

# Body mass and dependency

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## Abstract

### Objectives

The relationship between body mass index (BMI) category and dependency in men and women aged 45 or older is examined cross-sectionally and prospectively.

### Data sources

Data are from the 2003 Canadian Community Health Survey and the 1994/95 through 2002/03 National Population Health Survey, household populations.

### Analytical techniques

Cross-sectional data were used to produce weighted frequencies, cross-tabulations and multiple logistic regression models to estimate the prevalence of dependency and its relationship to BMI category. Associations between BMI and dependency two years later were also explored. Models were adjusted for potential confounders.

### Main results

The prevalence of dependency was nearly the same among those who were underweight as among those in obese class III—the highest level of obesity. Even when the effects of potential confounders were controlled, underweight and obese people faced higher odds of co-existing dependency, compared with those in the normal BMI range. Obesity was also predictive of subsequent dependency.

## Keywords

activities of daily living (ADL), instrumental activities of daily living (IADL), body mass index, chronic illness, independent living, longitudinal studies

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As efforts to understand the factors that influence the quality of life of middle-aged and older adults gain importance,<sup>1</sup> the influence of weight on functional status has emerged as an area of study in the “epidemiology of disability.” Cross-sectional and prospective studies have indicated that individuals at the extremes of the body mass index (BMI) ranges are far more likely to experience physical disability than are those in the “normal” BMI category.<sup>2-5</sup> However, findings about the role of excess weight and other risk factors on functional limitation are inconsistent. Only about half of longitudinal studies of chronic conditions in relation to future functional limitation have found a significant relationship with obesity, although the variety of measures and analytical approaches used may account for the discrepant findings.<sup>6</sup>

This article provides a detailed examination of the association between BMI category and dependency (see *Analytical techniques*, *Data sources* and *Limitations*). Estimates are presented for the Canadian household population aged 45 or older. Because other studies have found women to be at consistently greater risk than men of functional decline over time, and that obesity seems to have a greater impact on women,<sup>5,7-10</sup> sex-specific analyses were conducted.

## Analytical techniques

*Cross-sectional analysis:* Based on data from the 2003 Canadian Community Health Survey (CCHS) (cycle 2.1), frequencies, cross-tabulations and multiple logistic regression models were produced using data weighted to the 2003 Canadian population. The bootstrap technique, which accounts for the design effects of the survey, was used to calculate variance.<sup>11-13</sup> Statistical significance was established as  $p < 0.05$ .

Multiple logistic regression modelling was used to examine associations between BMI categories and dependency, while controlling for confounding factors. Models were sex-specific. In addition to BMI, variables entered into regression models were selected based on findings from the literature and their availability in the survey. To distinguish variables having an indirect effect on dependency from those exerting a more direct influence, multiple logistic regression models were fitted hierarchically.<sup>5</sup> Variables were entered sequentially into four models (Appendix Tables A and B), as follows:

Model	Control variables
1	Age (continuous), education, main source of income, and living arrangements.
2	Variables in Model 1 <i>and</i> BMI category, smoking status, and leisure-time physical activity level.
3	Variables in Models 1 and 2 <i>and</i> respiratory disease and cancer.
4	Variables in Models 1, 2, 3 <i>and</i> high blood pressure, heart disease, diabetes and arthritis.

A variable for pain, based on sub-sample data (see *Data sources*), was also included in a separate model relating dependency to BMI level (see Table 3).

*Longitudinal analysis:* National Population Health Survey (NPHS) respondents were included in the analysis if they were at least 45 years old at the time of any of the cycle 1 to 4 survey interviews; provided data on their weight and height and their ability to perform personal and instrumental activities of daily living (ADL/IADL) in at least one survey interview, and data on ADL/IADL in the subsequent interview; and indicated at the time of the first of these interviews that they did not need the help of another person with these activities.

The longitudinal analysis was conducted using pooling of repeated observations, combined with logistic regression. Data on dependency were considered in two-cycle intervals (roughly corresponding to two-year periods, based on interview dates): 1994/95 to 1996/97 (cycle 1 to 2); 1996/97 to 1998/99 (cycle 2 to 3), 1998/99 to 2000/01

(cycle 3 to 4) and 2000/01 to 2002/03 (cycle 4 to 5). The first cycle in each two-cycle interval served as the baseline for the study of incident dependency; each eligible respondent was thus considered as many as four times. Respondents who were not dependent in the first cycle of the interval were re-assessed in the next cycle. For example, respondents who reported no need for assistance in cycle 1, but who were institutionalized or reported the need for assistance in cycle 2, were categorized as having become dependent. Similarly, respondents who had been categorized as not dependent in cycle 2 were included for assessment of dependency status in cycle 3. Respondents categorized as dependent in cycle 2, and then not dependent in cycle 3, were assessed again at cycle 4; respondents who were not dependent in cycle 4 were assessed at cycle 5. Thus an individual respondent could potentially contribute two counts of incident dependency—one in cycle 2 or 3, and one in cycle 4 or 5.

Multiple logistic regression analysis was used on the pooled set of observations to model the odds of a new (within a two-year interval) need for assistance or institutionalization in a long-term care facility, relative to BMI category at baseline, while controlling for the effects of other influences on this relationship. Variables to control for potential confounding included age, main source of income, level of education, living arrangements (alone or with others), chronic disease (cancer, respiratory disease), smoking and level of leisure-time physical activity.

The literature on the effects of obesity advises caution in controlling for risk factors or health problems that arise from obesity. Inclusion in multivariate models of conditions that may be intermediaries in the causal pathway from obesity to ADL/IADL dependency may mask the full effects of obesity.<sup>14,15</sup> Therefore, chronic conditions that were strongly positively related to BMI in preliminary analysis (high blood pressure, diabetes, arthritis), or otherwise known to be related to obesity (heart disease), were added to the multivariate models only as a final step.

All independent variables were based on data from cycles 1 through 4. For the models, the value of each independent variable was that reported in the first of two consecutive interviews, and the value of the dependent variable (incident dependency) was that reported in the second of these interviews.

Weighted data were used for all analyses. Coefficients of variation on estimates of proportion and differences between proportions and odds ratios were calculated using the bootstrap technique, which accounts for survey design effects.<sup>11-13</sup>

## Data sources

*Canadian Community Health Survey (CCHS):* Cross-sectional analysis of data was based on cycle 2.1 of the CCHS, which was conducted between January and December 2003. The CCHS is a general health survey that collects cross-sectional information about the health of Canadians every two years. It covers the non-institutionalized household population aged 12 or older in all provinces and territories, except regular members of the Canadian Armed Forces and residents of Indian reserves, Canadian Forces bases, and some remote areas. The overall response rate was 80.6%; the total sample size was 135,573, of whom 69,492 were 45 or older. The cross-sectional analyses (except those involving pain) were based on data from respondents in this sample. Because of non-response to individual questionnaire items, the actual number of respondents used in each tabulation or model varied. For example, data for the following number of respondents were missing: 165 for dependency; 1,859 for body mass index (BMI); and 5,705 for main source of income.

Questions on pain are part of the Health Utility Index (HUI). In 2003, the HUI was designated a "sub-sample" module; at the national level it was administered to a randomly selected subset of respondents. The health regions in Newfoundland and Labrador, Prince Edward Island, Nova Scotia, New Brunswick and Québec opted to have this module administered to all respondents in their provinces. Of these respondents and the subset in the remaining provinces and territories, 35,466 were 45 or older. In this sub-sample, data were missing on dependency (58), BMI (871) and main source of income (5,243).

A description of the CCHS methodology is available in a published report.<sup>16</sup>

*National Population Health Survey (NPHS):* Longitudinal analysis was based on data from the first five NPHS cycles, 1994/95 through 2002/03. Since 1994/95, the NPHS has collected information about the health of the Canadian population every two years. It covers household and institutional residents in all provinces and territories, except persons on Indian reserves, on Canadian Forces bases and in some remote areas.

In 1994/95, 20,095 individuals were selected for the longitudinal panel. Of these, 17,276 agreed to participate, for a response rate of 86.0%. The response rates for subsequent cycles, based on these 17,276 respondents, were: 92.8% in cycle 2 (1996/97); 88.2% in cycle 3 (1998/99); 84.8% in cycle 4 (2000/01); and 80.6% in cycle 5 (2002/03).

More detailed descriptions of the NPHS design, sample and interview procedures can be found in published reports.<sup>17,18</sup>

The 2002/03 NPHS cycle 5 longitudinal "square" master file was used for this analysis. This file contains records for all longitudinal respondents in the household component ( $n = 17,276$ ) whether or not they provided information for all five cycles (that is, individuals selected for the longitudinal sample for whom information is available for cycle 1). The longitudinal analysis in this study was based on data for respondents meeting the following criteria: aged 45 or older in cycle 1, 2, 3, or 4; not dependent (see *Definitions*) in at least one of these cycles and provided data on height and weight in that same cycle; and provided data on their dependency status in the following cycle.

Full descriptions of the CCHS and the National Population Health Survey are available on the Statistics Canada Web site @ <http://www.statcan.ca/english/sdds/0031t.htm>.

The relationship between level of BMI and co-existing dependency was studied using cross-sectional data from the 2003 Canadian Community Health Survey (CCHS). Then, the association between BMI and subsequent dependency was assessed with longitudinal data from the 1994/95 through 2002/03 National Population Health Survey (NPHS). For both analyses, several potentially confounding characteristics were taken

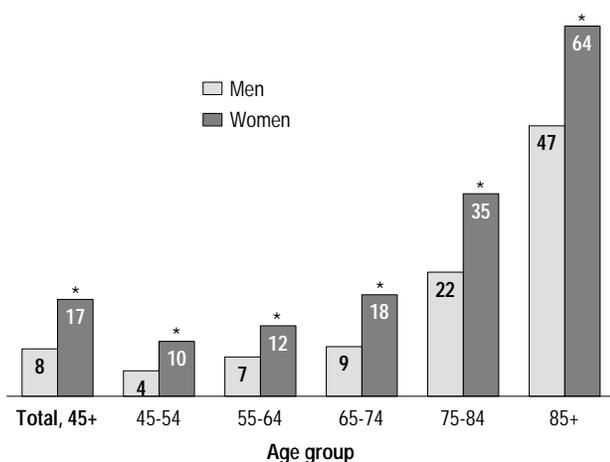
into account, including age, socio-economic status, living arrangements, health and behavioural risk factors, chronic diseases weakly or not related to obesity, chronic conditions strongly related to obesity, and chronic pain (see *Definitions*).

### Women at higher risk

For this analysis, CCHS respondents were considered to be dependent if they needed help with

personal care activities such as washing and dressing and/or with other daily activities including housework or meal preparation (see *Definitions*). In 2003, women aged 45 or older were twice as likely (16.8%) as their male counterparts (8.2%) to report dependency (Chart 1, Table 1). Women's need for help was especially pronounced for tasks involving transportation or physical effort, notably running errands or getting to appointments and doing everyday housework. Further analysis was undertaken to investigate the extent to which these differences may have resulted from gender roles or the older age distribution of women. Yet even at younger ages, women were more likely than men to report the need for help with meal preparation—traditionally a more “female” task (data not shown). The gap in dependency between the sexes persisted even when controlling for the effects of age, socio-economic status, BMI, health and lifestyle risk factors, and chronic disease. In fact, the odds of dependency for women were twice the corresponding odds for men (data not shown).

Chart 1  
Percentage of people who were dependent, by age group and sex, household population aged 45 or older, Canada, 2003



**Data source:** 2003 Canadian Community Health Survey  
**Note:** Compared with estimates for 45-to-54 age group, all other age group estimates are statistically different within each sex ( $p < 0.05$ ).  
\*Significantly higher than estimate for men ( $p < 0.05$ )

Table 1  
Percentage of people who were dependent, by task and sex, household population aged 45 or older, Canada, 2003

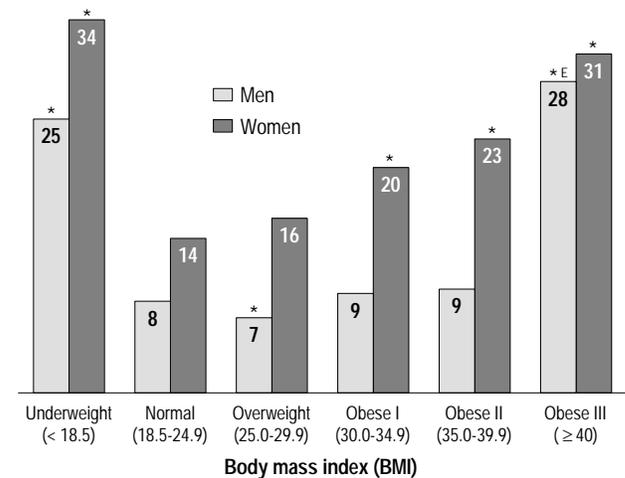
	Men	Women
	%	
<b>Total (any task)</b>	<b>8.2</b>	<b>16.8*</b>
Everyday housework	5.9	12.3*
Getting to appointments/ Running errands	5.6	12.1*
Preparing meals	3.6	5.2*
Personal care (e.g., washing, dressing, eating)	2.6	3.3*
Moving about in house	1.8	2.3*

**Data source:** 2003 Canadian Community Health Survey  
\*Significantly higher than estimate for men ( $p < 0.05$ )

## Underweight, obesity linked to dependence

Adults at both BMI extremes—underweight and obese class III—were significantly more likely than those in the “normal” category to be dependent (Chart 2). This “J-” or “U-shaped” relationship has been noted in other reports.<sup>19-22</sup> One-quarter of

Chart 2  
Percentage of people who were dependent, by body mass index and sex, household population aged 45 or older, Canada, 2003



**Data source:** 2003 Canadian Community Health Survey  
\*Significantly different from estimate for same sex in “normal” BMI category ( $p < 0.05$ )  
E Coefficient of variation 16.6% to 33.3% (interpret with caution)

underweight men (24.8%) and one-third of underweight women (33.8%) aged 45 or older were dependent. People with a BMI of 40 or more were categorized as obese class III; similar proportions of men (28.2%) and women (30.7%) in this group were dependent. For women, the relationship between obesity and dependency increased steadily with the level of obesity. The obesity–dependency relationship was weaker for men; only those in the class III category were more likely to be dependent than were men in the normal BMI range.

### Relationships persist

The relationships between BMI level and dependency persisted when the potential influences of age, socio-economic status and health-related behaviours were taken into account simultaneously (Appendix Tables A and B, Models 1 and 2). At the low end of the BMI range, the odds of dependency for underweight men and women were about twice those for each sex in the normal BMI category. Other research has attributed such a relationship to the likelihood of underlying illness in underweight individuals.<sup>1</sup> Although this study of CCHS data took numerous chronic conditions into account, the possibility of underweight indicating frailty or compromised health remains.

As expected, controlling for the effects of cancer and respiratory disease (conditions not necessarily related to BMI) had little effect on the strength of the association between BMI and dependency (Appendix Tables A and B, Model 3).

The literature on the effects of obesity advises caution in controlling for risk factors or health problems that arise from obesity. Including conditions that may be intermediaries in the causal pathway from obesity to ADL/IADL dependency in multivariate models may mask the full effects of obesity.<sup>14,15</sup> Therefore, chronic conditions that were strongly positively related to BMI in preliminary analysis, or that are otherwise known to be related to obesity, were added to the multivariate models only as a final step. When the potential effects of several obesity-related conditions—high blood pressure, heart disease, diabetes and arthritis—were also taken into account, the associations between

BMI and dependency were somewhat weakened (Appendix Tables A and B, Model 4; Table 2). In fact, only at the extremes of the BMI categories, underweight and obese class III, did the odds of dependency among men remain significantly elevated.

For women, the relationships between BMI and dependency were similar to those for men, but with

Table 2  
Adjusted odds ratios relating BMI category and other selected characteristics to dependency, by sex, household population aged 45 or older, Canada, 2003

	Men		Women	
	Adjusted odds ratio	95% confidence interval	Adjusted odds ratio	95% confidence interval
<b>Age (continuous)</b>	1.0*	1.0, 1.0	1.0*	1.0, 1.1
<b>Socio-economic factors</b>				
Less than secondary graduation	1.2	1.0, 1.3	1.0	0.9, 1.1
Secondary graduation or more <sup>†</sup>	1.0	...	1.0	...
Main source of income is				
social assistance <sup>‡</sup>	1.9*	1.6, 2.3	1.3*	1.1, 1.4
Lives alone <sup>‡</sup>	1.5*	1.3, 1.7	0.9	0.9, 1.0
<b>Body mass index (BMI)</b>				
Underweight (< 18.5)	2.0*	1.3, 3.2	1.9*	1.4, 2.6
Normal (18.5-24.9) <sup>†</sup>	1.0	...	1.0	...
Overweight (25.0-29.9)	0.9	0.7, 1.0	1.0	0.9, 1.1
Obese class I (30.0-34.9)	1.1	0.9, 1.4	1.2*	1.0, 1.4
Obese class II (35.9-39.9)	1.0	0.7, 1.4	1.6*	1.2, 2.0
Obese class III (≥ 40)	3.6*	2.0, 6.6	2.3*	1.6, 3.2
<b>Smoking status</b>				
Smoker	1.4*	1.1, 1.6	1.3*	1.2, 1.6
Non-smoker <sup>†</sup>	1.0	...	1.0	...
<b>Leisure-time physical activity</b>				
Inactive	2.6*	2.1, 3.3	2.4*	2.1, 2.9
Moderate	1.2	0.9, 1.6	1.1	0.9, 1.3
Active <sup>†</sup>	1.0	...	1.0	...
<b>Chronic conditions</b>				
Respiratory disease <sup>‡</sup>	2.2*	1.8, 2.6	2.1*	1.8, 2.5
Cancer <sup>‡</sup>	2.1*	1.7, 2.7	2.2*	1.7, 2.9
<b>Obesity-related chronic conditions</b>				
High blood pressure <sup>‡</sup>	1.2*	1.0, 1.4	1.1	1.0, 1.2
Heart disease <sup>‡</sup>	1.9*	1.6, 2.2	2.1*	1.8, 2.4
Diabetes <sup>‡</sup>	1.6*	1.3, 2.0	1.7*	1.4, 2.0
Arthritis <sup>‡</sup>	2.3*	2.0, 2.7	2.4*	2.1, 2.6

**Data source:** 2003 Canadian Community Health Survey  
**Notes:** Models are based on weighted data from records for 28,880 men and 37,783 women who provided information on mobility function. Variables for "missing" BMI and source of income were included in the models to maximize sample size, but the odds ratios are not shown. Because of rounding, some odds ratios with 1.0 as the lower confidence interval are statistically significant.  
<sup>†</sup> Reference category  
<sup>‡</sup> Reference category is absence of condition; for example, reference category for cancer is no reported diagnosis of cancer.  
 \* Significantly different from estimate for reference category ( $p < 0.05$ )  
 ... Not applicable

## Definitions

Data from the 2003 Canadian Community Health Survey (CCHS) were used to calculate prevalence estimates of *dependency*. Respondents were categorized as *dependent* if they answered "yes" to at least one of the following questions: "Because of any physical condition or mental condition or health problem, do you need the help of another person with:

- preparing meals?"
- getting to appointments and running errands such as shopping for groceries?"
- doing everyday housework?"
- personal care such as washing, dressing, eating or taking medication?"
- moving about inside the house?"

Respondents who answered "no" to all these questions were not considered to be dependent. Those with records that showed data missing for all questions, or with "no" responses to some questions and missing responses to any other(s), were excluded from this analysis.

Data from the 1994/95 through 2002/03 National Population Health Survey (cycles 1 through 5, NPHS) were used to examine incident dependency in relation to BMI category. For the longitudinal analysis, dependency was defined as a "yes" response to any of the preceding questions (with minor differences in wording, the same questions were used by both the CCHS and the NPHS), or a respondent's move from the household population into a long-term care facility.

*Body mass index* (BMI) is a measure of weight adjusted for height, calculated by dividing weight in kilograms by height in metres squared. BMI categories were defined using the standards adopted by Health Canada:

- underweight: < 18.5
- normal: 18.5 to 24.9
- overweight: 25.0 to 29.9
- obese class I: 30.0 to 34.9
- obese class II: 35.0 to 39.9
- obese class III:  $\geq 40.0$ .<sup>23</sup>

Height and weight were self-reported by CCHS and NPHS respondents.

The presence of a *chronic condition* was established by asking respondents if a doctor had told them that they had a chronic disease

that had lasted, or was expected to last, at least six months. Respondents were read a list of conditions; cancer, respiratory disease, high blood pressure, heart disease, arthritis and diabetes were selected for this analysis.

In middle-aged and older people, many of whom are retired and own their homes, level of income may not be a reliable indicator of socio-economic status. In an effort to identify people of limited means, respondents were asked about their *main source of income*. Response categories were: wages and salaries; income from self-employment; dividends and interest (for example, on bonds or savings); Employment Insurance; Workers' Compensation; Canada or Québec Pension Plan benefits; retirement pension, superannuation and annuities; Old Age Security and Guaranteed Income Supplement; Child Tax Benefit; provincial or municipal social assistance or welfare; child support; alimony; and other (rental income or scholarships, for example). Respondents who identified Canada or Québec Pension Plan benefits, Old Age Security and Guaranteed Income Supplement, or provincial/municipal social assistance or welfare were categorized as receiving *social assistance* as their main income source.

Two *smoking status* categories were defined: smokers and non-smokers. Smokers are those smoking either daily or occasionally and, in this case, "occasionally" includes only current occasional smokers who used to smoke every day. Non-smokers comprises people who had never smoked, plus occasional smokers who had never smoked every day, as well as former smokers (daily or occasional smokers who had quit smoking altogether).

Level of *leisure-time physical activity* was based on calculations that took into account the reported frequency and duration of a respondent's leisure-time physical activities in the three months before the survey, and the estimated metabolic energy demand of each activity.<sup>24,25</sup> Leisure was classified as active (3.0 or more kilocalories per kilogram per day), moderately active (1.5 to 2.9 kcal/kg/day), or inactive (below 1.5 kcal/kg/day).

*Living arrangements* were defined dichotomously as living alone or with others.

The presence of *pain* was established based on a "no" response to the question, "Are you usually free of pain or discomfort?"

an important exception. Although including obesity-related chronic diseases weakened the odds ratios slightly, BMI remained significantly related to dependency for women in all three categories of

obesity (Appendix Table B, Model 4; Table 2). Thus any degree of obesity appears to make its own contribution to dependency for women, aside from the influences of obesity-related conditions.

## Effects of pain compounded by obesity

Previous research has indicated that the likelihood of pain increases with BMI,<sup>26</sup> and that pain is strongly related to physical function.<sup>5,27</sup> For men, when pain was accounted for (see *Methods*) together with age, source of income and educational attainment, living arrangements, health-related behaviours and chronic conditions unrelated to obesity, the odds that those in obese classes II and III would be dependent were still significantly elevated (Table 3). In fact, the odds that men in

Table 3  
Adjusted odds ratios relating BMI category and selected characteristics to dependency, controlling for pain, by sex, household population aged 45 or older, Canada, 2003

	Men		Women	
	Adjusted odds ratio	95% confidence interval	Adjusted odds ratio	95% confidence interval
Age (continuous)	1.1*	1.1, 1.1	1.1*	1.1, 1.1
<b>Socio-economic factors</b>				
Less than secondary graduation	0.7*	0.5, 0.9	0.6*	0.5, 0.7
Secondary graduation or more†	1.0	...	1.0	...
Main source of income is social assistance‡	1.4*	1.0, 1.8	1.2	1.0, 1.4
Lives alone‡	1.2	0.9, 1.6	0.7*	0.6, 0.8
<b>Body mass index (BMI)</b>				
Underweight (< 18.5)	1.3	0.6, 3.2	1.5	1.0, 2.4
Normal (18.5-24.9)†	1.0	...	1.0	...
Overweight (25.0-29.9)	1.3	1.0, 1.7	1.0	0.8, 1.3
Obese class I (30.0-34.9)	1.2	0.8, 1.7	1.4*	1.1, 1.7
Obese class II (35.9-39.9)	2.2*	1.1, 4.6	2.2*	1.5, 3.1
Obese class III (≥ 40)	6.2*	2.8, 13.5	4.2*	2.5, 7.2
<b>Smoking status</b>				
Smoker	1.3	1.0, 1.7	1.2	1.0, 1.5
Non-smoker†	1.0	...	1.0	...
<b>Leisure-time physical activity</b>				
Inactive	3.9*	2.6, 5.9	3.5*	2.6, 4.7
Moderate	1.9*	1.2, 3.0	1.5*	1.0, 2.1
Active†	1.0	...	1.0	...
<b>Chronic conditions</b>				
Respiratory disease‡	3.1*	2.2, 4.4	2.0*	1.5, 2.6
Cancer‡	2.4*	1.4, 4.1	2.0*	1.3, 3.0
Pain‡	4.1*	3.1, 5.4	3.4*	2.9, 4.1

**Data source:** 2003 Canadian Community Health Survey

**Notes:** Based on records for 14,882 men and 19,502 women. Variables for "missing" BMI, leisure-time activity level and main source of income were included in the models to maximize sample size, but the odds ratios are not shown. Because of rounding, some odds ratios with 1.0 as the lower confidence interval are statistically significant.

† Reference category

‡ Reference category

‡ Reference category is absence of condition; for example, reference category for pain is no reported chronic pain.

\* Significantly different from estimate for reference category ( $p < 0.05$ )

... Not applicable

obese class III would be dependent were over 6 times higher than the odds for men in the normal BMI range when pain was taken into account.

The odds ratio for pain was also high, and strongly significant. Notably, with pain in the model, the relationship between underweight and dependency was no longer statistically significant. When an interaction term for obesity (classes I to III combined) and pain was included in the model, its odds ratio was also significantly elevated (2.3; 95% confidence interval = 1.1 - 4.7), indicating that for men with chronic pain, obesity compounds the probability of dependency (data not shown).

The results for women were similar (Table 3). For women, however, obesity at all three levels remained significantly related to dependency when pain was taken into account. The interaction term for obesity and pain was not significant for women (data not shown).

## Obesity predictive of dependency

Findings from respondents followed over time differed somewhat from those based on the 2003 data (partly because of a smaller sample size resulting in less statistical power). According to longitudinal data from the NPHS, before controlling for obesity-related chronic conditions, only men in obese class I at the outset of a two-year period had significantly elevated odds of dependency by the end (Table 4). Because of the small sample size in the category, the odds ratio for men in obese class III fell just short of significance ( $p = 0.051$ ). When controlling for well-known obesity-related conditions (heart disease, high blood pressure, diabetes, arthritis) and pain, underweight was the only BMI category to remain predictive of dependency among men.

The relationship between obesity and subsequent dependency was more pronounced for women (Table 5). Before the obesity-related conditions were taken into account, underweight women, as well as those in obese classes II and III, had significantly higher odds of becoming dependent over the next two years, compared with women in the normal BMI range. But when the obesity-related chronic

## Limitations

The analyses are based on self-reported data. Because overweight and obese people tend to underreport their weight,<sup>28</sup> the results may have been somewhat distorted by non-random misclassification. Such bias would weaken the observed strength of the association between body mass index (BMI) category and dependency.

BMI is based on height and weight, and does not take factors such as percentage of body fat or waist circumference into account. As well, the same BMI cutpoints are applied to both sexes, even though body fat mass is higher in women than men for the same BMI category.<sup>29</sup> Previous studies in which BMI categories were defined according to the distribution in a specific population cannot be generalized to represent other populations.<sup>2,3,6</sup> This point is especially relevant in view of the rapid increase of obesity among Canadian adults.<sup>30</sup>

No information is available on weight loss due to illness. Also, although it is reasonable to assume that underweight is an indicator of frailty and compromised health, this analysis may not have adequately controlled for these factors.

The potential for selection bias due to respondent attrition is problematic in longitudinal research. Selective loss to follow-up, or failure to collect information from respondents who were in poorer health or whose health deteriorated rapidly between survey cycles, may have weakened the observed relationship between obesity and the onset of physical dysfunction. The analysis was based on respondents aged 45 or older for whom requisite data were available over the first five NPHS cycles. From one survey cycle to the next, respondents were lost from the analysis for reasons such as refusal to participate, death, item non-response, or relocation out of the country. From the pooled total of 21,390 respondents assessed in the "baseline" cycles, 1,417 (6.6%) did not respond in the follow-up cycle.

### Respondents and non-respondents (unweighted sample), household population aged 45 or older, by two-cycle interval, National Population Health Survey, 1994/95 to 2002/03

	Number of respondents at baseline	Number of respondents at follow-up	Number (percentage) of respondents who became non-respondents at baseline next cycle
1994/95 to 1996/97 (Cycle 1 to 2)	5,547	5,247	300 (5.4%)
1996/97 to 1998/99 (Cycle 2 to 3)	5,388	5,097	291 (5.4%)
1998/99 to 2000/01 (Cycle 3 to 4)	5,241	4,875	366 (7.0%)
2000/01 to 2002/03 (Cycle 4 to 5)	5,214	4,754	460 (8.8%)
<b>Total</b>	<b>21,390</b>	<b>19,973</b>	<b>1,417 (6.6%)</b>

Loss to follow-up from the longitudinal panel was minimized in two ways. Instead of being excluded from the analysis, people who entered long-term care facilities were categorized as having become ADL-/IADL-dependent. Also, data from respondents were considered in two-year intervals. Therefore, those who were interviewed in at least two

successive survey cycles were included in the analysis, even though they may have been subsequently lost to follow-up. This approach also allowed those who became eligible for analysis (for example, reached age 45) sometime after the first interview cycle to be included.

To assess the effects of non-response on the results, the weighted proportions of non-respondents were compared for a few selected variables (age group, sex, BMI). No significant differences in the proportions of non-respondents emerged by sex or the six BMI categories. By age group, the proportion of non-respondents was slightly higher among those aged 45 to 64 (7.8%) than among seniors (6.3%).

### Non-respondents (weighted data), by selected variables, household component, National Population Health Survey, 1994/95 to 2002/03

	Non-respondents %
<b>Age group</b>	
45 to 64	7.8*
65 or older	6.3
<b>Sex</b>	
Men	7.4
Women	7.2
<b>Body mass index (BMI)</b>	
Underweight (< 18.5)	7.2
Normal (18.5 to 24.9)	7.7
Overweight (25.0 to 29.9)	6.9
Obese class I (30.0 to 34.9)	6.3
Obese class II (35.0 to 39.9)	5.6
Obese class III (≥ 40)	5.8

\* Significantly higher than proportion of non-respondents for 65-or-older age group ( $p < 0.05$ )

The survey weights were those applied to the cycle 1 (1994/95) data according to the response status at that time; the weights were not inflated to account for subsequent non-response. This could have biased the estimates if continuers in the longitudinal panel differed from non-respondents according to characteristics considered in the analysis.

No inference of causality or temporal ordering is possible from analyses based on the CCHS, because the data are cross-sectional. Although the NPHS longitudinal data were used to establish the chronological sequence between independent and dependent variables, causality (of dependency by obesity) cannot be inferred. The associations observed may result from factors not considered in this analysis.

The dependent variable, that is, the need for help from another person with selected instrumental and personal activities of daily living, was based on self-report and was not validated against objective criteria or by direct observation. Variation in unmeasured subjective factors, such as readiness to admit a need for assistance, likely explains some of the observed differences in responses.

Assessment of chronic diseases was made by asking respondents about conditions that had been diagnosed by a health practitioner and that had lasted, or were expected to last, six months or more. No clinical validation of these self-reported conditions was carried out.

Table 4  
Adjusted odds ratios relating BMI category and selected characteristics to subsequent dependency, male household population aged 45 or older, Canada, 2003

	Model 1		Model 2	
	Adjusted odds ratio	95% confidence interval	Adjusted odds ratio	95% confidence interval
Age (continuous)	1.1*	1.1, 1.1	1.1*	1.1, 1.1
<b>Socio-economic factors</b>				
Less than secondary graduation	1.1	0.9, 1.4	1.1	0.9, 1.5
Secondary graduation or more†	1.0	...	1.0	...
Main source of income is social assistance‡	1.5*	1.2, 1.9	1.4*	1.1, 1.7
Lives alone‡	1.1	0.8, 1.4	1.1	0.9, 1.5
<b>Body mass index (BMI)</b>				
Underweight (< 18.5)	2.5	1.0, 6.5	2.5*	1.0, 6.1
Normal (18.5-24.9)†	1.0	...	1.0	...
Overweight (25.0-29.9)	1.0	0.7, 1.3	0.9	0.7, 1.2
Obese class I (30.0-34.9)	1.5*	1.0, 2.1	1.2	0.8, 1.7
Obese class II (35.9-39.9)	0.8	0.3, 2.3	0.6	0.2, 1.7
Obese class III (≥ 40)	2.9	1.0, 8.2	1.9	0.6, 5.8
<b>Smoking status</b>				
Smoker	1.4*	1.0, 2.0	1.4*	1.0, 2.0
Non-smoker†	1.0	...	1.0	...
<b>Leisure-time physical activity level</b>				
Inactive	1.3	1.0, 1.6	1.3*	1.0, 1.6
Moderate/Active†	1.0	...	1.0	...
<b>Chronic conditions</b>				
Respiratory disease‡	3.2*	2.1, 4.9	2.6*	1.7, 4.1
Cancer‡	0.9	0.5, 1.6	0.7	0.3, 1.4
<b>Obesity-related chronic conditions</b>				
High blood pressure‡			1.4*	1.0, 1.8
Heart disease‡			1.7*	1.2, 2.4
Diabetes‡			1.9*	1.4, 2.7
Arthritis‡			1.1	0.8, 1.4
Pain‡			2.5*	1.8, 3.3

**Data source:** 1994/95 to 2002/03 National Population Health Survey  
**Notes:** Models 1 and 2 are based on 8,993 and 8,966 records, respectively. Because of rounding, some odds ratios with 1.0 as the lower confidence interval are statistically significant.  
 † Reference category  
 ‡ Reference category is absence of condition; for example, reference category for cancer is no reported diagnosis of cancer.  
 \* Significantly different from estimate for reference category ( $p < 0.05$ )  
 ... Not applicable

conditions and pain were introduced in the model, the odds ratios remained significantly elevated only for underweight and obese class III women.

The longitudinal relationship between BMI and dependency and a stronger effect of BMI in predicting disability in women than men are consistent with other research.<sup>3,5,7-10,31</sup> Among men,

Table 5  
Adjusted odds ratios relating BMI category and selected characteristics to subsequent dependency, female household population aged 45 or older, Canada, 2003

	Model 1		Model 2	
	Adjusted odds ratio	95% confidence interval	Adjusted odds ratio	95% confidence interval
Age (continuous)	1.1*	1.1, 1.1	1.1*	1.1, 1.1
<b>Socio-economic factors</b>				
Less than secondary graduation	1.1	0.9, 1.4	1.1	0.9, 1.3
Secondary graduation or more†	1.0	...	1.0	...
Main source of income is social assistance‡	1.2	1.0, 1.5	1.0	0.8, 1.3
Lives alone‡	0.9	0.8, 1.1	0.9	0.8, 1.1
<b>Body mass index (BMI)</b>				
Underweight (< 18.5)	1.9*	1.3, 2.9	2.2*	1.4, 3.3
Normal (18.5-24.9)†	1.0	...	1.0	...
Overweight (25.0-29.9)	1.2	1.0, 1.5	1.0	0.8, 1.3
Obese class I (30.0-34.9)	1.2	0.9, 1.6	1.0	0.7, 1.3
Obese class II (35.9-39.9)	2.0*	1.3, 3.0	1.5	1.0, 2.2
Obese class III (≥ 40)	3.0*	1.4, 6.5	2.6*	1.2, 5.5
<b>Smoking status</b>				
Smoker	1.6*	1.2, 2.0	1.6*	1.3, 2.0
Non-smoker†	1.0	...	1.0	...
<b>Leisure-time physical activity level</b>				
Inactive	1.6*	1.3, 1.9	1.4*	1.2, 1.7
Moderate/Active†	1.0	...	1.0	...
<b>Chronic conditions</b>				
Respiratory disease‡	1.7*	1.1, 2.5	1.3	0.9, 1.9
Cancer‡	1.4	0.8, 2.2	1.3	0.8, 2.1
<b>Obesity-related chronic conditions</b>				
High blood pressure‡			1.0	0.8, 1.2
Heart disease‡			1.7*	1.3, 2.3
Diabetes‡			2.3*	1.6, 3.2
Arthritis‡			1.4*	1.2, 1.7
Pain‡			2.5*	2.0, 3.1

**Data source:** 1994/95 to 2002/03 National Population Health Survey  
**Notes:** Models 1 and 2 are based on 10,882 and 10,857 records, respectively.  
 † Reference category  
 ‡ Reference category is absence of condition; for example, reference category for cancer is no reported diagnosis of cancer.  
 \* Significantly different from estimate for reference category ( $p < 0.05$ )  
 ... Not applicable

obesity-related diseases appear to be associated more directly with dependency than is obesity. By contrast, the relationship between obesity and dependency persisted for women even when the effects of obesity-related diseases and pain were taken into account.

## Concluding remarks

The findings of this study indicate that obesity is associated with co-existing dependency in middle-aged and older Canadians. This relationship persisted even when controlling for potentially confounding factors such as socio-economic status, living arrangements and level of physical activity, as well as chronic disease and pain. The results suggest that, in addition to its associations with pain and disease, obesity independently contributes to dependency.

Also important is the association between underweight and dependency. Both men and women who were categorized as underweight had strikingly higher odds of dependency when compared with their counterparts in the normal BMI range.

Longitudinal data from the National Population Health Survey were used to establish the order of events between obesity and dependency. Obesity was found to be predictive of future dependency in men and women aged 45 or older.

In Canada today, one of the most troubling public health dilemmas is the rising prevalence of overweight and obesity, now affecting the majority of middle-aged and older adults.<sup>30</sup> Despite cultural norms that stigmatize excess weight, along with ample evidence of its adverse health effects, the proportion of Canadian adults who are obese has risen considerably over the past few decades.<sup>30</sup>

Loss of independence is a dire consequence of obesity. Caring for people who need assistance with basic activities of daily living usually falls first to family members or friends. When these sources of help are unavailable, formal home care services may be sought. Dependency is also strongly predictive of eventual institutionalization.<sup>7</sup> In view of recent rapid increases in the proportion of people who are obese, coupled with the aging of the population, the burden on informal caretakers and the health care system can be expected to increase in the near future. ●

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## Appendix

Table A

Adjusted odds ratios relating BMI level and selected characteristics to dependency, male household population aged 45 or older, Canada, 2003

	Model 1		Model 2		Model 3		Model 4	
	Adjusted odds ratio	95% confidence interval						
Age (continuous)	1.1*	1.0, 1.1	1.1*	1.0, 1.1	1.0*	1.0, 1.1	1.0*	1.0, 1.0
<b>Socio-economic factors</b>								
Less than secondary graduation	1.5*	1.3, 1.7	1.2*	1.0, 1.4	1.2*	1.0, 1.4	1.2	1.0, 1.3
Secondary graduation or more <sup>†</sup>	1.0	...	1.0	...	1.0	...	1.0	...
Main source of income is social assistance <sup>‡</sup>	2.1*	1.8, 2.4	2.2*	1.9, 2.6	2.1*	1.8, 2.5	1.9*	1.6, 2.3
Lives alone <sup>‡</sup>	1.2*	1.1, 1.4	1.4*	1.2, 1.6	1.4*	1.3, 1.7	1.5*	1.3, 1.7
<b>Body mass index (BMI)</b>								
Underweight (< 18.5)			2.2*	1.4, 3.4	2.0*	1.2, 3.1	2.0*	1.3, 3.2
Normal (18.5-24.9) <sup>†</sup>			1.0	...	1.0	...	1.0	...
Overweight (25.0-29.9)			1.0	0.8, 1.2	1.0	0.9, 1.2	0.9	0.7, 1.0
Obese class I (30.0-34.9)			1.4*	1.1, 1.8	1.4*	1.1, 1.8	1.1	0.9, 1.4
Obese class II (35.9-39.9)			1.6*	1.1, 2.2	1.5*	1.1, 2.1	1.0	0.7, 1.4
Obese class III (≥ 40)			6.3*	3.0, 13.0	6.3*	3.0, 13.1	3.6*	2.0, 6.6
<b>Smoking status</b>								
Smoker			1.4*	1.2, 1.7	1.4*	1.1, 1.6	1.4*	1.1, 1.6
Non-smoker <sup>†</sup>			1.0	...	1.0	...	1.0	...
<b>Leisure-time physical activity</b>								
Inactive			2.8*	2.2, 3.5	2.7*	2.2, 3.4	2.6*	2.1, 3.3
Moderate			1.2	0.9, 1.6	1.2	0.9, 1.6	1.2	0.9, 1.6
Active <sup>†</sup>			1.0	...	1.0	...	1.0	...
<b>Chronic conditions</b>								
Respiratory disease <sup>‡</sup>					2.5*	2.1, 3.0	2.2*	1.8, 2.6
Cancer <sup>‡</sup>					2.4*	1.9, 3.0	2.1*	1.7, 2.7
<b>Obesity-related chronic conditions</b>								
High blood pressure <sup>‡</sup>							1.2*	1.0, 1.4
Heart disease <sup>‡</sup>							1.9*	1.6, 2.2
Diabetes <sup>‡</sup>							1.6*	1.3, 2.0
Arthritis <sup>‡</sup>							2.3*	2.0, 2.7

**Data source:** 2003 Canadian Community Health Survey

**Notes:** Based on weighted data from records of 29,313 (Model 1), 29,112 (Model 2), 29,059 (Model 3), and 28,880 (Model 4) male respondents who provided information on mobility function. Variables for "missing" BMI and main source of income were included in the models to maximize sample size, but the odds ratios are not shown. Because of rounding, some odds ratios with 1.0 as the lower confidence interval are statistically significant.

<sup>†</sup> Reference category

<sup>‡</sup> Reference category

<sup>‡</sup> Reference category is absence of condition; for example, reference category for cancer is no reported diagnosis of cancer.

\* Significantly different from estimate for reference category ( $p < 0.05$ )

... Not applicable

Table B  
Adjusted odds ratios relating BMI level and selected characteristics to dependency, female household population aged 45 or older, Canada, 2003

	Model 1		Model 2		Model 3		Model 4	
	Adjusted odds ratio	95% confidence interval						
<b>Age (continuous)</b>	1.1*	1.1, 1.1	1.1*	1.1, 1.1	1.1*	1.1, 1.1	1.0*	1.0, 1.1
<b>Socio-economic factors</b>								
Less than secondary graduation	1.3*	1.2, 1.4	1.1	1.0, 1.2	1.1	0.9, 1.2	1.0	0.9, 1.1
Secondary graduation or more†	1.0	...	1.0	...	1.0	...	1.0	...
Main source of income is social assistance‡	1.3*	1.2, 1.5	1.4*	1.3, 1.6	1.4*	1.2, 1.6	1.3*	1.1, 1.4
Lives alone‡	0.9*	0.8, 0.9	1.0	0.9, 1.1	0.9	0.9, 1.0	0.9	0.9, 1.0
<b>Body mass index (BMI)</b>								
Underweight (< 18.5)			2.0*	1.5, 2.6	1.8*	1.3, 2.4	1.9*	1.4, 2.6
Normal (18.5-24.9)†			1.0	...	1.0	...	1.0	...
Overweight (25.0-29.9)			1.1	1.0, 1.2	1.1	1.0, 1.2	1.0	0.9, 1.1
Obese class I (30.0-34.9)			1.6*	1.4, 1.8	1.5*	1.3, 1.8	1.2*	1.0, 1.4
Obese class II (35.9-39.9)			2.2*	1.8, 2.7	2.1*	1.7, 2.5	1.6*	1.2, 2.0
Obese class III (≥ 40)			3.6*	2.6, 4.9	3.4*	2.4, 4.6	2.3*	1.6, 3.2
<b>Smoking status</b>								
Smoker			1.4*	1.2, 1.6	1.3*	1.2, 1.5	1.3*	1.2, 1.6
Non-smoker†			1.0	...	1.0	...	1.0	...
<b>Leisure-time physical activity</b>								
Inactive			2.6*	2.2, 3.1	2.6*	2.2, 3.0	2.4*	2.1, 2.9
Moderate			1.2	1.0, 1.4	1.1	0.9, 1.4	1.1	0.9, 1.3
Active†			1.0	...	1.0	...	1.0	...
<b>Chronic conditions</b>								
Respiratory disease‡					2.6*	2.2, 3.0	2.1*	1.8, 2.5
Cancer‡					2.3*	1.8, 2.9	2.2*	1.7, 2.9
<b>Obesity-related chronic conditions</b>								
High blood pressure‡							1.1	1.0, 1.2
Heart disease‡							2.1*	1.8, 2.4
Diabetes‡							1.7*	1.4, 2.0
Arthritis‡							2.4*	2.1, 2.6

**Data source:** 2003 Canadian Community Health Survey

**Notes:** Based on records of 38,242 (Model 1), 38,035 (Model 2), 37,968 (Model 3), and 37,783 (Model 4) female respondents who provided information on mobility function. Variables for "missing" BMI and main source of income were included in the models to maximize sample size, but the odds ratios are not shown. Because of rounding, some odds ratios with 1.0 as the lower confidence interval are statistically significant.

† Reference category

‡ Reference category

‡ Reference category is absence of condition; for example, reference category for cancer is no reported diagnosis of cancer.

\* Significantly different from estimate for reference category ( $p < 0.05$ )

... Not applicable