

# Impaired sleep, multimorbidity, and self-rated health among Canadians: Findings from a nationally representative survey

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## Abstract

**Background:** Self-rated health (SRH) is a globally recognized measure of health status. Both impaired sleep (IS) and the presence of multimorbidity are related to poorer SRH, but the precise nature of these associations remains unclear. This study explored the association between IS, multimorbidity, and SRH among Canadian adults.

**Method:** We used 2017-18 Canadian Community Health Survey (CCHS) data for this study. The main variable of interest, self-rated health (SRH), measured participants' health on a 5-point Likert scale, later categorized as "good or better" vs. "fair or poor". The primary predictor, IS, was derived from two variables and categorized into four groups: no sleep issues; fewer sleeping hours (<7 hours) only; trouble sleeping only; and fewer hours & trouble sleeping. Multimorbidity was present (yes/no) if a participant indicated being diagnosed with two or more chronic conditions.

**Results:** Just over one in ten Canadians reported fair/poor SRH and approximately one-quarter had multimorbidity or experienced few sleep hours in combination with trouble sleeping. The adjusted model indicated greater odds of fair/poor SRH associated with the 40-64 years age group, male sex, and lower socio-economic status. It also suggested the presence of multimorbidity (AOR= 4.63, 95% CI: 4.06-5.28) and a combination of fewer sleep hours and troubled sleep (AOR= 4.05, 95% CI: 2.86-5.74) is responsible for poor SRH. Forty-four percent of the total effect of IS on SRH was mediated by multimorbidity.

**Conclusion:** This unique finding highlights the mediating role of multimorbidity, emphasizing the importance of addressing it alongside sleep issues for optimal health outcomes.

## Keywords

Self-rated health, multimorbidity, impaired sleep, chronic diseases, noncommunicable diseases

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## Background

An individual's self-rated health (SRH) is a valid indicator of their health state.<sup>1</sup> As a single, easy-to-administer, self-administered health measure that reflects an individual's current health condition, SRH is often used in conjunction with objective health measures.<sup>2,3</sup> A validated tool used globally to obtain a quick assessment of one's health

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Data Availability Statement included at the end of the article



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perception is a five-point Likert scale, which provides the options of “excellent,” “very good,” “good,” “fair,” or “poor”. This scale enables individuals to rate their health status and provides an easy way to capture their overall perception of their health.<sup>1,4,5</sup> SRH has been shown to be closely related to physical health conditions, including functional ability and diseases.<sup>1,6</sup> Mortality and survival rates have also been predicted using SRH.<sup>2,3,7-10</sup> Wu et al. found that poor health isn’t just a matter of socio-economic status (SES), but also blood markers (red blood cells, haemoglobin, total cholesterol, and fasting blood sugar).<sup>1</sup> A recent exploratory study found similar findings and revealed that 57 biomarkers were associated with SRH,<sup>11</sup> suggesting that SRH being a reliable health indicator.

Inadequate sleep (<7 hours) is also significantly associated with poor SRH.<sup>12-19</sup> One cross-sectional study among young adults (n=689) showed that respondents who slept less than seven hours were significantly more likely to report poor SRH.<sup>17</sup> A large-scale multicounty survey conducted across 24 countries among 17,465 university students confirmed the same finding.<sup>19</sup> Some interesting findings were uncovered in a study of older individuals from Spain and Australia. According to the study, both shorter and longer sleep durations are associated with poor SRH in older adults in these countries, with the exception of Spanish males.<sup>12,16</sup> Another recent article also demonstrated an inverted U-shaped relation between sleep duration and poor SRH for all age people in Netherland, indicating that short and long sleep duration may be associated with poorer SRH.<sup>18</sup> Andreasson et al.<sup>18</sup> and Ding et al.<sup>14</sup> suggest that, in addition to sleep duration, sleep quality may positively affect health outcomes, and that both indicators should be used to better understand the impact of sleep on SRH.

In addition to sleep characteristics, multiple studies have revealed that people with more than two chronic conditions, known as multimorbidity<sup>20</sup> are significantly more likely to report poorer SRH.<sup>21-23</sup> On the other hand, studies revealed that insufficient sleep is often considered a common risk factor for poor health and multimorbidity.<sup>10,24-27</sup> Sivertsen et al. discovered that there is a significant association between insomnia and chronic diseases, i.e., arrhythmia, myocardial infarction, asthma, osteoporosis, and depression.<sup>28</sup> A longitudinal study found that disrupted sleep can accelerate the onset of multimorbidity in elderly individuals.<sup>29</sup> Based on these studies, it is clear that impaired sleep (IS) and multimorbidity are both associated with poorer SRH. However, it remains unclear what is the role of multimorbidity in the relationship between IS and SRH. One possibility might be a mediational role of multimorbidity similar to the findings from Smith et al.<sup>30</sup> Smith et al. identified that few anxieties, stress, and post-traumatic stress disorder mediate the relationship between sleep duration and intensity of pain among the selected

participants.<sup>30</sup> Nevertheless, as far as we know, there hasn’t been any prior research focusing on the mediational aspect of multimorbidity. Therefore, there is still much to uncover regarding the role of multimorbidity as a mediator.

Therefore, we hypothesized that both IS and multimorbidity are individual predictors of poor SRH, and multimorbidity can mediate the relationship between IS and SRH. So, our primary objective for the study was to explore the nature of the relationship between multimorbidity, IS, and SRH in the Canadian adult population. Besides we examined the association of social determinants and other lifestyle factors with SRH among Canadian adults.

## Method

We used the Canadian Community Health Survey (CCHS): 2017-2018 Public Use Microdata file. CCHS is a multistage complex cross-sectional survey that captured extensive information, including some objective & subjective measures of health & sociodemographic information from a nationally representing random sample. In 2017-2018, data were collected from ten provinces and three territories across Canada and enrolled the respondents above 12 years (n=113,290). Detailed sampling techniques and data collection procedures have been described elsewhere.<sup>31</sup> CCHS 2017-18 collected sleep data from the four provinces (Prince Edward, Quebec, Alberta, and British Columbia) and two territories (Yukon and Nunavut). The sleep inclusion sample size was 56,675. However, as our population of interest was adult Canadians, we had a subpopulation sample of adults (aged more than 18 years) who had responded to the sleep inclusion flag. Hence, we finally used a subpopulation sample of 52,378 participants for this report.

The dependent variable, SRH, was determined by perceived health from a self-rated Likert scale. Data collected asked participants, “In general, would you say your health is... ((poor/ fair/ good/ very good/excellent)”. Later, we recoded a dichotomized into good or better (good, very good, and excellent) vs. fair or poor (fair or poor) for our analysis, similar to previous studies.<sup>32,33</sup>

The primary predictor IS derived from two variables: “Number of sleeping hours per night” and “trouble going to sleep or staying asleep frequency.” For the sleep duration, data was collected by asking, “How long do you usually spend sleeping each night?”. For trouble sleeping, the original question was, “How often do you have trouble going to sleep or staying asleep?”. We categorized sleep hours into three categories: less than 7 hours, between 7-9 hours and more than 7 hours, similar to the previous article.<sup>18</sup> We coded the trouble sleeping variable into “trouble sleeping” and “no trouble in sleeping.” Finally, we generated the IS variable by combining these two variables and categorized them into four groups: No sleep issues,

Fewer sleeping hours (<7 hours) only, Trouble sleeping only, Fewer hours & trouble sleeping.

We considered the thirteen chronic conditions for our mediator variable (multimorbidity), reported under the chronic condition groups on the CCHS 2017-18 survey. All of the responses were self-reported. These were: asthma, chronic obstructive pulmonary disease (COPD), arthritis, hypertension (HTN), high cholesterol, heart disease, stroke, diabetes mellitus (DM), cancer, allergies, hay fever, mood disorder (including: depression, bipolar, mania & dysthymia), and anxiety.<sup>34</sup> We cumulated the score by simply counting if the person was diagnosed with that disease and later dichotomized into two categories (Less than two chronic conditions & two or more than two chronic conditions).

For sociodemographic characteristics, we recoded the age (18-39 years, 40-64 years, and 65+ years) and marital status (Married/common-law, Widowed/divorced/separated, and Single) into three and income (less than 40 thousand and more than 40 thousand) into two categories. Besides, we also extracted the following variables for consideration as other covariates in our study: sex (male and female), ethnicity (white and non-white), education (less than secondary school, secondary school graduate, post-secondary degree), employment (working status for last 12 months: yes or no), Body Mass Index (BMI) (underweight or normal, overweight, and obese), smoking status (at present: yes or no), alcohol consumption (ever in your life: yes or no), physical activity (below recommendation level., above recommendation level, and not at all).

Figure 1 depicts the theoretical framework for this study. It revealed that multimorbidity (mediator) might be in the path between IS and SRH. Prior research demonstrated that low-income, unemployed, women and older-aged participants had a significant impact on sleep, so we consider

looking at the interaction between age, sex, income and employment with IS.<sup>35,36</sup> Lifestyle factors were considered as confounders for this study.

Statistical analyses were conducted using STATA version-15.<sup>37</sup> An appropriate survey weight was used for all analyses. Population characteristics were presented as a weighted percentage. Bivariable logistic regression determined the unadjusted association between IS & SRH. The variables with  $p < 0.20$  based on bivariable logistic regression became candidates for multivariable logistic regression. We analyzed the possible interaction between IS with age group, sex, income & employment. However, the interaction between IS and age group was significant and retained in the final model. We reported the adjusted & unadjusted odds ratio with 95% CI. Mediation analysis was performed by Generalized structural equation modeling (GEM) with bootstrap variance estimation. The mediational effect was assessed by the ratio of the indirect effect to the total effect (RIT) and the ratio of the indirect effect to the direct effect (RID).<sup>38</sup>

## Results

Table 1 shows the distribution (weighted percentage) of the SRH across the sociodemographic and individual factors (lifestyle & multimorbidity); and IS variables. This table also showed the unadjusted odds for the association of SRH with the covariates. It showed that fair/poor SRH increased with age and decreased with education level, income, and employment status. Among participants aged 65 years and above, nearly 20% (19.35%; 95% CI: 18.44-20.30) reported having fair/ poor SRH. The odds of fair or poor health among the 65 years and above group were nearly four times higher than the 18-39 years group (OR=3.76; 95% CI: 3.35-4.23,  $p < 0.001$ ). The weighted percentage of fair or poor

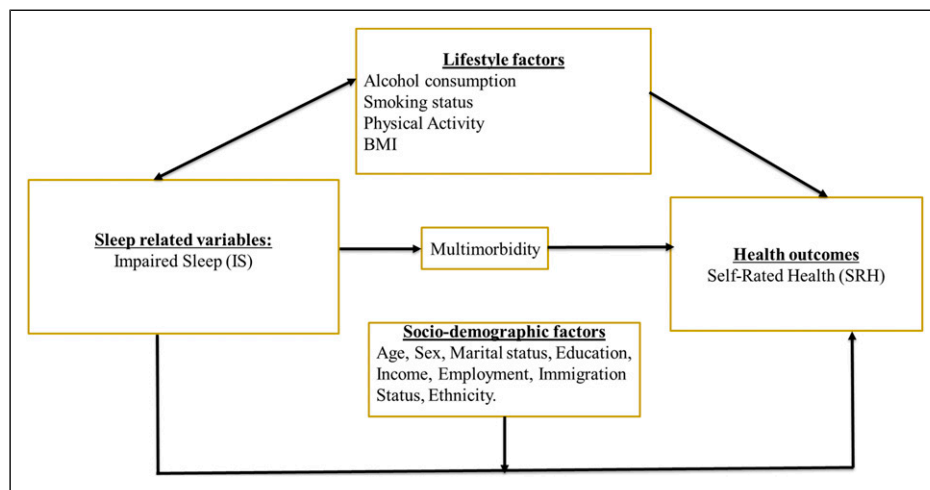


Figure 1. Theoretical framework for this study.

**Table 1.** Distribution of participants' characteristics (in terms of weighted percentages) and the unadjusted odds ratio (95% Taylor linearization confidence intervals) (OR<sub>unadj</sub> (95% CI)) for the association of sociodemographic and lifestyle factors with SRH: CCHS 2017-18, Canada.

Variables	Self-Rated Health (SRH)		OR <sub>unadj</sub> (95% CI) Vs Fair or poor	Good or better	p-value
	Good or Better weighted % (88.90%)	Fair or poor weighted % (11.11%)			
Age group					
18-39 years	94.01	5.99	1		0.000
40-64 years	88.44	11.56	2.05 (1.81-2.31)		0.000
65 and above	80.65	19.35	3.76 (3.35-4.23)		0.000
Sex					
Male	89.37	10.63	1		
Female	88.44	11.56	1.09 (1.00-1.19)		0.029
Ethnicity					
White	89.91	10.90	1		
Non-white	89.71	10.29	0.94 (0.82-1.07)		0.332
Marital status					
Married/ Common-law	90.29	9.71	1		
Widowed/divorced/separated	80.82	19.18	2.21 (2.01-2.43)		0.000
Single	89.52	10.48	1.09 (0.97-1.22)		0.142
Highest education					
Less than secondary school	75.25	24.75	1		
Secondary school graduate	88.27	11.73	0.40 (0.36-0.46)		0.000
Post-Secondary degree	91.91	8.09	0.27 (0.24-0.30)		0.000
Income					
Less than 40 thousand	80.33	19.67	1		
More than 40 thousand	91.08	8.92	0.40 (0.37-0.44)		0.000
Employment (Working status-last 12 month)					
Yes	93.59	6.41	1		
No	78.05	21.95	4.11 (3.73-4.52)		0.000
Immigration status					
No-immigrant	88.94	11.06	1		
Immigrant	88.92	11.08	1.01 (0.90-1.12)		0.970
Body Mass Index (BMI)					
Underweight or normal	92.07	7.93	1		
Overweight	91.21	8.79	1.12 (1.01-1.26)		0.060
Obese	84.28	15.72	2.17 (1.95-2.40)		0.000
Smoking status (at present)					
Not at all	90.13	9.87	1		
Occasionally	86.65	13.35	1.41 (1.11-1.78)		0.004
Daily	81.30	18.70	2.10 (1.90-2.32)		0.000
Alcohol Consumption					
No	84.90	15.11	1		
Yes	89.24	10.76	0.68 (0.58-0.80)		0.000
Physical Activity					
Below recommendation	92.44	7.56	1		
Above recommendation	89.28	10.72	1.47 (1.31-1.64)		0.000
Not at all	78.44	21.56	3.36 (3.04-3.71)		0.000
Multimorbidity					
Less than two chronic conditions	94.66	5.34	1		
Two or more Chronic condition	71.96	28.04	6.91 (6.30-7.59)		0.000

(continued)

**Table 1.** (continued)

Variables	Self-Rated Health (SRH)		OR <sub>unadj</sub> (95% CI) Vs Fair or poor	p-value
	Good or Better weighted % (88.90%)	Fair or poor weighted % (11.11%)		
Impaired sleep (IS)				
No Sleeping issue	93.75	6.25	1	
Fewer Sleeping hours only	92.93	7.07	1.14 (0.98-1.33)	0.085
Trouble Sleeping only	88.33	11.67	1.98 (1.76-2.24)	0.000
Fewer sleeping hours and trouble sleeping	89.75	16.56	2.97 (2.66-3.33)	0.000

SRH across different sex, ethnic and immigrant groups were nearly equal (Male vs. Female: 10.63% vs. 11.56%; White vs. Non-white: 10.90% vs. 10.29% & Non-immigrant vs. Immigrant 11.06% vs. 11.08% respectively). However, in the bivariable analysis we found females had a significantly higher chance of fair or poor SRH (OR=1.09; 95%CI: 1.00-1.19,  $p=0.029$ ).

Among Widowed/ divorced/separated, 19.18% (95% CI: 18.03-20.38) had fair or poor SRH, which is two times higher than married people (OR=2.21; 95% CI: 2.01-2.43,  $p<0.001$ ). The post-secondary education group had reported the least fair or poor SRH (8.09%; 95% CI: 7.65-8.54. Nearly 20% (19.67%; 95% CI: 18.69-20.69) of the participants in the lower-income (<40 thousand/year) group had reported fair or poor SRH. Similarly, those unemployed (not worked for the last 12 months) reported having 21.95% (95% CI: 20.78-23.18) fair or poor SRH. The unemployed group had reported 4.11 times higher (95% CI: 3.73-4.52,  $p<0.001$ ) of fair or poor health compared to the employed group.

Table 1 also shows that among the obese group, 15.72% (95% CI: 14.84-16.65) reported having fair or poor SRH. In bivariable analysis, it was revealed that the obese group had reported 2.17 times (95% CI: 1.95-2.40,  $p<0.001$ ) higher odds than the underweight group. It also showed that among the daily smokers, approximately 20% (18.70%; 95% CI: 17.39-20.08) had fair or poor SRH. People who smoke daily had 2.10 times (95% CI: 1.90-2.32,  $p<0.001$ ) of a higher chance of having fair or poor health than those who never smoked. Like smokers, 21.56% (95% CI: 20.40-22.77) of the participants with no physical activity had reported fair or poor SRH. However, the risk of reporting fair or poor SRH was more in physically inactive respondents than daily smokers (OR=3.36; 95% CI: 3.04-3.71,  $p<0.001$ ). Surprisingly, alcohol consumption showed a protective factor for good or better on unadjusted analysis; however, later, it was found to be a non-significant protective factor in adjusted regression analysis.

Among the multimorbid participants, more than one-fourth (28.04%; 95% CI: 26.97-29.14) of the respondents had a higher percentage of fair or poor SRH. In our

bivariable analysis we found that the odds are alarming for two or more chronic conditions in compared to one or less chronic condition. (OR=6.91; 95% CI: 6.30-7.59,  $p<0.001$ ). The percentage of fair or poor SRH was highest among the participants who had fewer sleeping hours and trouble sleeping (16.56%; 95% CI: 15.56-17.60). It was noted that that the risk for fair or poor SRH was increased with sleep health issues. In comparison to those who had no sleep issues, who had fewer sleeping hours and trouble sleeping had three times higher chance of getting fair or poor health (OR=2.97, 95% CI: 2.66-3.33,  $p<0.001$ ) (Table 1)

We considered age group, sex, ethnicity, marital status, highest education, income, employment (working status last 12 months), BMI, smoking status, alcohol consumption status, physical activity, multimorbidity, and IS in our multivariable model. We also considered the interaction term of IS and age group in the final model.

Table 2 represents the adjusted odds from multivariable logistic regression. In multivariable analysis, we observed the odds of fair or poor SRH decreased by 16% for females compared to males (AOR= 0.84; 95% CI: 0.74-0.95,  $p=0.004$ ). The likelihood of fair or poor SRH was 1.44 times higher (95% CI: 1.20-1.72,  $p<0.001$ ) among non-white than the white ethnic group. Widowed or divorced or had reported higher odds (AOR= 1.33; 95% CI: 1.15-1.54,  $p<0.001$ ) of having fair or poor SRH than married or common-law partners. Fair or poor SRH decreased by 45% among the post-secondary participants (AOR= 0.55; 95% CI: 0.46-0.65,  $p<0.001$ ) than the group with less than secondary school education. The odds of fair or poor SRH significantly decreased in the "more than 40 thousand" than "less than 40 thousand" income group (AOR= 0.74; 95% CI: 0.64-0.85,  $p<0.001$ ). Respondents who were not employed for the last 12 month had nearly three times (AOR=2.81; 95% CI: 2.43-3.25,  $p<0.001$ ) more likely to have fair or poor SRH.

Compared to moderately physically active (below recommendation level), participants who had a history of no physical activity had 2.10 times higher odds (95% CI: 1.82-2.42,  $p<0.001$ ). Compared to normal or underweight, obese had 1.54 times higher odds of having fair or poor SRH (95%

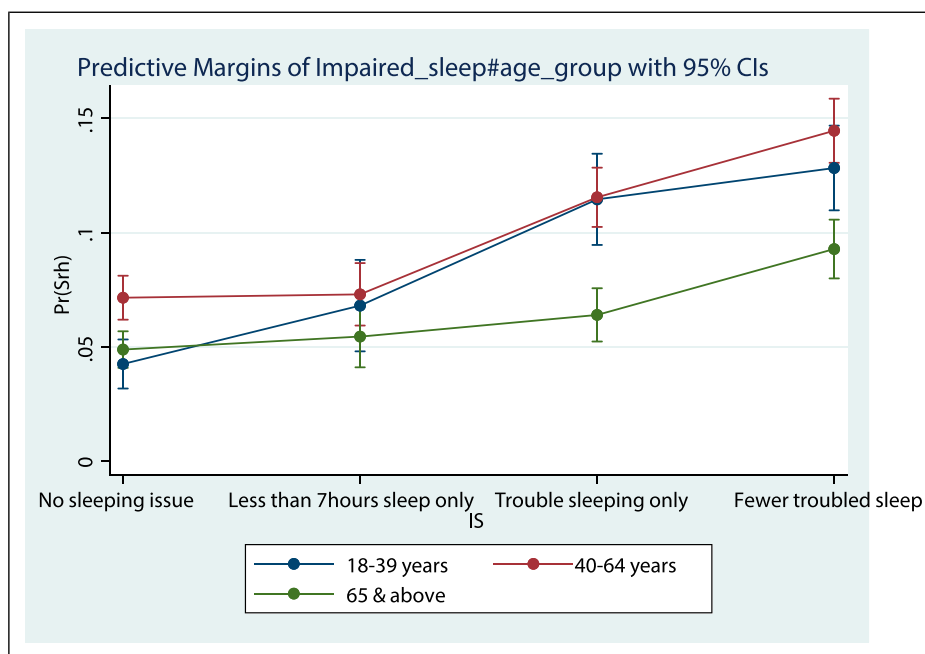
**Table 2.** Adjusted odds ratios with 95% Taylor Linearization confidence intervals (OR<sub>adj</sub> (95% CI)) for the association of sociodemographic and lifestyle factors with SRH, CCSH, 2015–2016, Canada.

Variables	OR <sub>adj</sub> (95% CI)
Age group	
18-39 years	
40-64 years	<b>1.88 (1.34-2.64)</b>
65 and above	1.18 (0.81-1.71)
Sex	
Male	
Female	<b>0.84 (0.74-0.95)</b>
Ethnicity	
White	
Non-white	<b>1.44 (1.20-1.72)</b>
Marital status	
Married/ Common-law	
Widowed/divorced/separated	<b>1.33 (1.15-1.54)</b>
Single	<b>1.31 (1.11-1.55)</b>
Highest education	
Less than secondary school	
Secondary school graduate	<b>0.68 (0.57-0.83)</b>
Post-Secondary degree	<b>0.55 (0.46-0.65)</b>
Income	
Less than 40 thousand	
More than 40 thousand	<b>0.74 (0.65-0.85)</b>
Working status-last 12 month	
Yes	
No	<b>2.81 (2.43-3.25)</b>
Body Mass Index (BMI)	
Underweight or normal	
Overweight	0.98 (0.83-1.15)
Obese	<b>1.54 (1.33-1.78)</b>
Physical Activity	
Below recommendation level	
Above recommendation level	<b>1.21 (1.05-1.39)</b>
Not at all	<b>2.10 (1.82-2.42)</b>
Smoking status (at present)	
Not at all	
Occasionally	<b>1.84 (1.36-2.48)</b>
Daily	<b>1.91 (1.65-2.22)</b>
<b>Alcohol consumption</b>	
No	
Yes	0.78 (0.61-1.00)
Multimorbidity	
Less than two chronic conditions	
Two or more chronic conditions	<b>4.64 (4.07-5.29)</b>
Impaired sleep	
No Sleeping issue	
Fewer Sleeping hours only	<b>1.77 (1.13-2.76)</b>
Trouble Sleeping only	<b>3.50 (2.43-5.05)</b>
Fewer sleeping hours and trouble sleeping	<b>4.10 (2.90-5.81)</b>
Interaction: Impaired sleep & age group	
No Sleeping issue*18-39 years	
No Sleeping issue* 40-64years	<b>1.88 (1.33-2.64)</b>

(continued)

**Table 2.** (continued)

Variables	OR <sub>adj</sub> (95% CI)
No Sleeping issue* *65 above	1.18 (0.81-1.71)
Fewer Sleeping hours only* 18-39 years	<b>1.77 (1.13-2.76)</b>
Fewer Sleeping hours only* 40-64years	<b>1.93 (1.32-2.82)</b>
Fewer Sleeping hours only*65 above	1.34 (0.88-2.06)
Trouble Sleeping only* 18-39 years	<b>3.50 (2.43-5.05)</b>
Trouble Sleeping only* 40-64years	<b>3.54 (2.54-4.93)</b>
Trouble Sleeping only*65 above	<b>1.64 (1.11-2.41)</b>
Fewer sleeping hours and trouble sleeping * 18-39 years	<b>4.10 (2.90-5.81)</b>
Fewer sleeping hours and trouble sleeping * 40-64years	<b>4.87 (3.51-6.77)</b>
Fewer sleeping hours and trouble sleeping * 65 above	<b>2.63 (1.84-3.77)</b>



**Figure 2.** Interaction between impaired sleep and age based on logistic regression of the prevalence plots for impaired sleep and age groups showing the predicted probability of fair or poor SRH.

CI: 1.33-1.78,  $p < 0.001$ ). Fair or poor SRH was reported twice among the regular smokers (AOR=1.91; 95%CI:1.65-2.22,  $p < 0.001$ ) than non-smokers. Notably, respondents with multimorbidity had 4.64 times higher odds (95% CI: 4.07-5.29,  $p < 0.001$ ) of having fair or poor SRH than those without multimorbid.

Figure 2 shows a significant interaction between the age group and IS. It revealed that participants aged between 40-64 years and who had reported fewer sleeping hours and trouble sleeping had the chance of higher probability (AOR= 4.87; 95% CI: 3.51-6.77,  $p < 0.001$ ; from Table 2) of getting fair or poor SRH in comparison with participants aged 18-39 years and with no sleep issues. The second most vulnerable group was participants aged between 18-39 years and

who had reported fewer sleeping hours and trouble sleeping had the chance of higher probability (AOR= 4.10; 95% CI: 2.90-5.81,  $p < 0.001$ ; from Table 2).

As per pieces of the literature suggested there might be a possibility that the impact of IS on SRH can be mediated by multimorbidity; we ran the mediation analysis using the GSEM command. As background analysis, we did the unadjusted logistic regression analysis between IS and multimorbidity as prerequisites for mediation analysis, as suggested by Baron & Kenny.<sup>38</sup> We found that increasing sleep issues increased the chance of multimorbidity (Supplementary Table-1). Participants with fewer sleeping hours and trouble sleeping had reported two times higher odds of having multimorbidity.



Figure 3 shows the mediational effect of multimorbidity in the relationship between IS and SRH. It shows the indirect effect of IS on SRH via multimorbidity ( $a*b$ ), total effect of IS on SRH ( $C = (a*b) + c'$ ). The indirect ratio of indirect effect to total effect ( $RIT = (a*b)/C$ ) is 0.4383. And the ratio of the indirect effect to the direct effect ( $RID = (a*b)/c'$ ) is 0.7804. So, we can interpret that, 44% of the total impact of IS on SRH was mediated by multimorbidity, suggesting large sized effect. The mediated effect is about 0.793 times larger than the normal effect.

## Discussion

The aim of the present study was to examine the nature of the relation between the IS, multimorbidity and SRH. The result showed that multimorbidity was strongly associated with fair or poor SRH. It was found that over one-fourth of participants with multimorbidity had reported having poor SRH. This finding is not surprising, as chronic diseases often co-occur, and multimorbidity has been linked to a higher risk of poor SRH and decreased quality of life. It was found that individuals with multimorbidity were 6.91 times more likely to report fair or poor SRH, which is consistent with previous research.<sup>39</sup> Yang et al. reported comparable odds (7.63) of poor SRH for individuals with two or more chronic conditions, also found similar results among Chinese participants.<sup>39</sup> Similar findings were found in a study conducted in Russia<sup>23</sup> that supported the link between multimorbidity and diminished self-perceived health. In addition to emphasizing that this association extends beyond specific populations or regions, these findings

demonstrate the global nature of the relationship between multimorbidity and SRH.

Aside from examining the relationship between multimorbidity and SRH, this study also shed light on IS. We found that individuals who reported experiencing both fewer sleeping duration and trouble sleeping had a threefold greater likelihood of reporting poor SRH than those without sleep issues, which is consistent with previous research conducted by Ding et al.<sup>14</sup> In the study conducted by Ding et al., valuable insights were gained into the joint effect of short sleep duration and poor sleep quality on the health of individuals.<sup>14</sup> Ding et al. found that even greater odds of poor SRH were associated with short sleep duration and poor sleep quality. Despite the fact that our study did not assess the combined effect of these two factors, Ding et al. emphasize the importance of taking into account multiple dimensions of sleep when evaluating their impact on SRH.<sup>14</sup>

Moreover, individuals with short sleep duration and trouble sleeping were twice as likely to have multimorbidity (secondary findings). This observation aligns with the results of the HUNT study in Norway. Sivertsen et al. established that insomnia can predict the cumulative occurrence of various chronic conditions in the Norwegian population.<sup>28</sup> Lin et al. reported findings similar to ours; they found that people who suffered from short or long sleep had a higher chance of multimorbidity.<sup>25</sup> Lin et al. also found that respondents with poor sleep quality reported two times higher odds of multimorbidity in their study.<sup>25</sup> Another survey among German elders by Helbig et al. reported similar odds of having multimorbidity among women with

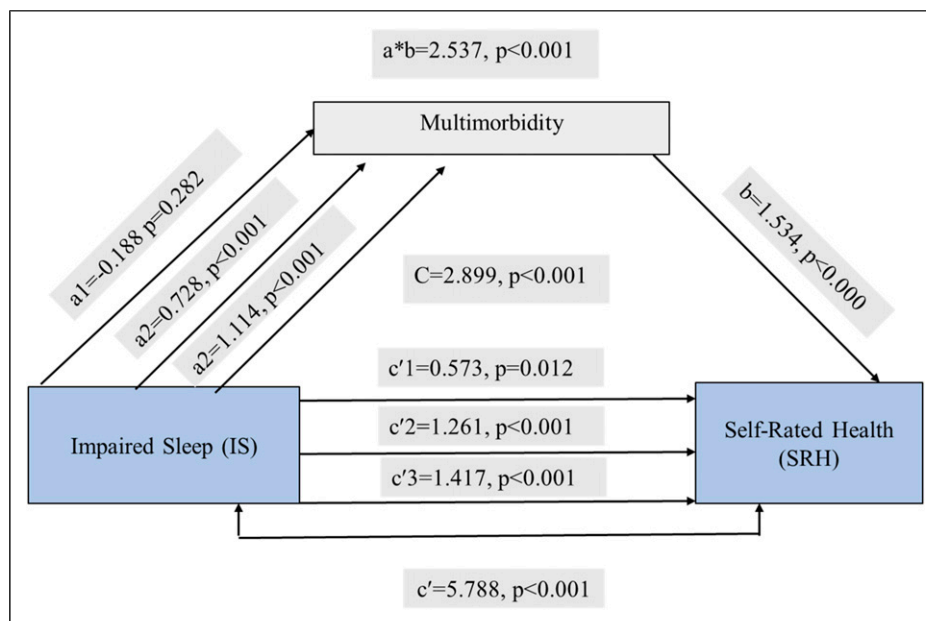


Figure 3. Mediation model of the relationship among impaired sleep, multimorbidity and SRH.



short sleep duration.<sup>36</sup> However, German men didn't show any significant association between short sleeping hours and multimorbidity, which indicates that a sex-stratified future analysis is needed.<sup>36</sup> These combined findings emphasize the requirement for a dedicated prospective study to explore further the connection between sleep issues, multimorbidity, and the potential impact of gender on this association

Furthermore, this study explored the intricate dynamics between multimorbidity, IS, and SRH, not only exploring the direct associations between IS and SRH but also shedding light on the role multimorbidity plays in enhancing this relationship. There was a significant mediating effect of multimorbidity (44%), suggesting that it played a part in explaining the relationship between IS and SRH. However, as the concept of mediating effects in the context of multimorbidity is relatively new, there is a scarcity of articles to compare with. In a recent study, Smith et al. demonstrated that stress, anxiety, and post-traumatic stress disorder (non-communicable mental health conditions) played an important role in explaining the relationship between sleep disturbances, pain intensity, and overall health status.<sup>30</sup> Where, our study emphasizes the importance of taking into account the cumulative impact of chronic conditions on individuals' health outcomes by including multimorbidity as a mediator. According to the findings, it demonstrates the importance of considering chronic conditions together. It provides a basis for future research and the development of targeted interventions to improve subjective health assessments among individuals with sleep issues and multimorbidity.

Moreover, the interaction between the age group and IS was a unique finding of this study. Many studies argued that sleep duration and quality of sleep impacted health individually and combinedly.<sup>14,16,18</sup> However, our study considered both the sleeping duration and quality of sleep and found that participants aged between 40-64 years who reported fewer sleeping hours and trouble sleeping were found to have a higher probability of fair or poor SRH. Where else the older group (65 years and above) had reported the least probability of fewer sleeping hours and trouble sleeping. A large-scale Australian study found a similar result; they reported the "U" shaped relation with age and sleep duration.<sup>16</sup> They have reported the highest odds among the 45-65years grouped people, similar to ours. Magee et al. explained that age-related factors might act differently on sleep and health.<sup>16</sup>

In addition to the primary goal, we found that social determinants and lifestyle factors are associated with SRH among our study participants. The results showed fair or poor SRH increased with age, sex, widowed/divorced/separated, lower income, unemployment, physical inactivity, and multimorbidity. In contrast, fair or poor SRH decreased with higher education, higher income, and employment status. These results are consistent with the

previous studies that have reported the association between socioeconomic status, lifestyle factors, and chronic conditions with SRH.<sup>1,5,9,42</sup> However, the primary focus of this study was to see the association between poor SRH and IS and the impact of multimorbidity in their relationship.

We found that most participants reported having good or better health, and only 11.11% reported having poor or fair health. Bonner et al. also reported similar findings for the Canadian population.<sup>40</sup> Bonner et al. also found that the percentage of getting less than good health (poor health) was increased in the 65 and above age group.<sup>40</sup> The trend is also similar to our study, where we found that the prevalence of fair or poor health in the 65 and above age group was 19.35%. We observed an increasing trend of having poor health with increased aged, similar to Norwegians.<sup>41</sup> This finding could be attributed to the age-related decline in physical health and functional status.

Like American, Spanish, and French people, Canadian women also rated their health worse (with an odds ratio of 1.09) than men.<sup>5,42,43</sup> However, the odds of poor SRH health among the Spanish were much higher (1.72) than our findings. On the other hand, Mildestvedt et al. reported no gender difference in fair or poor SRH.<sup>41</sup> This disparity suggests that fair or poor SRH is not limited to a specific sex group and depends on other factors. Moreover, the study found that widowed, divorced, or separated individuals were more likely to report poor SRH, with an odds ratio of 2.21. While previous studies did not directly examine the relationship between marital status and SRH, a recent systematic meta-analysis found a significant association between all-cause mortality and unmarried men (including those divorced or separated), suggesting that poor health outcomes may be associated with marital status.<sup>44</sup> This result indicates the impact of loneliness and the adverse effects of social isolation on health outcomes.<sup>41,45</sup>

On the other hand, we found that higher levels of education were associated with better SRH, which is consistent with several other studies.<sup>1,9,46</sup> Our study revealed that individuals with less than a secondary education who had a post-secondary degree reported 60% fewer fair or poor SRH outcomes. This finding is similar to a study in Korea, which said that individuals with a middle school education or less were 1.39 times more likely to have poor health outcomes.<sup>46</sup> This may be due to better health literacy and greater access to health-promoting resources among those with higher levels of education. However, the findings of the Korean study suggested that poor SRH is associated with employment and stable financial status, which is opposite to our findings.<sup>46</sup> This difference may be due to the nature of the Korean study sample, which included only working individuals. Our study found that individuals with lower income and those who were unemployed had higher odds of reporting poor SRH, consistent with findings from a previous population-based study of Canadians, Chinese,

and Malaysians.<sup>1,40,47</sup> This association between financial instability (based on unemployment and income) and fair or poor health may be due to increased stress and limited access to healthcare services.

Furthermore, this study also addressed the association between various lifestyle factors and SRH among the study participants. We have seen that the prevalence of fair or poor SRH was higher among obese individuals compared to those who were normal weight or overweight. This finding is consistent with previous research that has shown a negative impact of obesity on health outcomes, including poor SRH.<sup>5</sup> Therefore, promoting healthy weight management strategies to improve overall health and well-being is important. Another lifestyle factor that was associated with fair or poor SRH was smoking. Our study also revealed that another lifestyle factor, smoking had an impact on fair or poor SRH. The odds of having fair or poor SRH were 2.10 times higher in daily smokers than in those who never smoked. This finding is consistent with a previous randomized control trial that has demonstrated that current smokers had reported worse self-reported physical health than those who never smoked among the American.<sup>5</sup> Sahril et al. described that limited daily activities could cause two times higher chance to developed poor SRH, which supports our findings that revealed people with a lack of physical activity had a three times higher chance of getting fair or poor SRH.<sup>47</sup> However, the results related to lifestyle factors indicate that all potential risk factors of non-communicable diseases (NCDs)<sup>48</sup> are responsible for developed fair or poor SRH. Therefore, it is essential to promote a healthy lifestyle to improve overall health and well-being.

This study has several strengths, including its nationwide representation and the enrollment of participants from all provinces and territories. The findings underscore the importance of addressing health inequalities related to education, income, employment status, physical activity, smoking, and multimorbidity. These results can inform policymakers and healthcare professionals in developing targeted interventions to improve SRH among different population groups. However, the study has some limitations. Firstly, since the data were collected cross-sectionally, it is difficult to determine the causal relationship between IS, multimorbidity, and SRH. Besides, no sleep or pain medication data are available, which might modify the association between IS and SRH. For the mediator variable, we considered multimorbidity; however, there is a possibility of mediational effects of separate chronic conditions (such as depression, anxiety, and mood disorder) in the path between IS and SRH. A series of sensitivity and mediation analyses of separate chronic conditions is needed to evaluate in the future. Despite these limitations, the study provides valuable insights into the distribution and associated factors of SRH in Canada. These findings can inform public health interventions to improve SRH among the adult population.

## Authors contribution

All authors made significant contributions to this paper. SBK: Conceptualization, Formal analysis, Writing - original draft. BJ and PP: Conceptualization, critical review & editing the manuscript. NS contributed to result interpretation and manuscript formatting. Finally, all authors reviewed and approved the final version of the manuscript.

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## Data availability statement

The study was conducted by using secondary data available from Canadian Community Health Survey (CCHS):2017-2018 Public Use Microdata file.

## Supplemental Material

Supplemental material for this article is available online.

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