Journal of Public Health | Vol. 38, No. 4, pp. e563–e570 | doi:10.1093/pubmed/fdv180 | Advance Access Publication December 11, 2015

Healthcare costs in chronically ill community-living older adults are dependent on mental disorders

Helen-Maria Vasiliadis[1,2], Samantha Gontijo Guerra[3], Veronica Chudzinski[4], Michel Préville[1,2]

[1]Department of Community Health Sciences, Faculty of Medicine and Health Sciences, Université de Sherbrooke, Sherbrooke, Quebec, Canada J1K 2R1
[2]Charles-Le Moyne Hospital Research Center, Greenfield Park, Quebec, Canada J4K 0A8
[3]Faculty of Medicine and Health Sciences, Université de Sherbrooke, Sherbrooke, Quebec, Canada J1K 2R1
[4]Bishop's University, Sherbrooke, Quebec, Canada J1M 1Z7
Address correspondence to Helen-Maria Vasiliadis, E-mail: helen-maria.vasiliadis@usherbrooke.ca

ABSTRACT

Background The economic impact on society associated with the healthcare of older adults depends on their health status. The aim was to estimate the excess costs associated with co-morbid mental and physical disorders.

Methods Data were from a health survey of 2004 older adults. Two-year healthcare costs were identified from administrative databases. Generalized linear models were used to study healthcare costs as a function of co-morbid mental disorders (MDs) and heart disease (HD), arthritis, diabetes, cancer, respiratory disease (RD) and cerebral vascular accident (CVA).

Results Participants with HD and CVA with MD incurred higher costs reaching $1696 (95% confidence interval (CI): $30, $3422) and $14 772 (95% CI: $1909, $31 454) than those without MD. RD and MD incurred higher costs reaching $5343 (95% CI: $343, $10 343) than those without RD. The excess annual adjusted healthcare costs associated with co-morbid MD and physical disorders reach close to $600 M per 1 000 000 population of older adults.

Conclusion The presence of MDs with HD, CVA and RDs has a synergistic effect on healthcare costs. These findings underline the need for improved primary care for the prevention and treatment of co-mental and physical disorders that can potentially save hundreds of millions to society.

Keywords chronic disorders, healthcare costs, mental health

Introduction

The recent *Lancet* paper by Prince *et al.*[1] on the burden of disease in ageing populations showed that chronic disorders account for close to 25% of disease burden in those aged 60 years and over. The burden was mostly associated with disability life years as opposed to mortality. The surveillance of chronic diseases is notably important in older adults, where the prevalence of multimorbidity ranges from 70% to over 90% in primary care settings.[2] Besides the numerous and known effects on different health outcomes (e.g. increased morbidity and mortality, reduced quality of life), chronic disorders have also been associated with significant higher healthcare costs due to increased hospitalizations, physician visits and pharmaceutical drug use.[3–5] Studies have shown that for every chronic physical disorder healthcare costs can increase up to five times on average.[6–8] Reports have suggested that chronic illnesses in the US make up almost 75% of all healthcare costs.[7] In Switzerland, a most recent report has shown that each additional chronic condition increases costs by up to 33% per year.[8]

The co-morbidity of mental and physical conditions, its determinants and consequences, is a particular topic that requires further attention.[9] Large population-based studies have reported prevalence rates reaching over 20% among

Helen-Maria Vasiliadis, Associate Professor, Epidemiology
Samantha Gontijo Guerra, PhD Student
Veronica Chudzinski, Research Assistant
Michel Préville, Professor of Health Sciences

general populations and close to 40% among dual Medicare–Medicaid enrolees.[10,11] A bidirectional association between physical and mental disorders (MDs) has been suggested.[12,13] Physical changes including reduction of senses (e.g. hearing loss, reduced vision, etc.), impaired mobility (e.g. heart disease, stroke, arthritis, etc.), and chronic pain (e.g. cancer, musculoskeletal disorders, peripheral vascular disorders, postherpetic neuralgia) can contribute to the onset or the aggravation of MDs.[14] In addition, common MDs have also been associated with reduced adherence to treatment in older adults with chronic disorders leading to impairment and mortality.[15] Recent reviews carried out by the Canadian Network for Mood and Anxiety Treatments highlighted the negative impact of co-morbid mental and physical illnesses on outcomes and proposed specific treatment recommendations.[12,16]

Comorbid physical and MDs have also been associated with increased functional disability, decreased quality of life, loss of productivity and higher societal costs[10,17–20] and this, regardless of the direction of association. In fact, a Canadian study[10] found a synergistic effect, on functional disability, between depression and chronic conditions like diabetes, hypertension and pain. Another recent study[19] also showed that among individuals with cardiovascular disorders, participants with clinical and sub-threshold anxiety were also more likely to have high blood pressure and co-morbid depression as opposed to those without anxiety.

By 2050, projections have estimated that the proportion of the older adult population will be more than double and the economic impact on society associated with the healthcare of this population will largely depend on its health status.[21] To this effect, two recent publications have highlighted the need to better understand the implications regarding the presence of chronic physical and mental health disorders on health service use and costs.[22,23] Some studies have shown higher healthcare costs associated with MDs in older medically ill adults[24–26] while others have not.[26,27] Differences may be due to health system settings, methods of outcomes ascertainment (self-reported versus administrative data) and level of control of confounding factors. To date, only a few studies have reported on the health system costs associated with the presence of multiple chronic disorders in older adults and have included a broad concept of mental health disorders; they have mostly focused on depression, anxiety or dementia.[8,28]

In a large representative population-based sample of community-living older adults in the province of Quebec, this study will estimate the healthcare costs attributable to the presence of chronic physical and mental health conditions and to assess whether there is an additive or synergistic effect on costs. Using both survey and administrative data, which increases the validity of results, this study offers a rare occasion, in a publically managed gatekeeper health system, to inform decision makers on the economic impact of chronic disorders. This to aid in resource allocation for more efficient primary care systems aimed at prevention.

Methods

Study sample

Data used in this study came from the first wave of a longitudinal survey, the Survey on the Health of the older adults (*Enquête sur la Santé des Aînés*—ESA) conducted in 2005–08 using a probabilistic sample of French-speaking community-dwelling adults aged 65 years and over.[29] A random digit dialling method was used to develop the study sampling frame, which included stratification according to three geographical areas (metropolitan, urban and rural). In each geographical area, a proportional sample of households was derived on the basis of Quebec's 16 health administrative regions. The response rate for this study was 77%. The study protocol was approved by the University of Sherbrooke ethics committee.

Data collection

Respondents presenting severe or moderate cognitive problems based on the Mini-Mental State Examination (<22)[30] were excluded at the beginning of the face-to-face interview. Respondents who completed the interview, were asked to provide written informed consent for the research team to access their health and pharmaceutical services use data from the province's public health insurance agency, the *Régie de l'assurance maladie du Québec* (RAMQ). The ESA survey data were linked to individual level information from the RAMQ's medical and pharmaceutical services databases and from the health ministry's database on hospitalizations (*Maintenance et exploitation des données pour l'étude de la clientèle hospitalière*—MED-ÉCHO) using the respondents' health insurance number or, in the case where this number was missing, using the name, sex, address as well as the respondents' month and year of birth. A success rate of 99.6% (2494) was obtained in the matching of the data. Of the 2494 participants that completed the at home interview, 2004 were covered by the RAMQ public drug plan for the 3 years period (1 year prior and the 2 years following the interview). Respondents with complete 3-year data did not differ from those who did not with respect to age, sex, marital status, education, region of residence, self-perceived mental health, and on the presence of depression or anxiety.[31]

Measures

Chronic condition

For the purpose of this study, we included the following seven categories of chronic conditions as reported in the Chronic

Disease Indicator Framework: arthritis, cancer, chronic respiratory diseases (RDs), diabetes, heart disease, mental illness and stroke (or cerebral vascular accident—CVA).[32] Data from RAMQ register was used to identify the ICD-9 codes corresponding to the medical conditions of interest, as registered by a physician. To date, the Canadian Chronic Disease Surveillance System coding algorithms, allowing the extraction of disease information from administrative database, do not include the following conditions: arthritis, cancer and CVA. Thus, the ICD-9 codes for these conditions were taken from validated studies or reports published by Canadian government agencies. A complete list of disease groups, definitions, codes and sources are presented in Table 1.

To be classified as having a chronic condition, participants must have incurred at some time in the 12 months before interview, at least one medical claim in which ICD-9 diagnostic codes corresponding to morbidities of interest were registered. All available codes, not just primary diagnostic codes, were reviewed. Individuals whose morbidities fell in a same major category were counted once while those whose conditions fell into different categories were counted as having multiple conditions.

Socio-demographic factors: the self-reported socio-demographic factors considered in the analysis were age (65–74 years versus ≥75 years), sex, marital status (married versus separated/divorced/widowed/never married), income (<$15 000 versus ≥$15 000), type of region of residence (urban/rural versus metropolitan) and administrative health region.

Cost data: Total healthcare costs presented are those incurred during the 2-year follow-up period, in 2010 Canadian dollars. The measurement and valuation of resources followed published guidelines for economic evaluations.[38] The healthcare costs considered included hospitalizations, emergency department visits, outpatient visits and medications and physician fees. Inpatient stays were identified from the Med-ECHO database and valued on a per diem basis: $585/day in a mental health facility or psychiatric ward in general hospital; $553/day in a general ward and $1522/day for a day surgery. Ambulatory visits in public institutions were identified from the RAMQ database and valued at a cost per visit: an emergency department visit reached $310; an outpatient visit reached $160 and an outpatient visit in a department of psychiatry reached $1745 per user per year and an additional $160 per visit. The RAMQ physician services database contains data on claims and physician fees paid out for consultations and medical services rendered. The RAMQ drug database, also contains for each drug dispensed the cost of the drug and pharmacist dispensing fee. A detailed description of the calculation of these unit and overall healthcare costs has been reported in a previous paper.[31]

Table 1 Chronic disease groups and definitions

Chronic condition group	*Morbidity*	*ICD-9 code*	*Source*
Diabetes	Diabetes	250.x	Public Health Agency of Canada[33]
RDs	Asthma	493.x	
	COPD	491.x, 492.x, 496.x	
Heart diseases	Hypertension	401.x–405.x	
	Ischemic heart disease	410.x–414.x	
	Heart failure	428.x	
Mental disorders	Anxio-depressive disorders	296.x, 300.x, 311.x	
	All other MDs	290.x–295.x, 297.x–299.x, 301.x–310.x, 312.x–319.x	
Cancer	Metastatic cancer	196.x–199.x	Quan *et al.*[34]
	Solid tumor without metastasis	140.x–172.x, 174.x–195.x	
	Lymphoma	200.x–202.x, 203.0, 238.6	
	Leukemia	204.x–208.x	d'Hoore *et al.*[35]
CVA	Stroke	430.x–432.x; 434.x, 436.x	Statistics Canada, 2009[36]
Arthritis	Osteoarthritis	715.x	Public Health Agency of Canada[37]
	Rheumatoid arthritis	714.x	
	Other inflammatory/connective tissue diseases	99.3, 274.x, 446.x, 696.0, 710.x–713.x; 720.x	
	Other arthritis conditions	716.x–719.x, 725.x–729.x	

Analyses

For each participant ($n = 2004$), two years of follow-up healthcare data was available following baseline interview. The attributable healthcare costs associated with the presence of MDs, arthritis, diabetes, cancer, cerebral vascular accident, heart and RD were assessed using hierarchical generalized linear models (GLM) to account for individuals nested within administrative health regions in Quebec and control for age, sex, income, marital status and type of region of residence. The impact of MDs on the attributable healthcare costs associated with each chronic condition group [four dummy variables were created for each category of chronic physical disorders (chronic condition × mental disorder)] was assessed. Secondary analyses were also carried out where the impact of specific MD sub groups [anxio–depressive and all other MDs] was also estimated. To account for the non-normal distribution of costs, GLM models with a gamma distribution and log link[39] were used. χ^2 tests were carried out for difference in proportions. All data presented were weighted to ensure that the true proportion of older adults within each of the geographical regions sampled were reflected.[40] SAS version 9.1 was used for all statistical analyses.

Results

In this study sample, 85.2% ($n = 1708/2004$) of respondents had a chronic physical disorder diagnosis. The characteristics of participants are presented in Table 2. The results also show that the highest adjusted 2-year total average healthcare costs are attributable (Table 2) to cancer, cerebral vascular accidents and diabetes.

The interaction between the presence of each chronic physical disorder and MD on healthcare costs is presented in Table 3. The results showed that participants with heart disease and a MD incurred on average $1696 (95% CI: $30, $3422) higher total healthcare costs than those without a MD. Among individuals with a MD, heart disease was associated with $2447 (95% CI: $130, $5024) higher healthcare costs. The results also showed that participants with a CVA and a MD incurred on average $14 772 (95% CI: $1909, $31 454) higher healthcare costs than those with CVA only. The difference in total costs associated with the presence of CVA among people with a MD reached $16 484 (95% CI: $66, $32 902) versus those without a MD. The secondary analyses showed that the cost differences were mainly driven by the all other MD subgroup (i.e. organic, schizophrenia/psychotic and other disorders). Finally, the total cost associated with the presence of RDs among people with a MD was $5343 (95% CI: $343, $10 343) higher than those without RDs, mainly driven by the presence of anxio-depressive disorders.

Discussion

The prevalence of diagnosed chronic physical disorders in this general population-based study reached 85 and, 57% had two or more chronic disorders. These estimates are similar to previous reports from a US study on Medicare fee-for-service beneficiaries aged 65 years and over showing rates reaching 82 and 65%, respectively.[6] In this study, the most prevalent reported chronic disorders included heart disease (59.5%), arthritis (36.7%), MDs (18.8%) diabetes (18.4%) and cancer (16.5%) and RD (10.5%). This is similar to the recent report by Prince *et al.*[1] that showed, in high-income countries, the rank order of the five leading contributors to disease burden in older adults, which included cardiovascular diseases, cancer, musculoskeletal disorders, neuropsychiatric disorders and chronic RDs. Further, the presence of a MD with a physical illness was close to 20% of participants, which is similar to data presented elsewhere.[25]

An earlier study in the USA, showed increased costs with the presence of chronic disorders reaching up to an average of $14 000 US for older adults aged 65 years and over with four or more chronic disorders as compared to an average of $211 in those without a chronic disorder.[6] A more recent study, in adults aged 50 years and over in Europe, showed differences reaching €3337 in primary care respondents with four or more chronic disorders versus those without.[7] Using claim data for about six million people from the USA, it has been shown that, depending on the number of chronic physical conditions, the average costs per patient may be increased by between 95.4 and 137% when MDs are present.[41]

In this study, participants diagnosed with a CVA and a MD incurred higher total healthcare costs reaching $14 772 as compared with those with a CVA but without a MD. Further, among individuals with a MD, the presence of a CVA was associated with higher costs reaching $16 484; whereas in those without a MD, the results did not show a significant difference in costs associated with a CVA. It has been suggested that the increase in costs among co-morbid patients with MDs may be associated with longer inpatient stays, increased hospital readmission and outpatient healthcare utilization.[42] Dossa *et al.*[43] found that stroke patients with mental health conditions were 1.44 times more likely to be readmitted in hospitals than patients without mental health conditions.

Our results also showed that participants with heart disease and a MD, falling in the other MD subgroup (i.e. organic, schizophrenia/psychotic and other disorders), had incurred significantly higher total healthcare costs reaching $1696 than those with heart disease but not a MD. Among those with a MD, the presence of a heart disease was associated with an increase in total healthcare costs reaching $2447, mainly

Table 2 Sample characteristics based on chronic physical and MDs

	Disease groups						
	Heart disease 1193/2004 (59.5%)	*Arthritis 735/2004 (36.7%)*	*Diabetes 368/2004 (18.4%)*	*Cancer 331/2004 (16.5%)*	*RD N = 210/2004 (10.5%)*	*Cerebral vascular accident45/2004 (2.2%)*	*MDs 376/2004 (18.8%)*
Age categories	[a]	[a]		[a]			
65–74 years	638/1166	403/1166	218/1166	174/1166	118/1166	23/1166	213/1166
75+ years	555/838	332/838	150/838	157/838	92/838	22/838	163/838
Sex	[a]	[a]	[a]	[a]			[a]
Males	527/844	280/844	174/844	190/844	111/844	20/844	141/844
Females	666/1160	455/1160	194/1160	141/1160	109/1160	25/1160	235/1160
Region							
Urban/metropolitan	721/1219	463/1219	222/1219	201/1219	140/1219	28/1219	236/1219
Rural	472/785	272/785	146/785	130/785	70/785	17/785	140/785
Income							
<15 000/year	288/461	168/461	79/461	69/461	57/461	9/461	84/461
15 000/year+	904/1543	567/1453	289/1543	262/1543	14/1543	36/1543	292/1543
Marital status:		[a]					[a]
Married	564/942	315/942	163/942	147/942	104/742	20/942	152/942
Not married	629/1062	420/1062	204/1062	184/1062	106/1062	25/1062	224/1062
Average attributable healthcare costs (95% CI)							
Outpatient costs	517	775	408	1716	1508	1792	1049
	(226, 809)	(478, 1071)	(38, 779)	(1336, 2095)	(783, 2234)	(827, 2757)	(684, 1415)
Inpatient costs	564	1194	667	2229	1633	4069	677
	(68, 1061)	(640, 1747)	(37, 1297)	(1579, 2879)	(840, 2426)	(2435, 5703)	(54, 1301)
Physician fees	345	408	264	788	730	779	361
	(225, 465)	(287, 530)	(112, 417)	(633, 944)	(443, 1016)	(381, 1176)	(210, 512)
Medications	1558	411	2817	1838	1581	1060	90
	(1206, 1897)	(46, 776)	(2379, 3255)	(1371, 2306)	(838, 2294)	(−126, 2246)	(−361, 542)
Total	2985	2788	4157	6571	5452	7699	2178
	(2026, 3944)	(1753, 3822)	(2943, 5370)	(5324, 7817)	(3921, 6983)	(4517, 10 882)	(765, 3590)
Total adjusted costs	5818	5718	7959	10 244	7411	9159	3736
	(1046, 10 591)	(926, 10 511)	(2927, 12 990)	(5045, 15 442)	(2202, 12 618)	(2032, 16 286)	(1115, 8587)

[a]Estimates adjusted for age, sex, income, marital status, region of residence.

attributable to anxio-depressive disorders. Hochlehnert *et al.*[44] similarly reported that, among German cardiovascular inpatients, psychiatric co-morbidity increased both average length of stay and total costs by almost 50%. A recent systematic review by Baumeister,[45] aimed at exploring in- and outpatient costs in patients with coronary artery disease (CAD) and comorbid mental diseases, reported increased overall and outpatient costs for patients with concurrent CAD and MDs.

Finally, among people with a MD, and specifically anxio-depressive disorders, the presence of RD was associated with higher total healthcare costs reaching $5343 as compared with those with a MD but without a RD. Similarly, in a retrospective cohort study including >7500 chronic obstructive pulmonary disease (COPD) patients (mean age >60), annual healthcare costs were significantly higher for the COPD-Depression cohort versus the COPD-Only cohort reaching $6449 US.[46]

If one were to apply Rothman's reasoning on additive models and synergistic interactions between risk factors on outcome effects,[47] the results presented suggest a synergistic interaction effect between the presence of MDs and cerebral vascular accidents and heart disorders and RDs on costs. When considering the attributable costs associated with the presence of MDs and physical disorders, the excess per capita costs reach close to $600 M per 1 000 000 population of older adults.

Table 3 Adjusted total attributable cost estimates by chronic disease diagnosis

*MD	*Anxio-depressive disorders (n = 296/2004)* Adjusted attributable costs[a]	*All other MDs (n = 125/2004)* Adjusted attributable costs[b]	*MDs overall (376/2004)* Adjusted attributable costs[c]	*Mean difference (95% CI)*	*P-value*
Heart disease no, MD no	$5378 ($4667, $6196)*	$5318 ($4661, $6069)*	$5229 ($4508, $6064)	$3940 ($2119, $5760)	$P < 0.0001$
Heart disease yes, MD no	$7595 ($7007, $8232)	$7600 ($7028, $8217)*	$7473 ($6879, $8118)	$1696 ($30, $3422)	$P = 0.02$
Heart disease no MD yes	$6039 ($4391, $8306)*	$8542 ($6465, $11 285)	$6722 ($5249, $8610)	$2447 ($130, $5024)	$P = 0.04$
Heart disease yes MD yes	$8739 ($7372, $10 361)	$10 684 ($7932, $14 389)	$9169 ($7748, $10 850)	Reference	
Arthritis no MD no	$5759 ($5221, $6352)*	$5743 ($5256, $6275)*	$5618 ($5082, $6210)	$3343 ($1735, $4952)	$P < 0.0001$
Arthritis yes MD no	$8326 ($7405, $9360)	$8264 ($7395, $9237)	$8228 ($7282, $9297)	$734 (−$1172, $2639)	NS
Arthritis no MD yes	$7112 ($5645, $8960)	$10 031 ($7419, $13 562)	$7710 ($6292, $9448)	$1251 (−$1166, $3670)	NS
Arthritis yes MD yes	$8472 ($7004, $10 247)	$9518 ($7578, $11 955)	$8962 ($7626, $10 531)	Reference	
Diabetes no MD no	$6013 ($5528, $6539)*	$5987 ($5545, $6463)*	$5869 ($5382, $6400)	$3303 ($1085, $5521)	$P = 0.0003$
Diabetes yes MD no	$10 066 ($8937, $11 337)	$9992 ($8885, $11 236)	$10 011 ($8868, $11 299)	−$838 (−$3436, $1759)	NS
Diabetes no MD yes	$7135 ($5989, $8502)	$9722 ($7659, $12 339)	$7739 ($6624, $9043)	$1433 (−$1160, $4026)	NS
Diabetes yes MD yes	$8746 ($6492, $11 785)	$9666 ($7226, $12 933)	$9172 ($7287, $11 544)	Reference	
Cancer no MD no	$6279 ($5947, $6630)*	$6288 ($5974, $6618)*	$5862 ($5385, $6382)	$4392 ($1553, $7230)	$P < 0.0001$
Cancer yes MD no	$12 212 ($10 758, $13 865)	$11 948 ($10 573, $13 501)	$11 484 ($9825, $13 421)	−$1230 (−$8813, $6352)	NS
Cancer no MD yes	$7755 ($6803, $8841)	$10 390 ($8344, $12 938)	$7855 ($6726, $9173)	$2399 (−$752, $5550)	NS
Cancer yes MD yes	$9296 ($7011, $12 324)	$11 505 ($8131, $16 278)	$10 254 ($7849, $13 393)	Reference	
Respiratory diseases no MD no	$6313 ($5845, $6818)*	$6274 ($5849, $6730)*	$6181 ($5711, $6689)	$6761 ($1928, $11 593)	$P < 0.001$
Respiratory diseases yes MD no	$9501 ($7994, $11 294)	$9620 ($8113, $11 407)	$9312 ($7792, $11 128)	$3629 (−$1583, $8842)	NS
RDs no MD yes	$7127 ($5990, $8479)*	$9344 ($7427, $11 756)	$7598 ($6529, $8843)	$5343 ($343, $10 343)	$P = 0.007$
RDs yes MD yes	$11 530 ($7763, $17 127)	$13 833 ($8232, $23 242)	$12 942 ($9006, $18 596)	Reference	
CVA no MD no	$6515 ($6052, $7013)*	$6505 ($6075, $6967)*	$6392 ($5924, $6898)	$17 887 ($1517, $34 258)	$P < 0.0001$
CVA yes MD no	$12 628 ($8812, $18 099)	$9453 ($7389, $12 092)*	$9507 ($7211, $12 535)	$14 772 ($1909, $31 454)	$P = 0.008$
CVA no MD yes	$7498 ($6368, $8830)	$8936 ($7218, $11 061)*	$7795 ($6751, $9002)	$16 484 ($66, $32 902)	$P = 0.0006$
CVA yes MD yes	$9825 ($6728, $14 348)	$40 978 ($22 686, $74 028)	$24 280 ($12 918, $45 638)	Reference	

[a]Estimates adjusted for age sex income marital status region of residence and all other chronic physical disorders and all other MDs.

[b]Estimates adjusted for age sex income marital status region of residence and all other chronic physical disorders and anxio-depressive disorders.

[c]Estimates adjusted for age sex income marital status region of residence and all other chronic physical disorders.

*$P < 0.05$, significant difference as compared with reference group.

The findings of this study need to be considered in light of a number of strengths and limitations. First, the data were collected from a large population-based sample. Secondly, the validity of the measures were increased with the possible linking of survey to administrative data, which permitted the control of a number of possible confounding variables and the decrease of recall bias with regard to healthcare resources used. The study also had a number of limitations however that need to be considered with regard to the interpretation of results. First, the ESA study excluded institutionalized older adults and therefore the results may not apply to these groups which tend to have more severe clinical profiles related to physical and mental co-morbidities and health service use patterns due to different levels of health service access. The exclusion of this sub-group of older adults may have led to an underestimation of healthcare costs and impact of MDs. Second, we included a sample of older adults from the province of Quebec which also similarly limits the generalizability of results to other populations and provinces in Canada. A recent report showed[48] that the reported prevalence of chronic conditions is significantly higher in First Nations people as opposed to non-aboriginals and this across Canada. Further, the prevalence of reported chronic conditions in Quebec, was lower than in all other provinces and territories with the exception of Alberta and British Columbia. Third, the presence of chronic physical and MDs was based on administrative data, which may be subject to information bias such as misclassification bias due to coding errors. Further, we have only included a limited number of chronic conditions. For this reason, some other diseases that are commonly seen in the older adults were not assessed (e.g. osteoporosis, dermatologic and digestive system disorders). However, supported by the recent literature, we focused on a group of chronic diseases that, besides of being highly prevalent in older adult populations, account for an important burden of disease.[1,32] Finally, healthcare costs were ascertained in the context of a public managed gatekeeping healthcare system in Canada which may limit extrapolation of data to other health systems.

In conclusion, the presence of co-morbid MDs with heart disease, CVA and RDs has a synergistic effect on healthcare costs, which concords with previous reports on a synergistic effect of MDs and physical conditions on physical incapacity. These findings underline the need for improved resource allocation in primary care for the prevention and treatment of co-morbid mental and physical disorders that can potentially save hundreds of millions to society. This brings us to Wittenberg's (2015)[49] argument that health care must shift its current focus on managing innumerable individual diseases' to a focus on managing multiple conditions; for more efficient healthcare systems.

Funding

This work was supported in part by a Canadian Institutes of Health Research (CIHR) operating grant (200903MOP–200683HSR). The ESA study was supported by a CIHR operating grant (200403MOP) and a Quebec Health Research fund—Fonds de recherche Québec—Santé (FRQS) (ref: 9854 and ref: 22251). Dr Vasiliadis is a Senior Research Scholar with the Fonds de Recherche Québec—Santé.

References

1 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(9967)**:549–62.

2 Fortin M, Hudon C, Haggerty J *et al*. Prevalence estimates of multimorbidity: a comparative study of two sources. *BMC Health Serv Res* 2010;**10**:111–7.

3 Kennedy BS, Kasl SV, Vaccarino V. Repeated hospitalizations and self-rated health among the elderly: a multivariate failure time analysis. *Am J Epidemiol* 2001;**153**:232–41.

4 van Oostrom SH, Picavet HS, de Bruin SR *et al*. Multimorbidity of chronic diseases and health care utilization in general practice. *Fam Pract* 2014;**15**:61.

5 Lehnert T, Heider D, Leicht H *et al*. Review: health care utilization and costs of elderly persons with multiple chronic disorders. *Med Care Res Rev* 2011;**68**:387–420.

6 Wolff J, Starfield B, Anderson G. Prevalence, expenditures, and complications of multiple chronic disorders in the elderly. *Arch Intern Med* 2002;**162**:2269–76.

7 Glynn L, Valderas J, Healy P *et al*. The prevalence of multimorbidity in primary care and its effect on health care utilization and cost. *Fam Pract* 2011;**28**:516–23.

8 Bähler C, Huber CA, Brüngger B *et al*. Multimorbidity, health care utilization and costs in an elderly community-dwelling population: a claims data based observational study. *BMC Health Serv Res* 2015;**15**:23.

9 Sartorius N. Comorbidity of mental and physical disorders: a main challenge to medicine in the 21st century. *Psychiatr Danub* 2013; **25(Suppl 1)**:4–5.

10 Schmitz N, Wang J, Malla A *et al*. Joint effect of depression and chronic disorders on disability: results from a population-based study. *Psychosom Med* 2007;**69**:332–8.

11 Centers for Medicare & Medicaid Services. Physical and Mental Health Condition Prevalence and Comorbidity among Fee-For-Service Medicare-Medicaid Enrollees, 2014. https://www.cms.gov/Medicare-Medicaid-Coordination/Medicare-and-Medicaid-Coordination/Medicare-Medicaid-Coordination-Office/Downloads/Dual_Condition_Prevalence_Comorbidity_2014.pdf (17 November 2015, date last accessed).

12 Ramasubbu R, Beaulieu S, Taylor V *et al*. The CANMAT task force recommendations for the management of patients with mood disorders and comorbid medical disorders: diagnostic, assessment, and treatment principles. *Ann Clin Psychiatry* 2012;**24**:82–90.

13 Katon WJ. Epidemiology and treatment of depression in patients with chronic medical illness. *Dialogues Clin Neurosci* 2011;**13**:7–23.

14 Whalen D. The Mental Health Needs of an Aging Population. Canadian Mental Health Association, 2006. http://www.cmhanl.ca/pdf/Healthy%20Aging.pdf (17 November 2015, date last accessed).

15 Gallo J, Lebowitz B. The epidemiology of common late-life mental disorders in the community: themes for the new century. *Psychiatr Serv* 1999;**50**:1158–66.

16 Ramasubbu R, Taylor V, Samaan Z *et al*. The Canadian Network for Mood and Anxiety Treatments (CANMAT 2) task force recommendations for the management of patients with mood disorders and select comorbid medical disorders. *Ann Clin Psychiatry* 2012;**24**:91–109.

17 Kessler R, Wittchen HU. Generalized anxiety and depression in primary care: prevalence, recognition, and management. *J Clin Psychiatry* 2002;**63**:24–34.

18 Druss BG, Walker ER. Mental disorders and medical comorbidity. *Synth Proj Res Synth Rep* 2011;**21**:1–26.

19 Grenier S, Potvin O, Hudon C *et al*. Twelve-month prevalence and correlates of subthreshold and threshold anxiety in community-dwelling older adults with cardiovascular diseases. *J Affect Disord* 2012;**36**:724–32.

20 Lim L, Jin A, Ng T. Anxiety and depression, chronic physical disorders, and quality of life in an urban population sample study. *Soc Psychiatry Psychiatr Epidemiol* 2012;**47**:1047–53.

21 Cohen JE. World Population in 2050: Assessing the Projections, 2002. http://www.bos.frb.org/economic/conf/conf46/conf46d1.pdf (25 June 2013, date last accessed).

22 Valderas J, Starfield B, Sibbald B *et al*. Defining comorbidity: implications for understanding health and health services. *Ann Fam Med* 2009;**4**:357–63.

23 Huntley A, Johnson R, Purdy S *et al*. Measures of multimorbidity and morbidity burden for use in primary care and community settings: a systematic review and guide. *Ann Farm Med* 2012;**10**:134–41.

24 Himelhoch S, Weller W, Wu A *et al*. Chronic medical illness, depression, and use of acute medical services among Medicare beneficiaries. *Med Care* 2004;**42**:512–21.

25 Unützer J, Schoenbaum M, Katon W *et al*. Healthcare costs associated with depression in medically Ill fee-for-service medicare participants. *J Am Geriatr Soc* 2009;**57**:506–10.

26 Vasiliadis HM, Dionne P, Préville M *et al*. The excess healthcare costs associated with depression and anxiety in elderly living in the community. *Am J Geriatr Psychiatry* 2013;**21**:536–48.

27 Kulkarni A, Balkrishnan R, Camacho F *et al*. Medication and health care service utilization related to depressive symptoms in older adults with psoriasis. *J Drugs Dermatol* 2004;**3**:661–6.

28 Vogeli C, Shields AE, Lee TA *et al*. Multiple chronic conditions: prevalence, health consequences, and implications for quality, care management, and costs. *J Gen Intern Med* 2007;**22(Suppl 3)**:391–5.

29 Préville M, Boyer R, Grenier S *et al*. The Epidemiology of Psychiatric Disorders in Quebec's Older Adult Population. *Can J Psychiatry* 2008;**53**:822–32.

30 Crum R, Anthony J, Bassett S *et al*. Population-based norms for the mini-mental state examination by age and education level. *JAMA* 1993;**269**:2386–91.

31 Vasiliadis H, Latimer E, Dionne P *et al*. The costs associated with antidepressant use in depression and anxiety in community-living older adults. *Can J Psychiatry* 2013;**58**:201–9.

32 Betancourt MT, Roberts KC, Bennett TL *et al*. Monitoring chronic diseases in Canada: the Chronic Disease Indicator Framework. *Chronic Dis Inj Can* 2014;**34(Suppl 1)**:1–30.

33 Public Health Agency of Canada. PHAC, 2014—Chronic disease InfobaseData Cubes, 2014. http://www.infobase.phac-aspc.gc.ca (3 June 2015, date last accessed).

34 Quan H, Sundararajan V, Halfon P *et al*. Coding algorithms for defining comorbidities in ICD-9-CM and ICD-10 administrative data. *Med Care* 2005;**43**:1130–9.

35 d'Hoore W, Bouckaert A, Tilquin C. Practical considerations on the use of the Charlson comorbidity index with administrative data bases. *J Clin Epidemiol* 1996;**49**:1429–33.

36 Statistics Canada. Comparable health indicators—Canada, provinces and territories—27-OI 180-day survival rate for stroke, 2009. Available at: http://www.statcan.gc.ca/pub/82-401-x/2009000/considerations/oi/27oi-eng.htm (Consulted 03.06.2015).

37 Public Health Agency of Canada (PHAC). Life with Arthritis in Canada: A personal and public health challenge, 2010. http://www.phac-aspc.gc.ca/cd-mc/arthritis-arthrite/lwaic-vaaac-10/pdf/arthritis-2010-eng.pdf (10 September 2015, date last accessed).

38 Drummond MF, Sculpher MJ, Torrance GW *et al*. *Methods for the Economic Evaluation of Health Care Programmes*. 3rd edn. Oxford (GB): Oxford Medical Publications, 2005.

39 McCullagh P, Nelder J. *Generalized Linear Models*. New York: Chapman & Hall, 1983.

40 Courtemanche R, Tarte F. Sampling Plan for the Québec Health Survey, *Technical Manual 87–02*. Quebec: Ministry of Health and Social Services, Goverment of Quebec, 1987.

41 Naylor C, Parsonage M, McDaid D *et al*. *Long-term conditions and mental health: the cost of co-morbidities*. The King's Fund, London, UK, 2012. ISBN 9781857176339. http://www.kingsfund.org.uk/sites/files/kf/field/field_publication_file/long-term-conditions-mental-health-cost-comorbidities-naylor-feb12.pdf.

42 Ghose SS, Williams LS, Swindle RW. Depression and other mental health diagnoses after stroke increase inpatient and outpatient medical utilization three years poststroke. *Med Care* 2005;**43**:1259–64.

43 Dossa A, Glickman ME, Berlowitz D. Association between mental health conditions and rehospitalization, mortality, and functional outcomes in patients with stroke following inpatient rehabilitation. *BMC Health Serv Res* 2011;**11**:311.

44 Hochlehnert A, Niehoff D, Wild B *et al*. Psychiatric comorbidity in cardiovascular inpatients: costs, net gain, and length of hospitalization. *J Psychosom Res* 2011;**70**:135–9.

45 Baumeister H, Haschke A, Munzinger M *et al*. Inpatient and outpatient costs in patients with coronary artery disease and mental disorders: a systematic review. *Biopsychosoc Med* 2015;**9**:11.

46 Dalal AA, Shah M, Lunacsek O *et al*. Clinical and economic burden of depression/anxiety in chronic obstructive pulmonary disease patients within a managed care population. *COPD* 2011;**8(4)**:293–9.

47 Rothman K, Greenland S. *Modern Epidemiology*. 2nd edn, Philadelphia: Lippincott-Raven, 1998.

48 Canadian Institute for Health Information. *Health Indicators 2013*. Ottawa, ON: CIHI, 2013.

49 Wittenberg R. The challenge of measuring multi-morbidity and its costs. *Isr J Health Policy Res* 2015;**4**:1.