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Functional disability and social participation restriction associated with chronic conditions in middle-aged and older adults

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ABSTRACT

Background We examine the population impact on functional disability and social participation of physical and mental chronic conditions individually and in combination.

Methods Cross-sectional, population-based data from community-dwelling people aged 45 years and over living in the 10 Canadian provinces in 2008–2009 were used to estimate the population attributable risk (PAR) for functional disability in basic (ADL) and instrumental (IADL) activities of daily living and social participation restrictions for individual and combinations of chronic conditions, stratified by age and gender, after adjusting for confounding variables.

Results Five chronic conditions (arthritis, depression, diabetes, heart disease and eye disease) made the largest contributions to ADL-related and IADL-related functional disability and social participation restrictions, with variation in magnitude and ranking by age and gender. While arthritis was consistently associated with higher PARs across gender and most age groups, depression, alone and in combination with the physical chronic conditions, was associated with ADL and IADL disability as well as social participation restrictions in the younger age groups, especially among women. Compared to women, the combinations of conditions associated with higher PARs in men more often included heart disease and diabetes.

Conclusions Our findings suggest that in community-dwelling middle-aged and older adults, the impact of combinations of mental and physical chronic conditions on functional disability and social participation restriction is substantial and differed by gender and age. Recognising the differences in the drivers of PAR by gender and age group will ultimately increase the efficiency of clinical and public health interventions.

INTRODUCTION

Many older North Americans live with multiple chronic health conditions. In a study of over 650 000 patients in the USA, over 50% of patients aged 45–64 years, over 75% of patients aged 65–84 years and almost 90% of patients aged 85 years or older have two or more chronic conditions,[1] with similar trends in Canada.[2] Increasing longevity and the demographic shift to a higher proportion of the population over the age of 65 years represents a new challenge for healthcare systems in North America and around the world.[3] Multimorbidity, the coexistence of two or more chronic conditions, where one is not necessarily more central than the others,[4] often has a significant impact on older adults' daily and social activities[5] and has been increasingly recognised as an independent risk factor for decreased quality of life,[6] increased functional disability[7] and premature mortality.[8]

Despite the significant increase in the number of publications addressing the subject, there is still no standard definition for multimorbidity. The European General Practice Research Network (EGPRN) suggested the following definition: "any combination of chronic disease with at least one other disease (acute or chronic) or biopsychosocial factor (associated or not) or somatic risk factor".[9] In this definition, a biopsychosocial factor can be any biological, psychological or social factor that plays a role in the disease process.[10] This definition is in line with much of the clinical thinking that multimorbidity must also take into context patient complexity as chronic disease management is substantially more complex when individuals have multimorbidity.[11] While it is generally agreed that patient-centred healthcare is most likely the most effective and efficient mechanism to optimise their health and well-being,[4] clinicians often struggle with the application of disease-specific guidelines to their older patients with multiple chronic conditions, especially when they have both mental and physical chronic conditions.[12]

Until now, few studies have examined multiple chronic conditions and their impact on disability. In previous work, it was found that among older adults the chronic conditions that drive functional disability differed by gender and age;[7] however, this study did not include mental health conditions. There is currently little research combining both physical and mental chronic conditions, as suggested by the EGPRN. To help consolidate this literature and provide evidence-based data for clinical practitioners, we have examined the population attributable risk (PAR) for functional disability associated with physical and mental chronic conditions, alone and in combination using population-based data from the Canadian Community Health Survey (CCHS) on Healthy Ageing.[13] These comparisons were conducted using the full spectrum of adults' activities, that is, activities of daily living (ADL), instrumental activities of daily living (IADL) and social participation.

METHODS

Study population

The CCHS-Healthy Ageing is a cross-sectional survey providing information about the health, health determinants and healthcare use of

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community-dwelling people aged 45 years and over living in the 10 Canadian provinces.[13] To maximise efficiency, a three-stage design was used to select the sample, with random sampling of geographical regions, then households within region, and finally one respondent within a household. Sample weights were calculated based on the complex sampling design such that estimates produced are representative of the target population. Data collection took place in participants' homes from December 2008 through November 2009 using computer-assisted personal interviewing. The content of the CCHS-Healthy Ageing was developed collaboratively by Statistics Canada and researchers from the Canadian Longitudinal Study on Ageing (CLSA). As part of the Statistics Canada-CLSA collaboration, CCHS participants were asked to provide consent that their survey data could be shared with the CLSA. This article includes data from CCHS participants between the ages of 45 and 85 years, who consented to share their data with the CLSA, henceforth referred to as the CCHS-CLSA sample. Separate weights were constructed for the CCHS-CLSA sample; thus, these data comprise a nationally representative sample of community-living Canadian residents.

Functional disability in ADL and IADL

The measure of functional status was adapted from the ADL section of part A of the Older Americans Resources and Services Multidimensional Functional Assessment Questionnaire (OMFAQ) (eTable 1). The OMFAQ contains 14 items pertaining to functional disability in basic ADL and IADL, answered on a six-point scale ranging from 1 (excellent functioning) to 6 (functioning totally impaired). For comparison with previous work,[7] functional disability was operationalised using two dichotomous variables indicating a need for help with, or an inability to perform, one or more of the (1) seven basic ADL tasks, or (2) seven IADL activities.

Social participation restriction

During the ageing process, the inability to perform activities at a societal level can be the first manifestation of the loss of independence (eTable 1).[14] Respondents were asked how often in the past 12 months they participated in eight different community-related activities. After completing the sections, participants were asked whether or not they had felt they wanted to participate in more activities and, if so, what prevented them from doing so. Social participation restriction was operationalised as: not participating as one desired because of limitations due to health conditions.

Chronic conditions

Eleven chronic medical conditions were identified a priori as putative risk factors for functional disability: heart disease, stroke, diabetes, respiratory disease, hearing impairment, eye disease, arthritis, depression, cognitive impairment, dementia and Parkinson's disease (eTable 1). Other than cognitive impairment, hearing impairment and depression, all chronic conditions were based on self-report of 'long-term conditions' which were expected to last, or had already lasted, 6 months or more and had been diagnosed by a health professional.

Hearing impairment was determined using the Health Utilities Index hearing domain.[15] Depression was measured using a shortened version of the WHO Composite International Diagnostic Interview Scale.[16] The Mental Alternation Test[17] (MAT), which measures executive function, was used to identify people at greatest risk of cognitive impairment. This was performed using a validated cut point of an age-standardised, sex-standardised and education-standardised MAT score.[18] Cognitive measures were not available for proxy respondents, which is why proxy respondents were not included in the current analyses.

It was reasoned that chronic conditions that were both prevalent and independently associated with both ADL and IADL would be the most relevant from a public health and clinical perspective, that is, associated with a higher PAR. Chronic conditions for the PAR analysis were selected if they were present in at least 10% of the population and had a statistically significant relationship to functional disability (ADL or IADL) and social participation restriction. Since including mental health conditions was a focus of this study, we also included depression despite the maximum prevalence of 8.7% across the age-sex strata. A summary of excluded chronic conditions and their association with disability and social restriction is included in eTable 2.

Potential effect modifying and confounding variables

Since it has been shown that trajectories of disability and the chronic conditions associated with functional disability differ by age and gender,[7] all analyses were stratified by age category (45–54, 55–64, 65–74 and 75–85) and gender (eTable 1). Other factors associated with functional disability and social participation that could be potential confounders included: living alone, ethnicity, body mass index and socioeconomic status (SES).[19] SES was operationalised using a relative measure of household income to household income of all other respondents in the same province.[20]

Statistical analysis

A PAR represents the proportion of cases of a health outcome that would not occur in a population if a particular risk factor were eliminated. From a population health perspective, it is also relevant to examine the PAR of combinations of conditions as well as a single condition, for example, estimating the proportion of ADL disability that will not occur if arthritis and diabetes were eliminated. The PAR for a combination of chronic conditions is not simply the sum of the PARs for the individual conditions. Part of the reason for this is that chronic conditions are generally not mutually exclusive. In our examples, there may be some people with arthritis but not diabetes, some people with diabetes but not arthritis, but there will also be some people with both. Therefore, the prevalence of arthritis or diabetes will be less than the summed prevalence of each condition.

The method proposed by Basu and Landis[21] was used to explore the population impact of selected chronic conditions on functional disability and social participation restriction, while adjusting for other chronic conditions and relevant covariates. In a population with significant levels of multimorbidity, it is critical to adjust for the effect of other comorbid conditions when estimating the PAR for a specific chronic condition. For each age-sex stratum, the PAR for single conditions and combinations of chronic conditions and their 95% CIs were estimated based on a series of unconditional multivariable logistic regression models using interactive risk attributable program software (US National Cancer Institute, 2002). Owing to the complex design used by the CCHS,[22] prevalence estimates used in the PAR calculation had to be adjusted using the sampling weights. Bootstrap methods were applied to obtain 1000 estimates from which appropriate non-parametric CIs were calculated.[23]

RESULTS

Study population

Of the 26 087 CCHS-CLSA participants, 18 553 (71.1%) completed the main survey and the cognition component. Of those, 15 799 (78.7%) had complete ADL, IADL, social participation and chronic conditions. The included participants tended to be slightly younger, more often men and have higher education and income ($p<0.05$).[18] The mean age of included participants was 63.6±10.3 years, 94.0% were white, 53.7% were women, 31.6% lived alone and the median household income was $50 000 CDN (data not shown).

Table 1 presents the proportion of participants with each chronic condition, ADL and IADL disability, and social participation restriction, overall and by age and sex strata. Overall, the prevalence of functional disability in ADL was 6.5% in men and 12.8% in women, IADL disability was 3.6% for men and 8.6% for women. The most common ADL and IADL limitation was trouble getting to the toilet on time and doing housework, respectively (data not shown). Social participation restriction was reported by 4.8% of men and 6.7% of women. A statistically significant increase in prevalence of ADL and IADL disability and social participation restriction was found with age (table 1). Eight of the 11 chronic conditions had a prevalence >10%, arthritis being the most common with a prevalence up to 55.5% in women aged 75–85, and were significantly related to functional disability or social participation restriction for at least one age-gender stratum (heart disease, diabetes, respiratory disease, hearing impairment, eye disease, arthritis, depression and cognitive impairment). These conditions were included in the PAR analyses. Although well below 10%, there was a strong association between the remaining three chronic conditions (Alzheimer's disease, Parkinson's disease and stroke) with functional disability and social participation restriction (eTable 2).

PARs for ADL disability

Table 2 presents the highest PARs by age and sex for ADL disability associated with single and combinations of two and three chronic conditions. For the younger age groups, men generally had higher PARs compared to women, but this trend reversed for the older age groups. Overall, the presence of arthritis, diabetes, eye disease, heart disease and depression contributed the most to PAR in ADL-related disability. For men, heart disease and arthritis were associated with the largest PARs in the younger age groups while diabetes, arthritis and eye disease, alone and in combination, were associated with higher PARs in the older age groups. In women, depression tended to be a stronger driver of ADL-related disability in the younger age groups, while arthritis, diabetes, respiratory disease and eye disease were associated with larger PARs in the older age groups. Compared to men, women less frequently had heart disease as a major contributor to the largest PARs for disability, but rather arthritis. In most cases, the chronic conditions with the highest PARs when considered alone were also represented in the combinations of chronic conditions with the highest PARs.

PARs for IADL disability

The PARs for chronic conditions associated with IADL disability tended to be higher than those for ADL disability (table 3). The magnitude of the PARs was similar for men and women in the youngest and oldest age groups, but higher for women between the ages of 55–74 years. Overall, arthritis, heart disease and respiratory disease were associated with the highest PARs across most age groups. However, depression had the second largest PAR for women in the two youngest age groups.

PARs for social participation restriction

The PARs for social participation restriction tended to be similar in magnitude to those for IADL disability (table 4). With the exception of men aged 75–85, arthritis had the highest PAR for social participation restriction for all age-gender strata. For both men and women, depression was a strong driver of the PAR for the younger age groups and diabetes in the older age groups. Similar to ADL disability, eye disease did not have the highest PAR, but contributed to many of the triplets.

DISCUSSION

This study demonstrated that physical and mental chronic conditions, alone and in combination, were strongly associated with functional disability and social participation restriction. In males, the PARs associated with combinations of three chronic conditions were generally over 30 and up to 57 for social participation restriction. In women, the magnitude of the PARs varied more but the highest PAR for a combination of three chronic conditions was also for social participation restriction, 70.9. In younger women, depression, alone and in combination with the physical chronic conditions such as arthritis, was commonly associated with ADL and IADL disability as well as social participation restrictions. Compared to women, the combinations of conditions associated with higher PARs in men more often included ischaemic heart disease (IHD) and diabetes. For both men and women and across all age groups, arthritis, alone and in combination with other chronic conditions, was consistently associated with high PARs for functional disability and social participation restrictions. In most cases, the conditions with the highest individual PARs were also represented in the combination of chronic conditions with highest PARs. Many of the triplets represented conditions that impact different organ systems.

The current study is unique in that we examine the drivers of functional disability in younger age groups, that is, 45–54 years. We found in the younger age groups that depression and arthritis were most often associated with the highest PARs for functional disability, especially in women. This finding is supported by data from the National Health Interview Survey where in 40–64 year-olds, arthritis and depression were ranked two and three (following back and neck pain) as conditions that caused one to need help with ADLs and IADLs, whereas depression was not in the top 10 chronic conditions associated with functional limitations in people over 65 years of age.[24] The authors did not report the data for men and women separately, but our results suggest that depression may be more prevalent and more highly associated with functional disability in women compared to men in the younger age groups.

Unlike previous work,[7] we found that the PARs associated chronic conditions for IADL disability tended to be higher than those for ADL disability and did not find a strong association with cognitive impairment. These findings may be explained by differences in the time period of the data sources and populations studied. The prior analysis included a population-based sample of Canadians aged 65 years and older which was conducted 25 years ago. This paper includes similar population-based data including people aged 45–85 years recruited in 2007/2008. Recent data indicate that in people aged 40–64 years, there has been a significant increase in IADL limitations, especially among women; however, the rates have remained the same or decreased in those aged 65 years or older,[24] which may

Table 1 Chronic conditions functional disability and social participation restriction in the study population, stratified by age and sex and overall

	Aged 45–54 years		Aged 55–64 years		Aged 65–74 years		Aged 75–85 years		Total population	
	Male (n=1444)	Female (n=1712)	Male (n=2736)	Female (n=3004)	Male (n=1956)	Female (n=2024)	Male (n=1182)	Female (n=1741)	Male (n=7318)	Female (n=8481)
Number of chronic conditions										
0	60.1 (55.0 to 65.2)	59.1 (54.9 to 63.4)	44.9 (41.9 to 48.0)	41.1 (38.3 to 43.9)	25.6 (22.7 to 28.5)	24.3 (21.5 to 27.2)	13.9 (11.3 to 16.4)	12.0 (9.8 to 14.2)	44.6 (42.1 to 47.0)	41.6 (39.7 to 43.5)
1	28.7 (23.8 to 25.3)	25.3 (21.7 to 29.0)	31.0 (28.4 to 33.7)	35.8 (32.8 to 38.8)	34.2 (31.2 to 37.2)	37.6 (34.5 to 40.7)	32.2 (28.6 to 35.9)	30.6 (27.4 to 33.8)	30.8 (28.6 to 32.9)	31.4 (29.7 to 33.1)
≥2	7.8 (5.7 to 9.9)	11.7 (9.1 to 14.2)	19.3 (17.2 to 21.4)	20.6 (18.5 to 22.8)	37.3 (34.3 to 40.4)	36.0 (32.9 to 39.1)	51.6 (48.1 to 55.1)	56.2 (52.9 to 59.5)	21.1 (19.8 to 22.4)	24.3 (22.8 to 25.7)
Cognitive impairment	2.5 (1.2 to 3.8)	1.7 (0.6 to 2.8)	4.1 (3.0 to 5.2)	2.1 (1.4 to 2.8)	9.0 (7.2 to 10.8)	7.3 (5.6 to 9.0)	15.8 (13.2 to 18.5)	14.0 (11.8 to 16.2)	5.5 (4.8 to 6.3)	4.3 (3.7 to 5.0)
Heart disease	7.0 (4.8 to 9.1)	2.8 (1.7 to 4.0)	12.2 (10.5 to 13.9)	6.9 (5.6 to 8.2)	22.9 (20.3 to 25.5)	12.8 (10.6 to 15.0)	32.6 (29.1 to 36.1)	21.6 (18.9 to 24.4)	14.0 (12.8 to 15.2)	8.2 (7.3 to 9.0)
Stroke	0.9 (0.2 to 1.6)	0.6 (0.1 to 1.1)	1.7 (0.9 to 2.5)	1.7 (0.9 to 2.4)	3.0 (2.1 to 3.9)	2.7 (1.5 to 3.9)	6.1 (4.4 to 7.7)	5.2 (3.3 to 7.0)	2.0 (1.6 to 2.5)	1.9 (1.4 to 2.3)
Diabetes	6.6 (4.5 to 8.7)	6.6 (4.2 to 8.9)	13.1 (11.4 to 14.9)	8.7 (7.4 to 10.1)	18.5 (16.1 to 20.9)	14.3 (12.1 to 16.5)	19.2 (16.0 to 22.5)	15.4 (13.2 to 17.6)	12.0 (10.9 to 13.2)	9.7 (8.6 to 10.8)
Respiratory disease	7.7 (4.7 to 16.6)	11.9 (9.2 to 14.6)	8.7 (7.2 to 10.2)	12.3 (10.4 to 14.1)	12.8 (10.8 to 14.9)	14.0 (11.6 to 16.3)	12.2 (9.7 to 14.6)	18.2 (14.8 to 21.6)	9.4 ((8.0 to 10.7)	13.2 (11.8 to 14.5)
Hearing impairment	2.2 (1.0 to 3.3)	2.2 (1.2 to 3.2)	5.9 (4.7 to 7.2)	2.3 (1.6 to 3.0)	12.3 (10.1 to 14.5)	5.5 (4.1 to 6.9)	21.0 (17.9 to 24.1)	13.1 (10.8 to 15.4)	7.0 (6.2 to 7.9)	4.2 (3.6 to 4.8)
Eye disease	2.2 (1.1 to 3.3)	2.8 (1.7 to 4.0)	6.4 (5.1 to 7.6)	8.3 (6.8 to 9.8)	17.6 (15.1 to 20.1)	23.7 (21.0 to 26.4)	31.4 (27.7 to 35.1)	39.3 (35.8 to 42.8)	9.2 (8.3 to 10.1)	12.7 (11.8 to 13.7)
Arthritis	12.6 (9.5 to 15.8)	16.1 (13.4 to 18.8)	22.1 (19.8 to 24.4)	36.2 (33.5 to 38.8)	33.8 (30.6 to 36.9)	45.1 (41.8 to 48.5)	37.5 (34.0 to 40.9)	55.5 (52.0 to 59.0)	21.8 (20.2 to 23.5)	32.3 (30.7 to 33.9)
Depression	6.3 (3.6 to 9.1)	8.4 (6.5 to 10.4)	5.0 (3.9 to 6.0)	8.7 (7.2 to 10.2)	3.3 (1.9 to 4.7)	3.2 (2.1 to 4.3)	1.9 (1.0 to 2.8)	3.0 (2.0 to 3.9)	4.9 (3.7 to 6.1)	6.9 (6.0 to 7.8)
Dementia	0.2 (−0.1 to 0.4)	0.0	0.2 (0.0 to 0.3)	0.3 (0.1 to 0.6)	0.4 (0.1 to 0.7)	0.4 (−0.1 to 0.8)	1.2 (0.3 to 2.1)	1.0 (0.3 to 1.7)	0.3 (0.1 to 0.5)	0.3 (0.1 to 0.4)
Parkinson's disease	0.5 (−0.1 to 1.0)	0.0	0.2 (0.0 to 0.4)	0.3 (0.0 to 0.6)	0.4 (0.2 to 0.7)	0.8 (0.0 to 1.6)	1.2 (0.4 to 2.1)	0.9 (0.4 to 1.5)	0.5 (0.2 to 0.7)	0.3 (0.2 to 0.5)
Functional disability										
ADL	3.7 (2.3 to 5.0)	8.9 (6.9 to 11.0)	5.6 (4.5 to 6.8)	11.0 (9.3 to 12.7)	9.5 (7.2 to 11.8)	15.7 (13.4 to 18.0)	15.2 (12.2 to 18.1)	25.5 (22.1 to 28.9)	6.5 (5.6 to 7.4)	12.8 (11.6 to 14.0)
IADL	1.0 (0.5 to 1.5)	3.3 (2.0 to 4.5)	2.6 (1.9 to 3.4)	6.0 (4.8 to 7.2)	5.4 (3.9 to 6.8)	11.2 (9.2 to 13.2)	14.1 (11.3 to 17.0)	27.8 (24.4 to 31.2)	3.6 (3.1 to 4.1)	8.6 (7.7 to 9.4)
Social participation restriction	3.2 (2.1 to 4.3)	5.3 (3.8 to 6.9)	5.2 (3.8 to 6.5)	6.4 (5.2 to 7.6)	5.7 (4.3 to 7.1)	7.7 (6.1 to 9.4)	8.4 (6.1 to 10.7)	10.4 (8.4 to 12.5)	4.8 (4.1 to 5.5)	6.7 (5.9 to 7.5)

The sums of the strata do not add up to the total number of participants because of missing values.
ADL, activities of daily living; IADL, instrumental activities of daily living.

Table 2 Population attributable risk for activities of daily living disability by gender and age category

	Males			Females		
Age group (years)	**1 Condition**	**2 Conditions**	**3 Conditions**	**1 Condition**	**2 Conditions**	**3 Conditions**
45–54	IHD 18.7 (5.4 to 32.4) RES 6.8 (−5.1 to 19.0) DIA 5.7 (−6.9 to 17.9) HER 2.6 (−0.3 to 8.6)	IHD+RES 25.3 (9.9 to 41.1) IHD+DIA 24.0 (7.8 to 39.7)	IHD+RES+DIA 29.6 (11.9 to 45.0) IHD+RES+HER 27.9 (12.6 to 43.3)	DEP 8.8 (1.8 to 15.7) IHD 4.6 (0.01 to 9.7) HER 1.2 (−2.5 to 5.0) ART 0.01 (−8.9 to 9.9)	DEP+IHD 13.4 (5.5 to 21.9) DEP+HER 10.0 (2.7 to 17.5)	DEP+IHD+HER 14.4 (6.3 to 23.2) DEP+HER+ART 13.4 (2.5 to 23.3)
55–64	ART 16.9 (4.7 to 28.1) IHD 14.5 (5.5 to 23.7) DIA 10.0 (0.9 to 18.8) RES 7.4 (−0.5 to 15.1)	ART+IHD 28.2 (15.9 to 40.7) ART+DIA 25.2 (12.4 to 37.8)	ART+IHD+DIA 34.6 (21.6 to 47.0) ART+IHD+RES 32.0 (19.4 to 44.1)	ART 12.2 (1.3 to 23.0) DEP 8.7 (3.8 to 13.4) EYE 6.1 (1.3 to 11.0) HER 2.0 (−0.3 to 4.6)	ART+DEP 19.9 (8.6 to 29.7) ART+EYE 17.5 (7.0 to 28.4)	ART+DEP+EYE 24.9 (13.8 to 35.1) ART+DEP+HER 21.3 (10.4 to 31.7)
65–74	DIA 18.2 (10.1 to 26.5) COG 4.9 (−1.4 to 11.7) EYE 1.8 (−5.6 to 9.4) ART 1.3 (−11.2 to 13.0)	DIA+COG 22.4 (12.4 to 31.4) DIA+EYE 19.8 (9.3 to 29.2)	DIA+COG+EYE 23.9 (13.0 to 34.0) DIA+COG+ART 23.5 (9.7 to 36.3)	ART 36.9 (25.5 to 47.7) DIA 19.9 (13.3 to 26.5) EYE 13.0 (5.0 to 21.5) IHD 10.4 (4.1 to 16.7)	ART+DIA 48.6 (38.8 to 57.3) ART+EYE 45.6 (35.2 to 54.9)	ART+DIA+EYE 55.3 (46.5 to 63.0) ART+DIA+IHD 53.0 (43.8 to 61.0)
75–85	DIA 13.6 (4.0 to 23.3) ART 12.4 (−3.9 to 28.5) EYE 8.6 (−3.8 to 21.3) IHD 8.5 (−4.2 to 20.6)	DIA+ART 24.1 (8.6 to 39.0) DIA+EYE 21.0 (6.2 to 35.3)	DIA+ART+EYE 30.9 (15.4 to 45.7) DIA+ART+IHD 30.4 (14.0 to 46.0)	ART 35.0 (23.8 to 45.9) RES 17.8 (11.2 to 24.0) EYE 14.0 (3.7 to 23.3) IHD 8.1 (0.5 to 14.8) DIA 7.6 (1.9 to 13.1)	ART+RES 47.1 (37.1 to 56.9) ART+EYE 44.1 (32.4 to 55.1)	ART+RES+EYE 54.3 (44.2 to 63.9) ART+RES+DIA 51.4 (41.6 to 61.2)

Adjusted for: living alone (yes, no), adjusted total household income to the provincial low income cut-off (above median, below median), ethnicity (white, non-white), BMI (<25, 25–30, >30), other comorbid conditions (any of Alzheimer's disease, Parkinson's disease or stroke).
ART, arthritis; BMI, body mass index; COG, cognitive impairment; DEP, depression; DIA, diabetes; EYE, eye disease; HER, hearing impairment; IHD, ischaemic heart disease; RES, respiratory disease.

explain our cohort effect. Compared to previous work, we also found little relationship between cognitive impairment and functional limitations. In the previous study, cognitive impairment was primarily a driver for functional disability PARs related to the subset of complex self-management tasks (inability to handle money, use the phone or self-medicate). In the CCHS-CLSA population, the prevalence of complex self-management disability among the age-gender groups ranged from 0.2% to 5%, and thus we did not have sufficient power to look at this outcome separately.

In this paper, we examined PARs for functional disability, as well as for social participation restriction. Epidemiological studies suggest that social activities are particularly important for older adults[25] and the WHO recognises the ability to participate in societal activities as one of the direct consequences of health;[26] thus, social participation has been integrated into research and policy frameworks of ageing. We found that the combinations of chronic conditions that had an impact on functional disability, especially in IADLs, also impacted social participation. This is consistent with the literature as greater disability can restrict social participation.[27] In fact, disability has been found to be one of the most powerful determinants of social participation.[28] These findings are particularly important as social participation restriction is associated with social isolation and frailty.[7 29]

This study draws on a large-scale national population-based sample that has a high response rate using a multicausal model-based estimation of PAR. Compared with previous investigations, we were able to estimate PARs associated with various combinations of chronic conditions (both mental and physical conditions) while controlling for other comorbid conditions and potential confounding factors. Single condition PARs are typically overestimated from the population where multimorbidity exists. The reason is that the number of events that occur for subjects having two or more exposures are counted 'double' when the PAR is calculated for one exposure only. The large sample size allowed us to examine the independent effect of single and combinations of chronic conditions while adjusting for the others.

Our study has some limitations. First, there is the issue of the accuracy of self-reported medical conditions in large-scale community surveys. Although we have not been able to examine physician-diagnosed conditions, self-reported diagnoses have shown to be valid, reliable and are standard in epidemiological research. Some conditions, such as foot problems and cancer, that have been shown to be related to disability, were either not measured in CCHS or not measured with sufficient detail to be included in our analyses. Also, we chose to operationalise depression using the adapted Composite International Diagnostic Interview Scale.[16] Other mental health conditions,

Table 3 Population attributable risk for instrumental activities of daily living disability by gender and age category

	Males			Females		
Age group (years)	**1 Condition**	**2 Conditions**	**3 Conditions**	**1 Condition**	**2 Conditions**	**3 Conditions**
45–54	ART 33.0 (−13.5 to 77.8) IHD 29.7 (−10.6 to 71.6) DEP 26.3 (−5.1 to 58.5) RES 21.5 (−16.3 to 62.5) DIA 19.0 (−13.1 to 60.0)	ART+IHD 51.3 (−6.6 to 100) ART+DIA 47.2 (−13.5 to 100)	ART+IHD+DEP 56.5 (1.2 to 100) ART+DEP+DIA 53.9 (0.9 to 100)	ART 36.4 (17.6 to 53.9) DEP 20.9 (4.4 to 35.9) RES 6.5 (−11.9 to 23.8) IHD 4.1 (−3.1 to 12.7)	ART+DEP 49.9 (33.4 to 66.1) ART+RES 42.0 (24.7 to 58.6)	ART+DEP+RES 53.7 (37.4 to 69.1) ART+DEP+IHD 51.3 (34.2 to 66.9)
55–64	ART 22.4 (0.6 to 43.5) DIA 19.2 (4.5 to 35.1) RES 18.8 (4.8 to 32.5) DEP 12.4 (1.7 to 24.3)	ART+RES 36.5 (16.2 to 56.2) ART+DIA 36.2 (14.2 to 55.8)	ART+DIA+RES 45.1 (24.6 to 64.0) ART+DIA+DEP 43.8 (25.4 to 62.1)	ART 34.3 (20.2 to 48.0) DEP 18.0 (10.3 to 25.7) RES 10.8 (2.1 to 19.8) DIA 9.2 (0.7 to 17.3)	ART+DEP 47.0 (34.8 to 59.0) ART+RES 40.1 (25.0 to 52.9)	ART+DEP+RES 51.6 (39.9 to 63.0) ART+DEP+DIA 51.2 (39.0 to 62.3)
65–74	ART 26.6 (9.5 to 43.3) IHD 16.7 (4.5 to 29.0) DEP 11.6 (4.5 to 19.1) COG 5.9 (−3.1 to 14.7)	ART+IHD 38.2 (19.7 to 54.0) ART+DEP 34.3 (18.5 to 50.1)	ART+IHD+DEP 46.0 (30.2 to 60.9) ART+IHD+COG 42.6 (23.9 to 58.2)	ART 49.3 (37.7 to 59.8) DIA 22.4 (13.7 to 30.8) RES 14.2 (5.7 to 22.3) EYE 13.6 (3.2 to 23.3)	ART+DIA 60.4 (50.4 to 69.8) ART+RES 58.7 (48.7 to 68.0)	ART+DIA+RES 68.0 (59.3 to 75.7) ART+DIA+RES 65.9 (56.8 to 74.2)
75–85	EYE 26.8 (13.1 to 39.4) IHD 22.8 (9.7 to 36.8) DIA 17.3 (6.5 to 28.8) ART 14.0 (−4.5 to 31.1) HER 12.6 (2.4 to 22.8) COG 10.6 (0.9 to 20.5)	EYE+IHD 43.1 (27.9 to 57.2) EYE+DIA 38.3 (24.0 to 52.0)	EYE+IHD+DIA 51.1 (36.2 to 65.1) EYE+IHD+COG 50.5 (34.2 to 64.1)	ART 29.1 (16.5 to 40.0) EYE 13.6 (4.1 to 23.3) IHD 13.5 (6.9 to 20.0) RES 10.8 (5.0 to 16.4)	ART+IHD 38.7 (27.4 to 48.5) ART+EYE 38.6 (25.6 to 50.0)	ART+IHD+EYE 46.8 (35.0 to 56.8) ART+IHD+RES 45.3 (35.0 to 54.2)

Adjusted for: living alone (yes, no), adjusted total household income to the provincial low income cut-off (above median, below median), ethnicity (white, non-white), BMI (<25, 25–30, >30), other comorbid conditions (any of Alzheimer's disease, Parkinson's disease or stroke).
ART, arthritis; BMI, body mass index; COG, cognitive impairment; DEP, depression; DIA, diabetes; EYE, eye disease; HER, hearing impairment; IHD, ischaemic heart disease; RES, respiratory disease.

such as anxiety, may also be related to disability and social participation restriction. Since the anxiety module was not included in the CCHS, we were not able to examine the potential impact of anxiety. Second, although the sample was large, we did restrict our analyses to participants with complete data. The people with complete data tended to be slightly younger, more often men and have higher education and income. In addition, since proxy respondents were excluded, it could be that the sample had slightly higher cognitive functioning. We have tried to mitigate the impact of the bias that could be introduced by stratifying our analyses by age and sex and by adjusting our estimates for potential confounders, such as SES. This could, however, limit our generalisability to community-living populations with higher levels of cognitive impairment.

Finally, the results generated from cross-sectional data need to be interpreted with care, given that causal direction cannot be definitive. While it is unlikely that functional disability causes arthritis, it is less clear with conditions such as depression. In fact, some of the associations examined are most likely bidirectional. To address these limitations, it would be beneficial to apply the PAR methodology to longitudinal data.

Implications for clinical and public health interventions

Knowing which chronic conditions are associated with greater functional disability and social participation restriction may help clinicians to target treatment strategies in patient populations. Awareness of the PAR for single conditions and combinations of conditions in different genders at different ages provides the opportunity for more precise targeting. For example, the very strong association among arthritis, functional disability and social participation restriction, especially in older women, may guide the physician towards more aggressive behavioural (eg, exercise), physical, pharmacological and possibly surgical management in that patient population. Similarly, the association among depression, functional disability and social participation in younger middle-aged women may prompt the physician to more carefully and systematically investigate for depressive symptoms in this patient population. In the event that major public health initiatives are directed towards specific conditions (eg, osteoarthritis), physicians and other clinicians will have an important role in disease management.

For policymakers, the PAR data for different demographic groups may help to develop preventive health strategies which

Table 4 Population attributable risk for social participation restriction by gender and age category

	Males			Females		
Age group	**1 Condition**	**2 Conditions**	**3 Conditions**	**1 Condition**	**2 Conditions**	**3 Conditions**
45–54	ART 26.3 (7.3 to 44.1) DEP 22.6 (8.3 to 39.0) IHD 14.7 (−1.5 to 30.3) EYE 7.8 (−1.3 to 19.5)	ART+DEP 39.6 (21.7 to 58.4) ART+IHD 37.5 (16.7 to 56.6)	ART+DEP+IHD 49.6 (31.1 to 69.8) ART+DEP+EYE 43.9 (26.1 to 63.0)	ART 33.4 (17.4 to 49.2) DEP 20.9 (9.2 to 32.1) RES 10.9 (−2.5 to 24.4) EYE 10.0 (2.9 to 17.9)	ART+DEP 44.8 (30.9 to 58.0) ART+EYE 41.3 (26.1 to 56.9)	ART+DEP+EYE 52.8 (41.1 to 65.4) ART+DEP+RES 49.7 (35.7 to 63.0)
55–64	ART 21.9 (7.0 to 38.1) DEP 18.5 (10.8 to 26.5) DIA 12.8 (3.7 to 22.4) IHD 11.0 (−0.1 to 21.5)	ART+DEP 34.8 (21.5 to 47.9) ART+DIA 32.6 (17.6 to 47.2)	ART+DEP+DIA 43.4 (30.2 to 56.4) ART+DEP+IHD 42.8 (30.6 to 54.6)	ART 26.8 (13.4 to 40.0) DEP 13.0 (5.9 to 20.5) RES 11.3 (2.2 to 20.5) IHD 7.7 (0.2 to 15.3)	ART+DEP 36.3 (23.0 to 48.2) ART+RES 34.6 (21.0 to 47.3)	ART+DEP+RES 43.5 (30.6 to 55.1) ART+DEP+IHD 41.2 (29.1 to 52.8)
65–74	ART 18.3 (3.0 to 34.5) DIA 14.0 (2.6 to 26.1) IHD 9.7 (−3.4 to 22.1) COG 3.3 (−5.4 to 11.6)	ART+DIA 29.9 (12.1 to 44.9) ART+IHD 26.4 (8.3 to 43.4)	ART+DIA+IHD 36.5 (19.3 to 51.3) ART+DIA+COG 32.4 (16.2 to 47.3)	ART 43.3 (28.5 to 59.3) DIA 25.1 (13.9 to 35.7) IHD 19.7 (10.9 to 29.1) EYE 9.4 (−3.4 to 21.6)	ART+DIA 59.2 (46.5 to 71.0) ART+IHD 55.9 (42.0 to 68.7)	ART+DIA+IHD 65.9 (54.8 to 76.4) ART+DIA+EYE 62.7 (50.6 to 73.7)
75–85	DIA 30.2 (16.9 to 43.2) ART 28.9 (7.0 to 48.0) EYE 16.1 (−0.2 to 32.6) RES 6.3 (−4.9 to 16.5) COG 4.6 (−7.3 to 15.9)	DIA+ART 49.4 (30.4 to 64.8) DIA+EYE 41.0 (24.1 to 56.6)	DIA+ART+EYE 57.0 (41.0 to 72.1) DIA+ART+COG 52.2 (32.3 to 68.7)	ART 62.1 (49.1 to 74.8) IHD 16.6 (6.2 to 26.9) EYE 5.1 (−10.7 to 19.7) DEP 4.5 (0.4 to 8.9) HER 4.4 (−1.9 to 11.9)	ART+IHD 69.3 (58.0 to 79.8) ART+EYE 63.9 (49.8 to 76.8)	ART+IHD+EYE 70.9 (59.4 to 81.8) ART+IHD+HER 70.7 (59.8 to 81.1)

Adjusted for: living alone (yes, no), adjusted total household income to the provincial low income cut-off (above median, below median), ethnicity (white, non-white), BMI (<25, 25–30, >30), other comorbid conditions (any of Alzheimer's disease, Parkinson's disease or stroke).
ART, arthritis; BMI, body mass index; COG, cognitive impairment; DEP, depression; DIA, diabetes; EYE, eye disease; HER, hearing impairment; IHD, ischaemic heart disease; RES, respiratory disease.

target individual conditions, as well as clusters of diseases which share risk factors and together impact functional disability. Syed *et al* describe an example of PAR being used to estimate the effect of vascular risk factor reduction in the population of Herefordshire (UK), population 182 441. Applying a nationally developed vascular risk factor screening programme to all adults aged 40–74 years, and instituting appropriate therapy would result in a reduction of 90 myocardial infarction events, 63 coronary heart disease events and 125 stroke events over 5 years.[30] A modelling study by Kite *et al*,[31] based on the population of New South Wales in Australia, used PAR and other tools to estimate the effects of a sector wide intervention to reduce obesity. The strategy involved dietary changes (reduction of energy dense, nutrient poor food and drinks, increased consumption of fruits and vegetables), promotion of greater participation in sport and other vigorous physical activity. In addition, societal changes would increase participation in walking and bicycling, and attempts would be made to move a greater percentage of the population closer to city centres and use public transport instead of private vehicles. This type of sector wide intervention would decrease the incidence of arthritis, depression and cardiovascular disease. Such proposals are ambitious and controversial, but knowledge of PAR for various conditions and clusters of conditions provides a useful tool to estimate the impact of these schemes.

PAR data from this study may inform at least two alternative (but related) strategies to reduce disability at population level. The first is a disease-specific strategy (eg, osteoarthritis), and the second is aimed at reduction of common risk factors for multiple conditions (eg, arthritis, diabetes, heart disease, depression). Of the modifiable risk factors for osteoarthritis, overweight/obesity, lack of exercise and joint injury are the most easily identified,[32] but significant challenges exist in implementation of, and adherence to, recommendations to avoid them. Once established, symptoms of hip and knee OA are alleviated by regular exercise,[33–35] including walking,[36] and there are evidence-based non-pharmacological and pharmacological treatments to relieve symptoms.[37] As eye diseases become more important drivers of disability in those over age 75 years, regular assessments by eye care professionals can be recommended, although screening in primary care for visual acuity is not recommended by the USPSTF.[38]

For the common risk factor strategy, weight control, diet and exercise have again emerged as important for both prevention and treatment of osteoarthritis, ischaemic heart disease and type 2 diabetes. Furthermore, there is evidence that exercise reduces the risk of developing depression,[39] as well as being a moderately effective treatment.[40] Although population level risk factor reduction is extremely challenging, it has been accomplished in

some jurisdictions including Finland.[41] Using longitudinal population-based data, it would be possible to estimate the effect on functional disability in different demographic groups, and even explore the cost-effectiveness of such strategies.

What is already known on this subject

- The association between single chronic conditions and functional disability is well documented. However, there is little research examining the combination of both physical and mental chronic conditions or functional disability or on social participation restriction.

What this study adds

- Our findings suggest that in community-dwelling older adults, the impact of some mental and physical chronic conditions on functional disability and social participation restrictions is substantial. In combination, arthritis, ischaemic heart disease or diabetes, and depression (especially in the younger age groups) were most often related to disability and social participation restrictions; however, the specific combinations and the magnitude of the population attributable risk (PARs) differed by gender and age. Such differences suggest that interventions will be most efficient if they are tailored to recognise the differences in the drivers of PAR by gender and age group.

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REFERENCES

1 Ornstein SM, Nietert PJ, Jenkins RG, *et al*. The prevalence of chronic diseases and multimorbidity in primary care practice: a PPRNet report. *J Am Board Fam Med* 2013;26:518–24.
2 Public Health Agency of Canada. *The chief public health officer's report on the state of public health in Canada 2010: growing older—adding life to years*. Public Health Agency of Canada, 2010. http://www.phac-aspc.gc.ca/cphorsphc-respcacsp/2010/fr-rc/pdf/cpho_report_2010_e.pdf
3 Prince MJ, Wu F, Guo Y, *et al*. The burden of disease in older people and implications for health policy and practice. *Lancet* 2015;385:549–62.
4 Boyd CM, Fortin M. Future of multimorbidity research: how should understanding of multimorbidity inform health system design? *Public Health Reviews* 2010;32:2010.
5 Berkman LF, Glass T, Brissette I, *et al*. From social integration to health: Durkheim in the new millennium. *Soc Sci Med* 2000;51:843–57.
6 Fortin M, Dubois MF, Hudon C, *et al*. Multimorbidity and quality of life: a closer look. *Health Qual Life Outcomes* 2007;5:52.
7 Griffith L, Raina P, Wu H, *et al*. Population attributable risk for functional disability associated with chronic conditions in Canadian older adults. *Age Ageing* 2010;39:738–45.
8 Gijsen R, Hoeymans N, Schellevis FG, *et al*. Causes and consequences of comorbidity: a review. *J Clin Epidemiol* 2001;54:661–74.
9 Le Reste JY, Nabbe P, Manceau B, *et al*. The European General Practice Research Network presents a comprehensive definition of multimorbidity in family medicine and long term care, following a systematic review of relevant literature. *J Am Med Dir Assoc* 2013;14:319–25.
10 Engel GL. The need for a new medical model: a challenge for biomedicine. *Science* 1977;196:129–36.
11 Schaink AK, Kuluski K, Lyons RF, *et al*. A scoping review and thematic classification of patient complexity: offering a unifying framework. *J Comorbidity* 2012;2:1–9.
12 Mercer SW, Gunn J, Bower P, *et al*. Managing patients with mental and physical multimorbidity. *BMJ* 2012;345:e5559.
13 Statistics Canada. Canadian Community Health Survey (CCHS)—Healthy Ageing. 2009. http://www statcan gc ca/cgi-bin/imdb/p2SV pl?Function=getSurvey&SDDS=5146&lang=en&db=imdb&adm=8&dis=2 (accessed 21 Aug 2011).
14 Whiteneck G, Dijkers MP. Difficult to measure constructs: conceptual and methodological issues concerning participation and environmental factors. *Arch Phys Med Rehabil* 2009;90:S22–35.
15 Feeny D, Furlong W, Torrance GW, *et al*. Multiattribute and single-attribute utility functions for the health utilities index mark 3 system. *Med Care* 2002;40:113–28.
16 Kessler RC, Andrews G, Mroczek D, *et al*. Composite International Diagnostic Interview—Short Form: the World Health Organization Composite International Diagnostic Interview Short-Form (CIDI-SF). *Int J Methods Psychatric Res* 1998;7:171–85.
17 Himmelfarb S, Murrell SA. Reliability and validity of five mental health scales in older persons. *J Gerontol* 1983;38:333–9.
18 Findlay L, Bernier J, Tuokko H, *et al*. Validation of cognitive functioning categories in the Canadian Community Health Survey—Healthy Ageing. *Health Rep* 2010;21:85–100.
19 Stuck AE, Walthert JM, Nikolaus T, *et al*. Risk factors for functional status decline in community-living elderly people: a systematic literature review. *Soc Sci Med* 1999;48:445–69.
20 Statistics Canada. Canadian Community Health Survey (CCHS): Healthy Ageing, derived variable documentation. Ottawa, Ontario, 2011. https://library.carleton.ca/sites/default/files/find/data/surveys/pdf_files/cchs-08_09-dv.pdf
21 Basu S, Landis JR. Model-based estimation of population attributable risk under cross-sectional sampling. *Am J Epidemiol* 1995;142:1338–43.
22 Sarafin C, Simard M, Thomas S. A review of the weighting strategy for the Canadian Community Health Survey. SSC Annual Meeting, Proceedings of the Survey Methods Section, Ottawa Ontario, 2007. http://www.ssc.ca/sites/ssc/files/survey/documents/SSC2007_C_Sarafin.pdf
23 DiCiccio TJ, Efron B. Bootstrap confidence intervals. *Stat Sci* 1996;11:189–228.
24 Martin LG, Schoeni RF. Trends in disability and related chronic conditions among the forty-and-over population: 1997–2010. *Disabil Health J* 2014;7:S4–14.
25 Betts Adams K, Leibbrandt S, Moon H. A critical review of the literature on social and leisure activity and well-being in later life. *Ageing Society* 2011;31:683–712.
26 World Health Organization. *The world health report 2008: primary healthcare now more than ever*. Geneva, Switzerland: World Health Organization, 2008.
27 Rimmer JH, Riley B, Wang E, *et al*. Accessibility of health clubs for people with mobility disabilities and visual impairments. *Am J Public Health* 2005;95:2022–8.
28 Everard KM, Lach HW, Fisher EB, *et al*. Relationship of activity and social support to the functional health of older adults. *J Gerontol B Psychol Sci Soc Sci* 2000;55:S208–12.
29 Etman A, Kamphuis CB, van der Cammen TJ, *et al*. Do lifestyle, health and social participation mediate educational inequalities in frailty worsening? *Eur J Public Health* 2015;25:345–50.
30 Syed AM, Talbot-Smith A, Gemmell I. The use of epidemiological measures to estimate the impact of primary prevention interventions on CHD, stroke and cancer outcomes: experiences from Herefordshire, UK. *J Epidemiol Glob Health* 2012;2:111–24.
31 Kite J, Hector DJ, St George A, *et al*. Comprehensive sector-wide strategies to prevent and control obesity: what are the potential health and broader societal benefits? A case study from Australia. *Public Health Res Pract* 2015;25:e2541545.

32 Richmond SA, Fukuchi RK, Ezzat A, *et al*. Are joint injury, sport activity, physical activity, obesity, or occupational activities predictors for osteoarthritis? A systematic review. *J Orthop Sports Phys Ther* 2013;43:515–B19.
33 Fransen M, McConnell S, Hernandez-Molina G, *et al*. Exercise for osteoarthritis of the hip. *Cochrane Database Syst Rev* 2014;(4):CD007912.
34 Fransen M, McConnell S, Harmer AR, *et al*. Exercise for osteoarthritis of the knee: a Cochrane systematic review. *Br J Sports Med* 2015;49:1554–7.
35 Desveaux L, Beauchamp M, Goldstein R, *et al*. Community-based exercise programs as a strategy to optimize function in chronic disease: a systematic review. *Med Care* 2014;52:216–26.
36 Loew L, Brosseau L, Wells GA, *et al*. Ottawa panel evidence-based clinical practice guidelines for aerobic walking programs in the management of osteoarthritis. *Arch Phys Med Rehabil* 2012;93:1269–85.
37 Hochberg MC, Altman RD, April KT, *et al*. American College of Rheumatology 2012 recommendations for the use of nonpharmacologic and pharmacologic therapies in osteoarthritis of the hand, hip, and knee. *Arthritis Care Res (Hoboken)* 2012;64:465–74.
38 US Preventive ServicesSiu AL, Bibbins-Domingo K, Grossman DC, *et al*. Screening for Impaired Visual Acuity in Older Adults: US Preventive Services Task Force Recommendation Statement. *JAMA* 2016;315:908–14.
39 Mammen G, Faulkner G. Physical activity and the prevention of depression: a systematic review of prospective studies. *Am J Prev Med* 2013;45:649–57.
40 Cooney GM, Dwan K, Greig CA, *et al*. Exercise for depression. *Cochrane Database Syst Rev* 2013;(9):CD004366.
41 Jousilahti P, Laatikainen T, Peltonen M, *et al*. Primary prevention and risk factor reduction in coronary heart disease mortality among working aged men and women in eastern Finland over 40 years: population based observational study. *BMJ* 2016;352:i721.