also play a contributing role. A recent meta-analysis noted how individuals who were identified as having greater psychological well-being experienced favourable lipid profiles.(43) However, these associations were largely mitigated once behavioural characteristics were taken into account.(43) Our study did not compare the extent to which life satisfaction is associated with ACSC compared to other types of hospitalization. This was out of scope for this current study, but in a future analysis could help provide insight into mechanisms.

Conclusions

This study demonstrates that life satisfaction is associated with hospitalizations for ACSCs, even after controlling for socioeconomic characteristics, health behaviours, comorbidities and mental health factors. Furthermore, more socioeconomically deprived individuals were shown to be at

an increased risk. While governments plan to improve the sustainability and functioning of their health systems, there is a greater need to understand social supports that can improve life satisfaction costly and preventable conditions such as ACSCs. The findings of this study suggest that broader considerations, such as life satisfaction, can potentially influence avoidable hospitalizations, a burden to individuals and healthcare systems. Further research in this area may contribute to the development of wide-ranging approaches to target a potentially avoidable burden on the health system.

Tables

Table 1: Weighted[a] distributions of baseline characteristics across five levels of life satisfaction (N= 129,467)

	Very Satisfied (N= 49,502)	Satisfied (N= 67,978)	Neither Satisfied or Dissatisfied (N= 7,312)	Dissatisfied (N= 3,779)	Very Dissatisfied (N= 896)	Unweighted Ns (N= 129,467)
ACSC Hospitalization						
Yes	1.12	1.61	2.51	4.81	5.39	3,037
No	98.88	98.39	97.49	95.19	94.61	126,430
Sex						
Male	47.5	50.53	47.34	49.93	47.32	59,292
Female	52.5	49.47	52.66	50.07	52.68	70,175
Age group						
18-34	30.64	33.09	30.78	23.91	14.53	35,255
35-49	31.9	33.21	31.14	36.12	33.6	35,063
50-64	26.31	24.97	27.37	31.04	41.39	38,662
65-74	11.15	8.72	10.7	8.93	10.49	20,487
BMI						
Underweight < 18.5	2.22	2.79	3.79	4.08	3.35	2,674
Normal weight, 18.5-24.9	46.83	46.02	43.31	39.31	37.18	53,327
Overweight, 25-29.9	35.48	33.55	32.37	31.78	32.34	43,915
Moderately obese, 30-34.9	11.72	12.44	13.15	15.62	16.57	17,840
Severely obese, > 34.9	3.75	5.2	7.38	9.22	10.57	7,815
ADG® Score [b]						
Mean (SD)	3.42 (0.06)	3.95 (0.22)	5.76 (0.80)	7.29 (1.13)	10.13 (0.709)	129,467
Physical Activity Status						
Active	32.24	24.09	18.2	16.94	14.95	35,482
Moderate	27.08	24.73	19.25	18.8	14.5	33,791
Inactive	40.65	51.14	62.22	64.2	70.55	60,149
On-Marg Deprivation						
1 (Least Marginalized)	24.86	20.76	12.81	15.84	15.43	23,405

2	22.03	20.22	18.21	15.72	13.13	25,427
3	19.84	19.72	18.93	19.23	17.55	26,391
4	16.74	18.99	22.71	20.01	21.85	26,386
5 (Most Marginalized)	15.57	19.29	26.2	28.04	31.52	26,073
Education Level						
< secondary	4.62	6.52	9.87	12.4	12.91	12,302
Secondary grad	10.79	12.25	13.65	12.78	16.24	18,047
> secondary	79.93	75.6	69.26	68.55	61.28	94,084
Unknown	4.66	5.63	7.22	6.28	9.57	5,034
Alcohol Consumption						
Heavy Drinker	7.94	8.62	8.08	9.11	11.6	11,502
Moderate Drinker	24.62	20.19	15.43	12.57	7.58	17,934
Light Drinker	15.37	13.61	11.42	9.26	7.44	28,413
Never Drinker	50.79	56.33	63.66	67.55	71.93	69,785
Smoking Status						
Current Smoker	17.38	22.71	31.65	36.52	43.75	30,875
Former Smoker	22.92	20.53	17.48	19.76	19.43	32,623
Never Smoked	56.06	53.48	48.15	40.86	34.91	61,357
Immigrant Status						
Yes	26.22	33.84	40.73	36.21	29.25	25,228
No	72.5	64.24	57.2	61.64	67.89	102,911
Household Income Quintile						
Q1 (Lowest Income)	9.5	14.16	23.52	32.29	38.88	17,369
Q2	12.19	15.72	18.68	16.97	15.92	18,687
Q3	16.34	17.68	16.93	15.25	15.41	24,063
Q4	22.29	21.61	16.05	13.11	12.73	29,029
Q5 (Highest Income)	30.74	20.71	12.36	11.18	7.92	31,515
Unknown	8.94	10.12	12.47	11.2	9.13	8,804

[a] Weighted through surveysampling weights provided by Statistics Canada.
[b] ADG® Score is a weighted score based on an individual's ADGs. This method has been validated elsewhere.(26)

Table 2: Weighted[a] distributions of baseline characteristics according to hospitalization for an ACSC (N= 129,467)

	ACSC Hospitalization Yes (N= 3,037)	ACSC Hospitalization No (N= 126,430)	Unweighted N's	
Sex				
Male	56.12	49.09	59,292	
Female	43.88	50.91	70,175	
Age group				
18-34	9.35	32.07	35,255	
35-49	20.5	32.89	35,063	
50-64	48.6	25.49	38,662	
65-74	21.56	9.55	20,487	
BMI				
Underweight <18.5	2.19	2.68	2,674	
Normal Weight, 18.5 – 24.9	29.19	46.2	53,327	
Overweight, 25-29.9	33.96	34.13	43,915	
Moderately obese, 30-34.9	21.39	12.18	17,840	
Severely obese, >34.9	13.27	4.8	7,815	
ADG® Score [b]				
Mean (SD)	11.8 (0.39)	3.86 (0.05)	*129,467*	
Physical Activity Status				
Active	17.33	26.64	35,482	
Moderate	21.27	25.12	33,791	
Inactive	61.41	48.2	60,149	
On-Marg Deprivation				
(Least Deprived) 1	14.91	21.74	23,405	
2	19.67	20.62	25,427	
3	16.62	19.74	26,391	
(Most Deprived) 4	21.42	18.38	26,386	
Education Level				
Less than secondary	19.16	6.01	12,302	
Secondary graduate	15.18	11.78	18,047	
More than secondary	60.1	76.81	94,084	
Unknown	5.57	5.4	5,034	
Alcohol Consumption				
Heavy Drinker	6.95	8.39	11,502	

Moderate Drinker	16.37	21.34	17,934	
Light Drinker	9.67	14.05	28,413	
Never Drinker	65.23	54.95	69,785	
Smoking Status				
Current Smoker	36.7	21.53	30,875	
Former Smoker	29.26	21.07	32,623	
Never Smoked	31.09	54.04	61,357	
Immigrant Status				
Yes	25.03	31.59	25,228	
No	72.45	66.71	102,911	
Household Income				
Q1 (Lowest Income)	20.72	13.51	17,369	
Q2	16.09	14.61	18,687	
Q3	16.56	17.07	24,063	
Q4	17.57	21.31	29,029	
Q5 (Highest Income)	18.58	23.65	31,515	
Unknown	10.48	9.84	8,804	

[a] Weighted through survey sampling weights provided by Statistics Canada.
[b] ADG® Score is a weighted score based on an individual's ADGs. This method has been validated elsewhere.(26)

Table 3: Multivariable AHRs and 95% CIs From Proportional Hazards Regression (N= 129,467)

	Unadjusted		Age-Sex Adjusted		Minimally Adjusted [a]		Fully Adjusted [b]	
Life Satisfaction	HR (95% CI)	p-value	HR (95% CI)	p-value	HR (95% CI)	p-value	HR (95% CI)	p-value
Very Satisfied	(ref)	(ref)	(ref)	(ref)	(ref)	(ref)	(ref)	(ref)
Satisfied	1.44 (1.27 - 1.64)	P < 0.0001	1.56 (1.37 - 1.77)	P < 0.0001	1.48 (1.30 - 1.69)	P < 0.0001	1.32 (1.15 - 1.50)	P < 0.0001
Neither Satisfied or Dissatisfied	2.22 (1.79 - 2.76)	P < 0.0001	2.37 (1.91 - 2.95)	P < 0.0001	2.11 (1.69 -2.65)	P < 0.0001	1.71 (1.36 - 2.14)	P < 0.0001
Dissatisfied and Very Dissatisfied	4.51 (3.17 - 6.41)	P < 0.0001	4.48 (3.16 - 6.34)	P < 0.0001	3.79 (2.66 - 5.41)	P < 0.0001	2.71 (1.87 - 3.93)	P < 0.0001

HR – hazard ratio, CI – confidence interval

[a] Minimally adjusted models controlled for age, sex and household income

[b] Fully adjusted models controlled for age, sex, household income, physical activity, BMI, alcohol consumption and smoking status

Table 4: Multivariable AHRs[a] and 95% CIs From Proportional Hazards Regression After Additionally Adjusting for ADG® score, Mood Disease and Anxiety (N= 129,467)

	Fully Adjusted with ADG® Score		Fully Adjusted with Mood Disease		Fully Adjusted with Anxiety	
	HR (95% CI)	p-value	HR (95% CI)	p-value	HR (95% CI)	p-value
Life Satisfaction						
Very Satisfied	(ref)	(ref)	(ref)	(ref)	(ref)	(ref)
Satisfied	1.28 (1.12 - 1.46)	0.0004	1.30 (1.13 - 1.50)	0.0002	1.31 (1.14 - 1.49)	0.0001
Neither Satisfied or Dissatisfied	1.56 (1.25 - 1.96)	0.0001	1.62 (1.29 - 2.05)	P < 0.0001	1.65 (1.31 - 2.08)	P < 0.0001
Dissatisfied and Very Dissatisfied	2.42 (1.68 - 3.51)	P < 0.0001	2.45 (1.68 - 3.55)	P < 0.0001	2.52 (1.76 - 3.61)	P < 0.0001

HR – hazard ratio, CI – confidence interval

[a] Both models controlled for age, sex, household income, physical activity, BMI, alcohol consumption, smoking status in addition to the variable specified.

Table 5: Multivariable AHRs and 95% CIs From Joint Effects Models (N= 129,467)

	Unadjusted		Fully Adjusted [a]	
Joint Effects	**HR (95% CI)**	**p-value**	**HR (95% CI)**	**p-value**
High Life Satisfaction and High Income	1.00	(ref)	1.00	(ref)
High Life Satisfaction and Middle Income	1.40 (1.18 – 1.65)	P < 0.0001	1.18 (0.99 – 1.40)	0.0581
High Life Satisfaction and Low Income	2.00 (1.66 – 2.42)	P < 0.0001	1.63 (1.35 – 1.99)	P < 0.0001
Neither Satisfied Nor Dissatisfied and High Income	1.84 (1.16 – 2.93)	0.0099	1.55 (0.98 – 2.46)	0.0614
Neither Satisfied Nor Dissatisfied and Middle Income	2.46 (1.84 – 3.29)	P < 0.0001	1.92 (1.42 – 2.60)	P < 0.0001
Neither Satisfied Nor Dissatisfied and Low Income	2.44 (1.7 – 3.53)	P < 0.0001	1.68 (1.16 – 2.45)	0.0067
Low Life Satisfaction and High Income	3.71 (1.08 – 12.78)	0.0377	2.81 (0.80 – 9.91)	0.1068
Low Life Satisfaction and Middle Income	3.67 (2.67 – 5.03)	P < 0.0001	2.30 (1.66 – 3.18)	P < 0.0001
Low Life Satisfaction and Low Income	6.95 (3.91 – 12.38)	P < 0.0001	3.80 (2.13 – 6.73)	P < 0.0001

HR – hazard ratio, CI – confidence interval

[a] Fully adjusted models controlled for age, sex, physical activity, BMI, alcohol consumption, smoking status

Contributors: LCR and VG conceptualized the study, TW created the database and ED planned the analysis, analyzed the data, and drafted and revised the paper. LCR is the guarantor. All authors contributed to the manuscript and revised the draft paper. All have approved the final version for publication.

Funding: This research was supported by a Canada Research Chair held by LCR (CRC-950-23072).

Disclaimer: This study was supported by ICES, which is funded by an annual grant from the Ontario Ministry of Health and Long-Term Care. The opinions, results and conclusions reported in this paper are those of the authors and are independent from the funding sources.

Competing interests: None declared

Data sharing statement: The data set from this study is held securely in coded form at ICES. While data sharing agreements prohibit ICES from making the data set publicly available, access may be granted to those who meet prespecified criteria for confidential access (available at www.ices.on.ca/DAS). The full data set creation plan and underlying analytic code are available from the authors upon request, understanding that the programs may rely upon coding templates or macros that are unique to ICES.

Figure 1: Flow chart of study participants

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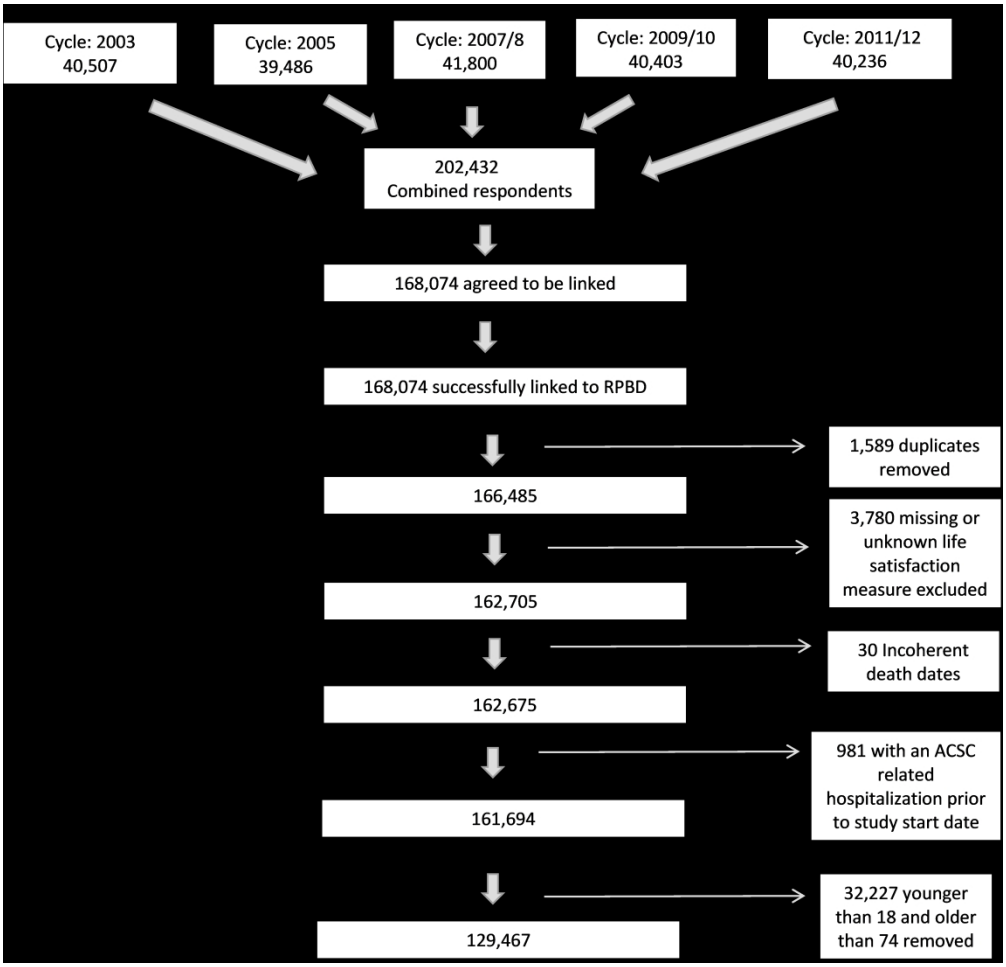


Figure 1: Flow chart of study participants

Supplement Table 1:

ICD-10-CA/ CCI codes for ACSC hospitalizations[1]

Condition	ICD-10-CA Code(s)
Grand mal status and other epileptic convulsions	G40, G41
Chronic obstructive pulmonary disease (COPD)	J41, J42, J43, J44, J47 (only when a secondary diagnosis of J44 is also present) J10.0, J11.0, J12–J16, J18, J20, J21, J22
Asthma	J45
Diabetes	E10.0, E10.1, E10.63, E10.64, E10.9 E11.0, E11.1, E11.63, E11.64, E11.9 E13.0, E13.1, E13.63, E13.64, E13.9 E14.0, E14.1, E14.63, E14.64, E14.9
Hypertension*	I10.0, I10.1, I11
Heart Failure and pulmonary edema	I50, J81
Angina*	I20, I23.82, I24.0, I24.8, I24.9

*Excluding cases with cardiac procedures, CCI codes for exclusion:

1.HA.58.^^, 1.HA.80.^^, 1.HA.87.^^, 1.HB.53.^^, 1.HB.54.^^, 1.HB.55.^^, 1.HB.87.^^, 1.HD.53.^^, 1.HD.54.^^, 1.HD.55.^^, 1.HH.59.^^, 1.HH.71.^^, 1.HJ.76.^^, 1.HJ.82.^^, 1.HM.57.^^, 1.HM.78.^^, 1.HM.80.^^, 1.HN.71.^^, 1.HN.80.^^, 1.HN.87.^^, 1.HP.76.^^, 1.HP.78.^^, 1.HP.80.^^, 1.HP.82.^^, 1.HP.83.^^, 1.HP.87.^^, 1.HR.71.^^, 1.HR.80.^^, 1.HR.84.^^, 1.HR.87.^^, 1.HS.80.^^, 1.HS.90.^^, 1.HT.80.^^, 1.HT.89.^^, 1.HT.90.^^, 1.HU.80.^^, 1.HU.90.^^, 1.HV.80.^^, 1.HV.90.^^, 1.HW.78.^^, 1.HW.79.^^, 1.HX.71.^^, 1.HX.78.^^, 1.HX.79.^^, 1.HX.80.^^, 1.HX.83.^^, 1.HX.86.^^, 1.HX.87.^^, 1.HY.85.^^, 1.HZ.53 rubric (except 1.HZ.53.LA-KP), 1.HZ.54.^^, 1.HZ.55 rubric (except 1.HZ.55.LA-KP), 1.HZ.56.^^, 1.HZ.57.^^, 1.HZ.59.^^, 1.HZ.80.^^, 1.HZ.85.^^, 1.HZ.87.^^, 1.IF.83.^^, 1.IJ.50.^^, 1.IJ.54.GQ-AZ, 1.IJ.55.^^, 1.IJ.57.^^, 1.IJ.76.^^, 1.IJ.80.^^, 1.IJ.86.^^, 1.IK.50.^^, 1.IK.57.^^, 1.IK.80.^^, 1.IK.87.^^, 1.IN.84.^^, 1.LA.84.^^, 1.LC.84.^^, 1.LD.84.^^, 1.YY.54.LA-NJ, 1.YY.54.LA-FS, 1.YY.54.LA-NM

[1] More information on CIHI methodology: http://indicatorlibrary.cihi.ca/display/HSPIL/Ambulatory+Care+Sensitive+Conditions

Supplement Table 2: Multivariable AHRs [a] and 95% CIs Across Sensitivity Analyses

	Five-year survival [b] (N= 129,467)		Excluding events from first two years [c] (N= 128,638)	
	HR (95% CI)	p-value	HR (95% CI)	p-value
Life Satisfaction				
Very Satisfied	(ref)	(ref)	(ref)	(ref)
Satisfied	1.32 (1.16 – 1.51)	P < 0.0001	1.38 (1.17 – 1.62)	P < 0.0001
Neither Satisfied or Dissatisfied	1.71 (1.36 – 2.14)	P < 0.0001	1.74 (1.33 – 2.28)	P < 0.0001
Dissatisfied and Very Dissatisfied	2.74 (1.89 – 3.98)	P < 0.0001	2.77 (1.69 – 4.55)	P < 0.0001

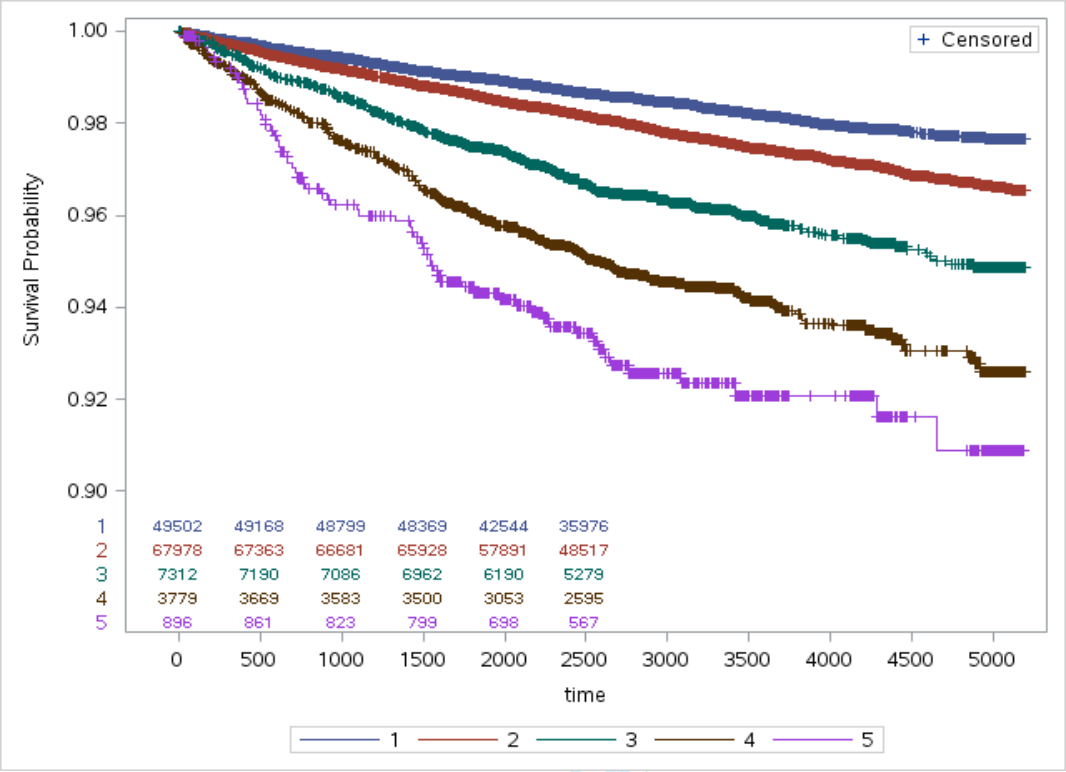
[a] All models were fully adjusted models which controlled for age, sex, physical activity, BMI, alcohol consumption, smoking status.
[b] Five-year survival models were run with a consistent survival time of five years.
[c] Models were run without individuals who had an event within the first two years of follow-up.

Supplement Table 3: Unadjusted HRs from The Subdistribution Hazard Model [a]

	HR (95% CI)	p-value
Life Satisfaction		
Very Satisfied	(ref)	(ref)
Satisfied	1.44 (1.30 - 1.60)	P < 0.0001
Neither Satisfied or Dissatisfied	2.20 (1.86 - 2.60)	P < 0.0001
Dissatisfied and Very Dissatisfied	4.38 (3.73 - 5.14)	P < 0.0001

[a] Subdistribution hazard model considered death as a competing risk.

Supplement Figure 1. Kaplan Meir survival curves for Life Satisfaction (most dissatisfied = 5; lease dissatisfied = 1)



STROBE Checklist – Location of Specific Items for "The relationship between life satisfaction and preventable hospitalizations: a longitudinal population-based cohort study"

	Item No	Page Number
Title and abstract	1	(*a*) Cover page (title page)
		(*b*) Abstract: 1
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Statistical methods	12	(*a*) Describe all statistical methods: 6 to 8
		(*b*) Subgroups and interactions: 8
		(c) Sensitivity Analyses: 8
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Descriptive data	14	8 and Table 1 to 2
Outcome data	15	9 and Table 3
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Other analyses	17	10 and Supplement Tables 1-3
Discussion		
Key results	18	10 to 11
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Interpretation	20	11 to 12
Generalisability	21	10
Other information		
Funding	22	19

BMJ Open

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Journal:	*BMJ Open*
Manuscript ID	bmjopen-2019-032837.R2
Article Type:	Original research
Date Submitted by the Author:	06-Feb-2020
Complete List of Authors:	De Prophetis, Eric; University of Toronto, Dalla Lana School of Public Health Goel, Vivek; University of Toronto, Dalla Lana School of Public Health; University of Toronto, Institute of Health Policy, Management and Evaluation Watson, Tristan; Institute for Clinical Evaluative Sciences Rosella, Laura; University of Toronto, Dalla Lana School of Public Health
Primary Subject Heading:	Epidemiology
Secondary Subject Heading:	Health services research, Health policy
Keywords:	Life Satisfaction, Avoidable hospitalization, EPIDEMIOLOGY

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The relationship between life satisfaction and preventable hospitalizations: a population-based cohort study in Ontario, Canada

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WORD COUNT: 3,390

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Abstract

Objective: To examine if low life satisfaction is associated with an increased risk of being hospitalized for an ambulatory care sensitive condition (ACSC), in comparison to high life satisfaction

Design and setting: Population-based cohort study of adults from Ontario, Canada. Baseline data was captured through the Canadian Community Health Survey (CCHS) and linked to health administrative data for follow-up information.

Participants: 129,467 men and women between the ages of 18 to 74.

Main outcome measures: Time to avoidable hospitalizations defined by ACSCs.

Results: Life satisfaction was measured at baseline through the CCHS and follow-up information on ACSC hospitalizations were captured by linking participant respondents to hospitalization records covered under a single payer health system. Within the study timeframe (maximum of 14 years), 3037 individuals were hospitalized. Older men in the lowest household income quintile were more likely to be hospitalized with an ACSC. After controlling for age, sex, socioeconomic (SES), and other behavioural factors, low life satisfaction at baseline had a strong relationship with future hospitalizations for ACSCs (hazard ratio 2.71; 95% CI, 1.87-3.93). The hazards were highest for those who jointly had the lowest levels of life satisfaction and low household income (hazard ratio 3.80; 95% CI, 2.13-6.73). Results did not meaningful change after running a competing risk survival analysis.

Conclusions: This study demonstrates that poor life satisfaction is associated with hospitalizations for ACSCs after adjustment for several confounders. Furthermore, the magnitude of this relationship was greater for those who were more socioeconomically disadvantaged. This study adds to the existing literature on the impact of life satisfaction on health system outcomes by documenting its impact on avoidable hospitalizations in a universal health system.

Strengths and Limitations

- This is the largest study to combine detailed survey variables linked to complete hospitalization outcomes form from health administrative databases to study the impact of life satisfaction on ambulatory care sensitive conditions (ACSCs).
- The linkage of various databases allowed for control of a wide range of confounders in addition to objective measures of comorbidity.
- The linkage and study design allowed measurement of baseline life satisfaction on a sample of individuals who did not have an ACSCs in the two years prior, which overcomes a limitation of previous studies that may have been influenced by the bidirectional relationship between poor health and life satisfaction.
- Life satisfaction was measured at one point in time and thus we were unable to capture changes in life satisfaction over the study period.
- This study did not directly address mechanisms by which life satisfaction could influence ACSCs.

Introduction

There has been broad recognition that upstream determinants have an influence on a range of health outcomes, including social determinants and risky health behaviours. In addition, subjective well-being, specifically life satisfaction is increasingly being recognized as playing an important role.(1-3) Shifting from health outcomes to a health system perspective, many ambulatory care sensitive conditions (ACSC) are preventable and result in high amounts of healthcare resources if left unmanaged.(4, 5) Hospitalizations for these conditions (e.g., diabetes) are regarded as avoidable due to the relationship of timely access to primary care preventing complications and acute episodes.(5-7) In many countries, hospitalizations for these conditions are used as an indicator to measure the effectiveness of the healthcare system. (8)

Positive affect (i.e. positive emotions, happiness), is the degree to which an individual experiences positive emotion (9), has been shown to be independently associated with reduced risk of coronary heart disease, even after adjustment for depressive symptoms. (10) Similarly, life satisfaction is associated with a reduced risk of various chronic conditions. (2, 11) Evidence from a recent prospective cohort study concluded lower life satisfaction was associated with a higher incidence of cancer, stroke, and type-2 diabetes (11) and others have shown its relationship with health behaviours. (12) Positive affect is distinct from life satisfaction in that it is an emotional response describing positive emotions or happiness, which can be transitory. This is conceptually distinct from the more stable and complex measure of being satisfied with life, which is based on an individual's self-judgments of several factors that they feel are valuable to their life.

Research on life satisfaction has also recently shown to impact future high-health care use.(13) Individuals with lower life satisfaction had three times the odds of being in the top 5% of healthcare resource utilization.(13) However, another important system indicator that is absent from the current life satisfaction literature is avoidable hospitalizations, such as those caused by ACSCs. Given the evidence around the interrelationships between emotional factors and chronic-disease self -management (14) and in particular how emotional and psychological distress can influence the ability of a patient to manage their chronic condition (15, 16), more research is needed that quantitatively measures the impact of subjective well-being on important healthcare system outcomes.

Upon a recent search, only eight studies were identified that fit the criteria of a similar exposure to life satisfaction and hospitalizations for one or more ACSCs as an outcome. Previous studies mostly focused on singular conditions, with small sample sizes, limited follow-up time and clinical or convenience-based samples (17, 18). Regarding the length of follow-up, these ranged from six months (19) to four years (20). Studies with shorter follow-up times can be limited because many of the conditions regarded as ACSCs are also chronic diseases (e.g., diabetes) require a longer follow-up time necessary to allow for outcomes to be observed. Furthermore, hospitalizations for ACSCs are a relatively rare event in Canada where people with an ACSC hospitalization constitutes only 0.4% of the population aged 12 to 74 (21), and therefore, the

limited sample sizes in previous studies may not be sufficient to observe an effect. We address these limitations by conducting the largest population-based cohort study to date. The low rate of ACSCs is typical of similar health systems in Europe, the UK and Australia.

The primary objective of this study was to determine if poor life satisfaction increased the risk of being hospitalized for an ACSC in a relatively healthy baseline cohort among an adult population using linked survey and complete hospitalization records. Our secondary objective was to determine if this association was stronger among those with lower socioeconomic status.

Methods

Participants

The study was a longitudinal population-based cohort study of adult Ontario participants of the Canadian Community Health Survey (CCHS) pooled across five cycles: Cycle 2.1 (2003-2004), Cycle 3.1 (2005-2006), Cycle (2007-2008), Cycle (2009-2010), and Cycle (2011-2012). The CCHS conducted surveys on a 2-year collection cycle (i.e., 2003, 2005) therefore no cycle existed for 2004 and 2006 and cycle naming conventions changed after 2005 to remove cycle numbers. The CCHS is a cross-sectional survey administered by Statistics Canada, representative of 98% of the Canadian population aged ≥12 years living in private dwellings with response rates >75%. (22,23) The respondents in the CCHS survey consented to participate in the survey and have their data linked to administrative data for research purposes. Where the CCHS is a cross-sectional survey, the longitudinal aspect of this study is achieved by retrieving the outcome measure from hospital administrative databases. The data was linked to population-based health administrative data held at ICES. These data sources capture all hospitalization records for every person living in the province of Ontario covered under the single-payer health system.

Eighty percent of the CCHS survey respondents consented to have their data linked to the single-payer health insurance data, referred to as the Ontario Health Insurance Plan (OHIP), which captures all related healthcare encounters. All survey respondents were linked to Ontario's population registry, the Registered Persons Database (RPDB), which captures core demographic and clinical information as well as death, in addition to the Discharge Abstract Database (DAD). The analytic sample included adults (aged 18 to 74) who reported on life satisfaction and did not have an ACSC-related hospitalization in the two years before their CCHS interview date (**Figure 1**).

Measures

Self-reported life satisfaction, the primary exposure variable, is captured from CCHS. The question that respondents answered regarding life satisfaction was, "*How satisfied are you with your life in general?"* With response options being: *very satisfied, satisfied, neither satisfied nor dissatisfied, dissatisfied, or very dissatisfied.* Due to small sample sizes within each category, we collapsed the categories of dissatisfied and very dissatisfied. Furthermore, we did not hypothesize significant conceptual differences between these two categories related to hospitalizations for ACSCs.

The primary outcome variable was hospitalizations for an ACSC, which we used as a composite outcome. The ACSCs that we chose to report on are grand mal status and other epileptic convulsions, chronic obstructive pulmonary disease, asthma, diabetes, heart failure and pulmonary edema, hypertension, and angina. These conditions are in accordance with the Canadian Institute for Health Information's (CIHI) methodology (24) and this composite outcome is an established health system indicator in Canada. The CIHI indicator applies only to individuals under the age of 75 as the hospitalizations in those above the age of 75 are not as clearly avoidable through timely and effective primary care. See **Supplement Table 1** for the list of included conditions and their corresponding ICD-10 codes.

Aggregate diagnosis groups (ADGs®)(25) were captured through administrative data as a summary measure of comorbidity and are based on the Johns Hopkins ACG® System, which is a person-focused, diagnosis-based method of categorizing subjects' illnesses [22]. ADGs have previously been used and validated as a reliable method of comorbidity adjustment in the Ontario population (26), and we used Version 10.0.1 in this analysis. Additionally, we used the Ontario Marginalization Index (ON-Marg) as a measure of socioeconomic status. The ON-Marg is a census-based, geographically derived index that was used to calculate area-level material deprivation.(27) Specifically, the material deprivation dimension measures the proportion of the population within a geographic region that is low income, without high school diploma, lone parent families, receiving government transfer payments, unemployed, and living in dwellings in need of repair. All other covariates were captured through self-report from the CCHS interview questions.

CCHS Variables

Household income quintile categorizes individuals based on their total household income in addition to the number of individuals living in the household. Individuals are then ranked from the lowest levels of household income (*Q1*) to the highest (*Q5*). Body Mass Index (BMI) was categorized into five categories ranging from "underweight" (BMI less than 18.5) to "severely obese" (BMI greater than 34.9). Physical activity was based on an individual's self-reported daily energy expenditure and further categorized into three levels: active, moderately active and inactive. Smoking status measured an individuals' self-reported past and present smoking habits by considering both the total amount of cigarettes smoked and the type of smoker they are (e.g., daily vs. occasional). This variable was categorized into three levels: current smoker, former smoker, never smoker. Alcohol consumption was based on the participant's sex and the quantity of alcohol consumed each day. This variable was then categorized into four levels: heavy drinker, moderate drinker, light drinker and never drinker. Mood disease was captured through the CCHS interview question "have you ever been diagnosed by a health professional for depression, bipolar disorder, mania or dysthymia?" This variable was used to control for depression. Anxiety disorder, which was captured through the question: "have you ever been diagnosed by a health professional for an anxiety disorder such as a phobia, obsessive-compulsive disorder, or panic disorder?" Education level is a derived variable which indicates

the highest level of education acquired by the participant; this variable was explored as a potential indicator for SES.

Statistical Analysis

We calculated the distribution of demographic, socioeconomic, health status and behaviour characteristics according to ACSCs and life satisfaction. Excluding those with an ACSC in the year prior allowed for the investigation of the upstream determinants (i.e. the factors associated with future development of an ACSC hospitalization in a cohort who were without a recent hospitalization for one of these conditions).

Cox proportional hazards models were used to estimate the hazards associated with baseline life satisfaction on the risk of being hospitalized for an ACSC. Time is defined as survey date until disease or censoring for study endpoint (max follow up until March 31, 2017) or death. The models were used to quantify the association between life satisfaction and the hazard of being hospitalized for an ACSC using "very satisfied" as the referent category. We calculated unadjusted, age-sex-adjusted, minimally adjusted and fully adjusted models to transparently demonstrate the impact of adjustment. The minimally adjusted model controlled for age, sex and household income while the fully adjusted model included age, sex, household income, smoking status, alcohol consumption, physical activity and BMI. In order to show the fully adjusted results were not meaningfully affected by over comorbidity, mood disorders and anxiety, we ran three additional models, which controlled for ADG score, mood disease, and anxiety separately. We ran these models separately in order to quantify their impact on the life satisfaction hazards in the fully adjusted model that controlled for sociodemographic and behavioural factors that we conceptualized as confounders (i.e. age, sex, household income, smoking status, alcohol consumption, physical activity and BMI).

To evaluate the proportional hazards assumption for life satisfaction, a plot of log(-log (survival)) versus the logarithm of follow-up time in days was run. With this method, the proportional hazards assumption is met if the plot produces parallel curves.

A joint-effects model was used to test if the relationship between life satisfaction and avoidable hospitalizations varied by SES. A joint-effects variable, which contains each combination of life satisfaction and household income, was included in the model while controlling for age, sex, smoking status, alcohol consumption, physical activity and BMI.

We ran sensitivity analyses by re-running the fully adjusted model with a consistent survival time of five years. Additionally, models for individuals who did not have an event in the first two years of the study were run to control for undocumented comorbidity. The subdistribution hazards model, which was initially developed by Fine and Gray (28), was run to test the possibility of death behaving as a competing risk.

Survey and bootstrap sampling weights provided by Statistics Canada were applied in all descriptive and survival regression analyses to account for the complex survey design and to maintain population representativeness. (29) The bootstrap sampling weights were applied using balanced repeated replication, in order to properly calculate confidence intervals. Additionally, this project received ethics approval from the Health Sciences Research Ethics Board at the University of Toronto (Ref # 36123, 15 August 2018). Finally, all statistical analyses were performed in 2018 and 2019 using SAS version 9.4.

Patient Involvement

Patients were not involved in the development of the research question, outcome measures, recruitment, design or the implementation of the study objectives. Furthermore, no patients were consulted on the interpretation of results, and there are no plans to disseminate the results of this study to the relevant participants or their communities.

Results

After combining the five cycles of data linked to the Registered Persons Database and excluding those less than 18, older than 74, in multiple survey cycles, missing life satisfaction, had an ACSC related hospitalization in the two years before the start of the study resulted in 129,467 individuals remaining. Those who experienced an ACSC-related hospitalization two years before their survey interview date were removed to examine the impact of life satisfaction on future hospitalizations for an ACSC and reduce the possibility of reverse causality (**Figure 1**). In the case of people in multiple survey cycles (n=1,589), we used the earliest survey response. Each respondent was followed for a maximum of 14 years or until the study end date, after which we determined that 3,037 individuals had experienced an ACSC-related hospitalization.

The distribution of baseline characteristics according to life satisfaction categories are shown in Table 1. Those with the lowest levels of life satisfaction (very dissatisfied) compared to the highest level of life satisfaction (very satisfied) had a lower proportion in the youngest (18-34 years) age group (14.5% versus 30.6%), more likely to have less than secondary education (12.9% versus 4.62%), had a greater proportion in the lowest income quintile (38.9% versus 9.5%), higher comorbidity levels (ADG score 10.1 versus 3.42) , and higher disease-related risk factors such as smoking (43.8% versus 17.4%) and physical inactivity (70.6% versus 40.7%) . (**Table 1**).

The distribution of all the cohort characteristics according to ACSC status are show in Table 2. Those that had an ACSC during the follow-up compared to those that did not were more likely to be in the older age group (65-74 years) (21.6% versus 9.55%), more likely to have less than secondary education (19.2% versus 6.01%), had a greater proportion in the lowest income quintile (20.7% versus 13.5%), higher comorbidity levels (ADG score 11.8 versus 3.86), and higher disease-related risk factors such as smoking (36.7% versus 21.5%) and physical inactivity (61.4% versus 48.2%). (**Table 2**).

Life satisfaction had a strong unadjusted relationship with hospitalization for ACSC (unadjusted Kaplan Meir curves are shown in Supplement Figure 1). **Table 3** presents the unadjusted and adjusted hazard ratios for the relationship between life satisfaction and ACSC-related hospitalizations, which include models that adjusted for age and sex, and then further adjusted for socioeconomic and lifestyle factors. Although full adjustment does reduce the size of the effect, the hazard ratio of an individual with the lowest levels of life satisfaction (dissatisfied and very dissatisfied combined) compared to those who were very satisfied is 2.71 (95% confidence interval 1.87 to 3.93). The observed relationship follows a dose-response pattern, or in other words, the hazard ratios increase in size for each decreasing level of life satisfaction. For example, in the fully adjusted model, the hazard ratio for the middle life satisfaction category (neither satisfied nor dissatisfied) was 1.71 (95% confidence interval 1.36 to 2.14) while the satisfied category produced a hazard ratio of 1.32 (95% confidence interval 1.15 to 1.50). Furthermore, the additional analyses (**Table 4**) that controlled for ADG score, mood disease and anxiety separately did not substantially reduce the observed effect sizes with the added adjustment of ADG score having the largest impact (hazard ratio of 2.42, 95% confidence interval of 1.68 to 3.51). Finally, as the plot of survival by time according to life satisfaction produced parallel curves, the proportional hazards assumption was satisfied.

Regarding the joint effects model (**Table 5**), individuals who identified as having both low life satisfaction and low household income produced a fully adjusted hazard ratio of 3.80 (95% confidence interval 2.13 to 6.73). Therefore, in comparison to the fully adjusted model presented in Table 3 (hazard ratio of 2.71), poor SES individuals are at an increased risk of being hospitalized when reporting low life satisfaction.

A range of sensitivity analyses were conducted to test the robustness of the study findings. Both the five-year survival model (where everyone was limited to a 5-year follow-up) and the model which excluded individuals who had an event within the first two years did not change the effect sizes to a significant degree. The hazard ratios for the lowest levels of life satisfaction compared to those who were very satisfied were 2.74 and 2.77, respectively (**Supplement Table 2**). In the competing risk analysis (**Supplement Table 3**), the unadjusted hazard ratios produced in the subdistribution hazard model were similar to those produced in the final model (4.38 vs 4.51 respectively).

Discussion

This study focuses on how life satisfaction can impact health system indicators such as avoidable hospitalizations in a general population cohort without a recent ACSC. We investigated this relationship and accounted for a wide variety of sociodemographic and behavioral risk factors. We saw a robust association that poor life satisfaction had a strong independent relationship with future ACSC hospitalizations. The lowest levels of life satisfaction (dissatisfied and very dissatisfied) being associated with almost a three times higher hazard of an avoidable

hospitalization compared to those who were very satisfied after accounting for several sociodemographic and behavioural confounders.

Previous studies have linked life satisfaction and related exposures (e.g. positive affect or happiness) to health outcomes such as stroke (11) and heart disease. (10) Life satisfaction has also been shown to be associated with a wide variety of health behaviours. (30, 31) For instance, one study found that those who exercised more were generally happier.(32) Furthermore, life satisfaction has also been shown to be experienced differently across categories of socioeconomic status.(33) Due to the detailed survey variables available from the survey data and the linkage of these data to complete hospitalization outcomes from health administrative databases, were able to adjust for these health behaviours and measures of socioeconomic status in our analysis as well as examine how the influence of life satisfaction is strengthen or lessened across levels of socioeconomic status.

This study addresses an important gap in the literature by providing a robust population sample size and examining how life satisfaction related to a meaningful health system outcome. There are few studies that addresses life satisfaction or other forms of subjective well being and their relationship to hospitalizations for ACSCs. Furthermore, the existing research is limited by small sample sizes and limited follow-up times to capture the relatively rare ACSC event. This study also has more direct implications for the health system given ACSCs are defined as conditions for which hospitalizations should be prevented, given timely and effective access to primary care. (7) Considering the preventable nature of these conditions, hospitalizations for ACSCs are an ineffective use of healthcare resources and insight into the risk factors for these conditions can help improve health system functioning.

Unlike previous studies, we measured baseline life satisfaction on a sample who did not have an ACSC hospitalization in the two years prior while also presenting analyses that additionally controlled for comorbidity. These aspects of the study help mitigate the possibility that that poor life satisfaction could have been the result of the bidirectional relationship between poor health and life satisfaction. A possible explanation for the observed results is that individuals who experience poor life satisfaction tend to have higher rates of depression, given its observed relationship with poor health outcomes. (34, 35) To address this, we further adjusted for mood disease and found that this has little effect on attenuated the observed association. The survey did not include continuous measures that could capture sub-threshold levels or undiagnosed anxiety or depression.

Limitations

We acknowledge that this study has some limitations and interpretive cautions. First, this study was an observational study and although we controlled for several potential confounders and excluded those with a recent history of ACSC at baseline through linkage, we cannot rule out the possibility of unmeasured or residual confounding. We note however that the effect sizes are large, and this study did control for many more confounders than previous studies through a

combination of survey data in addition to health administrative variables to capture comorbidity. Second, we measured life satisfaction at one point in time (survey interview date). Research on life satisfaction has shown it to be consistent over time (36); however, it is possible that life satisfaction could have changed during the study period. Therefore, we only capture the effect from that initial time point and cannot account for the influence of changes in life satisfaction that happen following the baseline assessment. Furthermore, there are other instruments that can be used to assess life satisfaction that were not available in this survey. Finally, life satisfaction is a subjective measure. It has been shown to be an accurate and robust measure, it is still up to the individuals to judge and reflect on their life satisfaction. This means that its meaning can differ based on the individual, which can result in variation in the exposure. Despite these limitations, this study has still provided an essential contribution to the literature by being one of the first assessments of life satisfaction on avoidable hospitalization that utilizes a longitudinal population-based study design while measuring this exposure before the hospitalization outcome.

Mechanisms

This study did not directly address mechanisms by which life satisfaction can influence avoidable hospitalizations; however, these have been studied by others. Out of the existing literature, there are three main mechanisms that could help explain the observed relationship: behavioural, health service use, and biological. Subjective well-being has been shown to impact a variety of health behaviours, such as increased physical activity (37-40) and reduced smoking habits (40). However, many of these studies lacked proper adjustment of confounding variables such as SES and psychological distress.(40) Regarding health service use, a study from 2014 found that participants who were identified as having a greater purpose in life were more likely to receive preventative health services such as mammograms or colonoscopies.(41) What remains to be seen regarding this mechanism is whether the use of these services reflects access to primary care, or the decisions made by the individuals themselves to seek these services. However, a recent population-based cohort study noted how hospitalizations for ACSCs could not be explained by a lack of access to primary care (42), and therefore it is possible that this phenomenon is a result of individual decisions that are influenced by their satisfaction with life. Finally, biological mechanisms could also play a contributing role. A recent meta-analysis noted how individuals who were identified as having greater psychological well-being experienced favourable lipid profiles.(43) However, these associations were largely mitigated once behavioural characteristics were taken into account.(43) Our study did not compare the extent to which life satisfaction is associated with ACSC compared to other types of hospitalization. This was out of scope for this current study, but in a future analysis could help provide insight into mechanisms that are specific to preventable hospitalizations. Our study did not examine whether ACSC hospitalizations were reduced for Ontario hospitals, but instead focused on individual's risk based on their life satisfaction measure. In future studies, analyses at the system level (i.e. ACSC hospitalizations in Ontario hospitals) would supplement these findings to better understand the health system impact.

Conclusions

This study demonstrates that life satisfaction is associated with hospitalizations for ACSCs, even after controlling for socioeconomic characteristics, health behaviours, comorbidities and mental health factors. Furthermore, more socioeconomically deprived individuals were shown to be at an increased risk. While governments plan to improve the sustainability and functioning of their health systems, there is a greater need to understand social supports that can improve life satisfaction costly and preventable conditions such as ACSCs. The findings of this study suggest that broader considerations, such as life satisfaction, can potentially influence avoidable hospitalizations, a burden to individuals and healthcare systems. Further research in this area may contribute to the development of wide-ranging approaches to target a potentially avoidable burden on the health system.

Tables

Table 1: Weighted[a] distributions of baseline characteristics across five levels of life satisfaction (N= 129,467)

	Very Satisfied (N= 49,502)	Satisfied (N= 67,978)	Neither Satisfied or Dissatisfied (N= 7,312)	Dissatisfied (N= 3,779)	Very Dissatisfied (N= 896)	Unweighted Ns (N= 129,467)
ACSC Hospitalization						
Yes	1.12	1.61	2.51	4.81	5.39	3,037
No	98.88	98.39	97.49	95.19	94.61	126,430
Sex						
Male	47.5	50.53	47.34	49.93	47.32	59,292
Female	52.5	49.47	52.66	50.07	52.68	70,175
Age group						
18-34	30.64	33.09	30.78	23.91	14.53	35,255
35-49	31.9	33.21	31.14	36.12	33.6	35,063
50-64	26.31	24.97	27.37	31.04	41.39	38,662
65-74	11.15	8.72	10.7	8.93	10.49	20,487
BMI						
Underweight < 18.5	2.22	2.79	3.79	4.08	3.35	2,674
Normal weight, 18.5-24.9	46.83	46.02	43.31	39.31	37.18	53,327
Overweight, 25-29.9	35.48	33.55	32.37	31.78	32.34	43,915
Moderately obese, 30-34.9	11.72	12.44	13.15	15.62	16.57	17,840
Severely obese, > 34.9	3.75	5.2	7.38	9.22	10.57	7,815
ADG® Score [b]						
Mean (SD)	3.42 (0.06)	3.95 (0.22)	5.76 (0.80)	7.29 (1.13)	10.13 (0.709)	129,467
Physical Activity Status						
Active	32.24	24.09	18.2	16.94	14.95	35,482
Moderate	27.08	24.73	19.25	18.8	14.5	33,791
Inactive	40.65	51.14	62.22	64.2	70.55	60,149
On-Marg Deprivation						
1 (Least Marginalized)	24.86	20.76	12.81	15.84	15.43	23,405

2	22.03	20.22	18.21	15.72	13.13	25,427
3	19.84	19.72	18.93	19.23	17.55	26,391
4	16.74	18.99	22.71	20.01	21.85	26,386
5 (Most Marginalized)	15.57	19.29	26.2	28.04	31.52	26,073
Education Level						
< secondary	4.62	6.52	9.87	12.4	12.91	12,302
Secondary grad	10.79	12.25	13.65	12.78	16.24	18,047
> secondary	79.93	75.6	69.26	68.55	61.28	94,084
Unknown	4.66	5.63	7.22	6.28	9.57	5,034
Alcohol Consumption						
Heavy Drinker	7.94	8.62	8.08	9.11	11.6	11,502
Moderate Drinker	24.62	20.19	15.43	12.57	7.58	17,934
Light Drinker	15.37	13.61	11.42	9.26	7.44	28,413
Never Drinker	50.79	56.33	63.66	67.55	71.93	69,785
Smoking Status						
Current Smoker	17.38	22.71	31.65	36.52	43.75	30,875
Former Smoker	22.92	20.53	17.48	19.76	19.43	32,623
Never Smoked	56.06	53.48	48.15	40.86	34.91	61,357
Immigrant Status						
Yes	26.22	33.84	40.73	36.21	29.25	25,228
No	72.5	64.24	57.2	61.64	67.89	102,911
Household Income Quintile						
Q1 (Lowest Income)	9.5	14.16	23.52	32.29	38.88	17,369
Q2	12.19	15.72	18.68	16.97	15.92	18,687
Q3	16.34	17.68	16.93	15.25	15.41	24,063
Q4	22.29	21.61	16.05	13.11	12.73	29,029
Q5 (Highest Income)	30.74	20.71	12.36	11.18	7.92	31,515
Unknown	8.94	10.12	12.47	11.2	9.13	8,804

[a] Weighted through surveysampling weights provided by Statistics Canada.
[b] ADG® Score is a weighted score based on an individual's ADGs. This method has been validated elsewhere.(26)

Table 2: Weighted[a] distributions of baseline characteristics according to hospitalization for an ACSC (N= 129,467)

	ACSC Hospitalization Yes (N= 3,037)	ACSC Hospitalization No (N= 126,430)	Unweighted N's	
Sex				
Male	56.12	49.09	59,292	
Female	43.88	50.91	70,175	
Age group				
18-34	9.35	32.07	35,255	
35-49	20.5	32.89	35,063	
50-64	48.6	25.49	38,662	
65-74	21.56	9.55	20,487	
BMI				
Underweight <18.5	2.19	2.68	2,674	
Normal Weight, 18.5 – 24.9	29.19	46.2	53,327	
Overweight, 25-29.9	33.96	34.13	43,915	
Moderately obese, 30-34.9	21.39	12.18	17,840	
Severely obese, >34.9	13.27	4.8	7,815	
ADG® Score [b]				
Mean (SD)	11.8 (0.39)	3.86 (0.05)	*129,467*	
Physical Activity Status				
Active	17.33	26.64	35,482	
Moderate	21.27	25.12	33,791	
Inactive	61.41	48.2	60,149	
On-Marg Deprivation				
(Least Deprived) 1	14.91	21.74	23,405	
2	19.67	20.62	25,427	
3	16.62	19.74	26,391	
(Most Deprived) 4	21.42	18.38	26,386	
Education Level				
Less than secondary	19.16	6.01	12,302	
Secondary graduate	15.18	11.78	18,047	
More than secondary	60.1	76.81	94,084	
Unknown	5.57	5.4	5,034	
Alcohol Consumption				
Heavy Drinker	6.95	8.39	11,502	

Moderate Drinker	16.37	21.34	17,934	
Light Drinker	9.67	14.05	28,413	
Never Drinker	65.23	54.95	69,785	
Smoking Status				
Current Smoker	36.7	21.53	30,875	
Former Smoker	29.26	21.07	32,623	
Never Smoked	31.09	54.04	61,357	
Immigrant Status				
Yes	25.03	31.59	25,228	
No	72.45	66.71	102,911	
Household Income				
Q1 (Lowest Income)	20.72	13.51	17,369	
Q2	16.09	14.61	18,687	
Q3	16.56	17.07	24,063	
Q4	17.57	21.31	29,029	
Q5 (Highest Income)	18.58	23.65	31,515	
Unknown	10.48	9.84	8,804	

[a] Weighted through survey sampling weights provided by Statistics Canada.
[b] ADG® Score is a weighted score based on an individual's ADGs. This method has been validated elsewhere.(26)

Table 3: Multivariable AHRs and 95% CIs From Proportional Hazards Regression (N= 129,467)

	Unadjusted		Age-Sex Adjusted		Minimally Adjusted [a]		Fully Adjusted [b]	
Life Satisfaction	HR (95% CI)	p-value	HR (95% CI)	p-value	HR (95% CI)	p-value	HR (95% CI)	p-value
Very Satisfied	(ref)	(ref)	(ref)	(ref)	(ref)	(ref)	(ref)	(ref)
Satisfied	1.44 (1.27 - 1.64)	P < 0.0001	1.56 (1.37 - 1.77)	P < 0.0001	1.48 (1.30 - 1.69)	P < 0.0001	1.32 (1.15 - 1.50)	P < 0.0001
Neither Satisfied or Dissatisfied	2.22 (1.79 - 2.76)	P < 0.0001	2.37 (1.91 - 2.95)	P < 0.0001	2.11 (1.69 -2.65)	P < 0.0001	1.71 (1.36 - 2.14)	P < 0.0001
Dissatisfied and Very Dissatisfied	4.51 (3.17 - 6.41)	P < 0.0001	4.48 (3.16 - 6.34)	P < 0.0001	3.79 (2.66 - 5.41)	P < 0.0001	2.71 (1.87 - 3.93)	P < 0.0001

HR – hazard ratio, CI – confidence interval

[a] Minimally adjusted models controlled for age, sex and household income

[b] Fully adjusted models controlled for age, sex, household income, physical activity, BMI, alcohol consumption and smoking status

Table 4: Multivariable AHRs[a] and 95% CIs From Proportional Hazards Regression After Additionally Adjusting for ADG® score, Mood Disease and Anxiety (N= 129,467)

	Fully Adjusted with ADG® Score		Fully Adjusted with Mood Disease		Fully Adjusted with Anxiety	
	HR (95% CI)	p-value	HR (95% CI)	p-value	HR (95% CI)	p-value
Life Satisfaction						
Very Satisfied	(ref)	(ref)	(ref)	(ref)	(ref)	(ref)
Satisfied	1.28 (1.12 - 1.46)	0.0004	1.30 (1.13 - 1.50)	0.0002	1.31 (1.14 - 1.49)	0.0001
Neither Satisfied or Dissatisfied	1.56 (1.25 - 1.96)	0.0001	1.62 (1.29 - 2.05)	P < 0.0001	1.65 (1.31 - 2.08)	P < 0.0001
Dissatisfied and Very Dissatisfied	2.42 (1.68 - 3.51)	P < 0.0001	2.45 (1.68 - 3.55)	P < 0.0001	2.52 (1.76 - 3.61)	P < 0.0001

HR – hazard ratio, CI – confidence interval

[a] Both models controlled for age, sex, household income, physical activity, BMI, alcohol consumption, smoking status in addition to the variable specified.

Table 5: Multivariable AHRs and 95% CIs From Joint Effects Models (N= 129,467)

	Unadjusted		Fully Adjusted [a]	
Joint Effects	**HR (95% CI)**	**p-value**	**HR (95% CI)**	**p-value**
High Life Satisfaction and High Income	1.00	(ref)	1.00	(ref)
High Life Satisfaction and Middle Income	1.40 (1.18 – 1.65)	P < 0.0001	1.18 (0.99 – 1.40)	0.0581
High Life Satisfaction and Low Income	2.00 (1.66 – 2.42)	P < 0.0001	1.63 (1.35 – 1.99)	P < 0.0001
Neither Satisfied Nor Dissatisfied and High Income	1.84 (1.16 – 2.93)	0.0099	1.55 (0.98 – 2.46)	0.0614
Neither Satisfied Nor Dissatisfied and Middle Income	2.46 (1.84 – 3.29)	P < 0.0001	1.92 (1.42 – 2.60)	P < 0.0001
Neither Satisfied Nor Dissatisfied and Low Income	2.44 (1.7 – 3.53)	P < 0.0001	1.68 (1.16 – 2.45)	0.0067
Low Life Satisfaction and High Income	3.71 (1.08 – 12.78)	0.0377	2.81 (0.80 – 9.91)	0.1068
Low Life Satisfaction and Middle Income	3.67 (2.67 – 5.03)	P < 0.0001	2.30 (1.66 – 3.18)	P < 0.0001
Low Life Satisfaction and Low Income	6.95 (3.91 – 12.38)	P < 0.0001	3.80 (2.13 – 6.73)	P < 0.0001

HR – hazard ratio, CI – confidence interval

[a] Fully adjusted models controlled for age, sex, physical activity, BMI, alcohol consumption, smoking status

Contributors: LCR and VG conceptualized the study, TW created the database and ED planned the analysis, analyzed the data, and drafted and revised the paper. LCR is the guarantor. All authors contributed to the manuscript and revised the draft paper. All have approved the final version for publication.

Funding: This research was supported by a Canada Research Chair held by LCR (CRC-950-23072).

Disclaimer: This study was supported by ICES, which is funded by an annual grant from the Ontario Ministry of Health and Long-Term Care. The opinions, results and conclusions reported in this paper are those of the authors and are independent from the funding sources.

Competing interests: None declared

Data sharing statement: The data set from this study is held securely in coded form at ICES. While data sharing agreements prohibit ICES from making the data set publicly available, access may be granted to those who meet prespecified criteria for confidential access (available at www.ices.on.ca/DAS). The full data set creation plan and underlying analytic code are available from the authors upon request, understanding that the programs may rely upon coding templates or macros that are unique to ICES.

Figure 1: Flow chart of study participants

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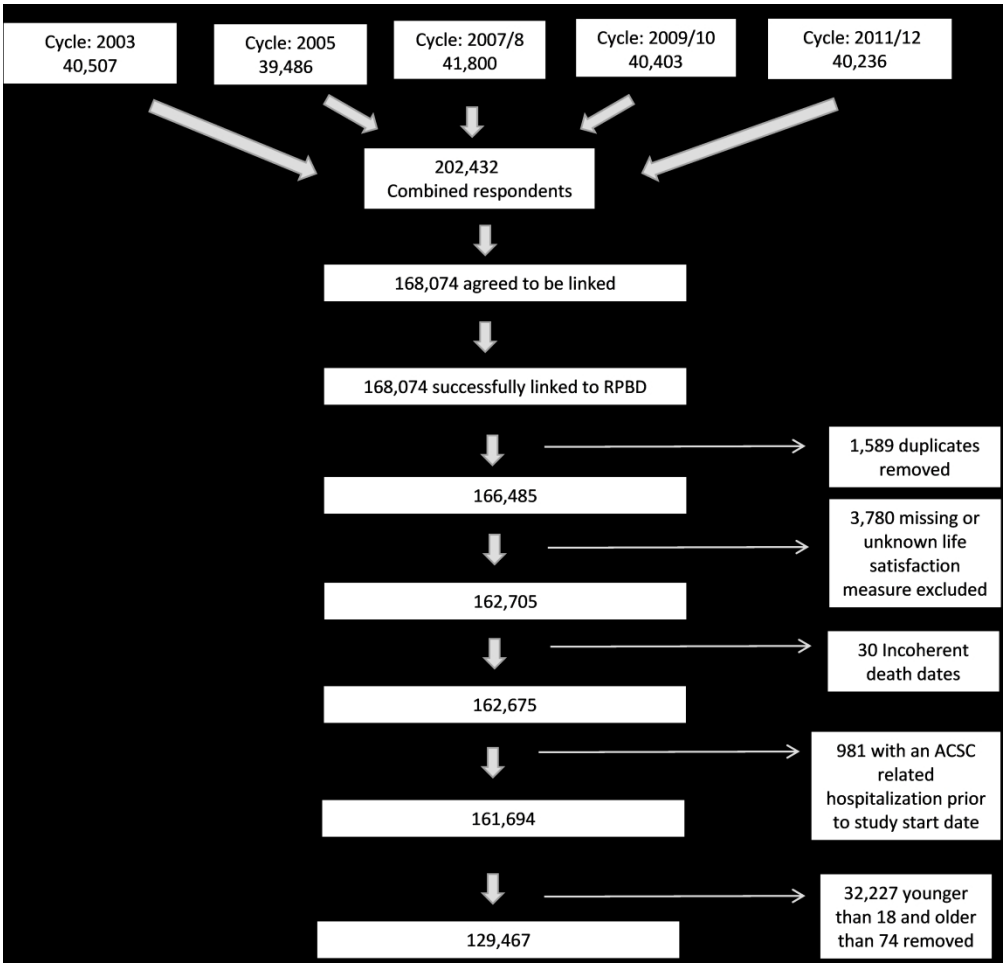


Figure 1: Flow chart of study participants

Supplement Table 1:

ICD-10-CA/ CCI codes for ACSC hospitalizations[1]

Condition	ICD-10-CA Code(s)
Grand mal status and other epileptic convulsions	G40, G41
Chronic obstructive pulmonary disease (COPD)	J41, J42, J43, J44, J47 (only when a secondary diagnosis of J44 is also present) J10.0, J11.0, J12–J16, J18, J20, J21, J22
Asthma	J45
Diabetes	E10.0, E10.1, E10.63, E10.64, E10.9 E11.0, E11.1, E11.63, E11.64, E11.9 E13.0, E13.1, E13.63, E13.64, E13.9 E14.0, E14.1, E14.63, E14.64, E14.9
Hypertension*	I10.0, I10.1, I11
Heart Failure and pulmonary edema	I50, J81
Angina*	I20, I23.82, I24.0, I24.8, I24.9

*Excluding cases with cardiac procedures, CCI codes for exclusion:

1.HA.58.^^, 1.HA.80.^^, 1.HA.87.^^, 1.HB.53.^^, 1.HB.54.^^, 1.HB.55.^^, 1.HB.87.^^, 1.HD.53.^^, 1.HD.54.^^, 1.HD.55.^^, 1.HH.59.^^, 1.HH.71.^^, 1.HJ.76.^^, 1.HJ.82.^^, 1.HM.57.^^, 1.HM.78.^^, 1.HM.80.^^, 1.HN.71.^^, 1.HN.80.^^, 1.HN.87.^^, 1.HP.76.^^, 1.HP.78.^^, 1.HP.80.^^, 1.HP.82.^^, 1.HP.83.^^, 1.HP.87.^^, 1.HR.71.^^, 1.HR.80.^^, 1.HR.84.^^, 1.HR.87.^^, 1.HS.80.^^, 1.HS.90.^^, 1.HT.80.^^, 1.HT.89.^^, 1.HT.90.^^, 1.HU.80.^^, 1.HU.90.^^, 1.HV.80.^^, 1.HV.90.^^, 1.HW.78.^^, 1.HW.79.^^, 1.HX.71.^^, 1.HX.78.^^, 1.HX.79.^^, 1.HX.80.^^, 1.HX.83.^^, 1.HX.86.^^, 1.HX.87.^^, 1.HY.85.^^, 1.HZ.53 rubric (except 1.HZ.53.LA-KP), 1.HZ.54.^^, 1.HZ.55 rubric (except 1.HZ.55.LA-KP), 1.HZ.56.^^, 1.HZ.57.^^, 1.HZ.59.^^, 1.HZ.80.^^, 1.HZ.85.^^, 1.HZ.87.^^, 1.IF.83.^^, 1.IJ.50.^^, 1.IJ.54.GQ-AZ, 1.IJ.55.^^, 1.IJ.57.^^, 1.IJ.76.^^, 1.IJ.80.^^, 1.IJ.86.^^, 1.IK.50.^^, 1.IK.57.^^, 1.IK.80.^^, 1.IK.87.^^, 1.IN.84.^^, 1.LA.84.^^, 1.LC.84.^^, 1.LD.84.^^, 1.YY.54.LA-NJ, 1.YY.54.LA-FS, 1.YY.54.LA-NM

[1] More information on CIHI methodology: http://indicatorlibrary.cihi.ca/display/HSPIL/Ambulatory+Care+Sensitive+Conditions

Supplement Table 2: Multivariable AHRs [a] and 95% CIs Across Sensitivity Analyses

	Five-year survival [b] (N= 129,467)		Excluding events from first two years [c] (N= 128,638)	
	HR (95% CI)	p-value	HR (95% CI)	p-value
Life Satisfaction				
Very Satisfied	(ref)	(ref)	(ref)	(ref)
Satisfied	1.32 (1.16 – 1.51)	P < 0.0001	1.38 (1.17 – 1.62)	P < 0.0001
Neither Satisfied or Dissatisfied	1.71 (1.36 – 2.14)	P < 0.0001	1.74 (1.33 – 2.28)	P < 0.0001
Dissatisfied and Very Dissatisfied	2.74 (1.89 – 3.98)	P < 0.0001	2.77 (1.69 – 4.55)	P < 0.0001

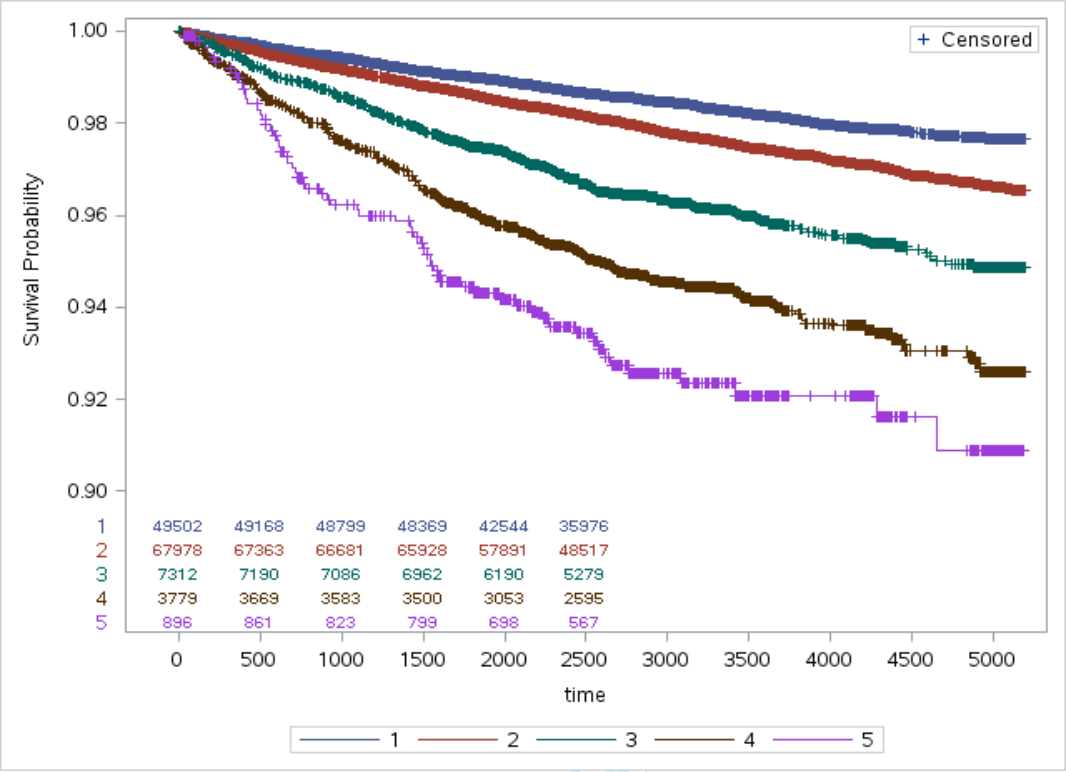
[a] All models were fully adjusted models which controlled for age, sex, physical activity, BMI, alcohol consumption, smoking status.
[b] Five-year survival models were run with a consistent survival time of five years.
[c] Models were run without individuals who had an event within the first two years of follow-up.

Supplement Table 3: Unadjusted HRs from The Subdistribution Hazard Model [a]

	HR (95% CI)	p-value
Life Satisfaction		
Very Satisfied	(ref)	(ref)
Satisfied	1.44 (1.30 - 1.60)	P < 0.0001
Neither Satisfied or Dissatisfied	2.20 (1.86 - 2.60)	P < 0.0001
Dissatisfied and Very Dissatisfied	4.38 (3.73 - 5.14)	P < 0.0001

[a] Subdistribution hazard model considered death as a competing risk.

Supplement Figure 1. Kaplan Meir survival curves for Life Satisfaction (most dissatisfied = 5; lease dissatisfied = 1)



STROBE Checklist – Location of Specific Items for "The relationship between life satisfaction and preventable hospitalizations: a longitudinal population-based cohort study"

	Item No	Page Number
Title and abstract	1	(*a*) Cover page (title page)
		(*b*) Abstract: 1
Introduction		
Background/rationale	2	5
Objectives	3	5 to 6
Methods		
Study design	4	6
Setting	5	6
Participants	6	6
Variables	7	6 to 7
Data sources/ measurement	8	6 to 8
Bias	9	6
Study size	10	3
Quantitative variables	11	6 to 7
Statistical methods	12	(*a*) Describe all statistical methods: 6 to 8
		(*b*) Subgroups and interactions: 8
		(c) Sensitivity Analyses: 8
Results		
Participants	13	8 and Figure 1
Descriptive data	14	8 and Table 1 to 2
Outcome data	15	9 and Table 3
Main results	16	9 to 10 and Tables 3 to 4
Other analyses	17	10 and Supplement Tables 1-3
Discussion		
Key results	18	10 to 11
Limitations	19	11
Interpretation	20	11 to 12
Generalisability	21	10
Other information		
Funding	22	19