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Research Article

# Impact of Chronic Conditions and Multimorbidity on the Disability Burden in the Older Population in Belgium

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## Abstract

**Background:** The increase in longevity along with a high prevalence of chronic conditions contribute to increased disability burden. Despite the high occurrence of multimorbidity observed in advanced ages, most studies are restricted to the investigation of individual diseases. In this study, we assessed the impact of chronic conditions and multimorbidity on the disability burden in the older population in Belgium.

**Methods:** Data from 9,482 participants in the 2001, 2004, or 2008 Belgian Health Interview Surveys aged 55 years or older were analyzed. Disability was defined based on the Global Activity Limitation Indicator (GALI). To attribute disability to single chronic conditions and disease pairs, a multiple additive hazard model was fitted.

**Results:** Musculoskeletal conditions (45.3%), chronic respiratory diseases (11.2%), and cardiovascular diseases (10.2%) diseases were the most frequent conditions. Cardiovascular diseases, the co-occurrence of chronic respiratory diseases and depression, neurological diseases, cancer, and the combination of diabetes and cardiovascular diseases were the top five disabling conditions. The disability prevalence in the older population in Belgium was 35.6% (confidence interval =35.0; 36.2%). The most important contributors to the disability burden were musculoskeletal, cardiovascular, and chronic respiratory diseases.

**Conclusions:** The present findings provide a deeper understanding of the role of chronic conditions and multimorbidity on the disability burden in the older population in Belgium. Although the disease pairs showed a low contribution to the disability burden, their occurrence presented a high impact on disability. Prevention strategies to tackle disability should target the main contributors to the disability burden and the most disabling conditions/disease pairs, especially in the clinical practice.

**Keywords:** Disability—Chronic conditions—Multimorbidity—GALI—Older population

Population aging is accompanied with a growing proportion of older individuals living with chronic conditions. Chronic diseases/conditions are among the main causes of disability (1,2), impacting quality of life and health care use (3). Multimorbidity, that is, the co-occurrence of diseases within an individual (4), is also common in advanced ages and is related with complex clinical management, disability, and mortality (5–8).

Few studies have assessed the impact of multimorbidity on disability using cross-sectional data (1,2,9–12). Among the studies that investigated the role of multimorbidity on disability, this association was assessed using logistic (2,10,11) or linear (1,9,12) regression models. Although logistic regression can be used to calculate the population attributable fraction, it does not allow the partition of the total disability rate into additive cause-specific rates in the presence of multimorbidity. To attribute disability to chronic conditions and multimorbidity using cross-sectional data, Nusselder and Looman have proposed the use of multiple additive hazards models (13), analogous to the mortality analysis in the presence of competing risks (14–16). Although the attribution method has been widely

used to assess the cause-specific disability prevalence in several countries (13,17–22), multimorbidity was not taken into account in any previous study.

Several disability measurements have been developed (based on activities of daily living (ADLs) and instrumental activities of daily living, for example) and the use of different disability indicators hampers comparability between studies. To improve international harmonization in the disability measurement, the Global Activity Limitation Indicator (GALI) has been proposed to assess self-perceived long-term activity limitations based on a single-item question (23). The GALI has been included in several European surveys and it is used to calculate the indicator "Healthy Life Years" proposed by the European Union to monitor population health (24).

In this study, we investigated the impact of chronic conditions and multimorbidity on the disability burden in the population aged 55 years and older in Belgium, using the attribution method (13) with the GALI (25) as the disability indicator.

## Methods

### Data

Participants aged 55 years or older who participated in the Health Interview Survey (HIS) in Belgium in 2001, 2004, or 2008 were included in the analysis. The HIS is a national household survey representative of the Belgian population, including approximately 10,000 individuals per year, selected based on multistage design. The response rate varied from 55% (2008) to 61% (2001 and 2004). The sample included older individuals living in nursing homes and homes for the older adults, and proxy interviews were allowed. The sampling design was taken into account by the inclusion of sample weights in the analysis. A detailed description of the HIS methodology can be found elsewhere (26).

Of the 12,645 individuals aged 55 years or older in the pooled data of the three HIS, 2,516 (20%) did not have information on disability and 908 (7%) on chronic conditions, resulting in a sample of 9,482 (75% of the original sample) participants. A higher proportion of women, oldest old individuals, low educated, proxy interviews, institutionalized individuals, individuals admitted to hospitals, and individuals with severe limitations (difficulties in performing at least one ADL task and/or mobility restriction) were observed among individuals who were excluded from the analysis (Supplementary File 1).

### Disability

Disability was based on the GALI, which was included in the self-administered questionnaire of the three surveys. The GALI was previously validated against other disability measures in several European countries (25,27,28). It consists of a single question related to general activity restrictions: "For the past 6 months or more have you been limited in activities people usually do because of a health problem?". The possible answers are 1. "Yes, strongly limited"; 2. "Yes, limited"; 3. "No, not limited" (19). In this study, the term "disability" is used to represent "difficulties in performing usual activities," as captured by the GALI. Disability was defined as answer 1 or 2 to the GALI question.

### Chronic Conditions

Participants were asked about the presence of selected chronic conditions in the year preceding the interview. We focused on six chronic conditions/groups: chronic respiratory diseases (asthma, chronic bronchitis, and chronic pulmonary diseases), diabetes, cancer, depression, cardiovascular diseases (ischemic heart diseases or stroke), musculoskeletal conditions (low back pain, osteoporosis, rheumatoid arthritis, or osteoarthritis), and neurological diseases (epilepsy and Parkinson's disease). These diseases were included in the analysis because they were available in the three HIS and showed an important contribution to the ADL and mobility limitation prevalence in Belgium (22).

The questions related to ischemic heart diseases and back pain were modified over the three surveys. Although the wording "serious heart disease or heart attack" was included in the 2001 and 2004 HIS, two separate questions were included in the 2008 HIS: "myocardial infarction" and "coronary heart diseases (angina pectoris)." In the present analysis, these two 2008 HIS questions were grouped, and "ischemic heart disease" was considered present if the participant reported at least one of the two diseases.

In 2001 and 2004, back pain was defined as "chronic spinal condition for longer than 3 months, lumbago, sciatica, and disc prolapsed," but in 2008, it was modified to "low back disorder or other chronic back problems." Back pain was considered present if an individual answered "yes" to any of these questions.

### Statistical Analysis

To assess the contribution of chronic conditions to the disability burden using cross-sectional data, the attribution method (13,29) was used. The rationale of the method is analogous to the cause-specific mortality analysis, in which one underlying cause of death is assigned in the death certificate: here, we aim to attribute each disability case identified in the survey to chronic conditions, even if individuals report more than one chronic condition (multimorbidity) or none (29). Disability that is not attributed to any chronic condition included in the analysis is labeled "background." The background represents the disability that is not associated with any condition, disability causes not included in the survey (such as injuries and dementia), and underreported and underdiagnosed conditions (13,18,29).

The attribution of disability to chronic conditions depends on the prevalence of each chronic condition and the hazard rate of disability for each condition. The disability hazard rates are obtained using the multiple additive hazards model, as shown in Equation (1). Analogous to the multiple decrement life table analysis (16), in which an exponential function is used to convert a probability (cause-specific probability of death) to a rate (cumulative force of mortality) in the presence of competing risks (14–16), in the attribution method, the exponential function is applied to the disease-specific disability hazard rate to obtain the disability probability by cause, in the presence of multimorbidity (13,29).

$$\hat{y} = 1 - \exp[-(\eta)],$$

$$\eta = \alpha + \sum_{d=1}^{m} \beta_d X_d. \quad (1)$$

In the model, the exponential function is used to obtain the estimated disability probability ( $\hat{y}$ ) as a function of the total disability hazard rate ($\eta$). The total disability hazard rate is defined as the sum of the background disability hazard rate ($\alpha$) and the disease-specific disability hazard rate (disabling impact) for each condition and disease combinations ($\beta_d$); and $X_d$ represents the dummy variable for each condition and disease combinations $d$.

The estimation of the hazard rates of disability using cross-sectional data is feasible given the assumptions of the method: (i) the distribution of disability by cause (chronic conditions) at the time of the survey is entirely explained by the conditions that are still present at the time of the survey and the background; (ii) the distribution of disability by cause is proportional to the distribution of the risk to become disabled in the period preceding the survey; (iii) all individuals aged 55 years or older are exposed to the same background disability hazard rate; (iv) the start of the time at risk for disability from each cause is the same; and (v) the disease-specific disability rates do not vary across age groups. Different from previous studies (13,29), we violate the assumption of independence between competing causes (chronic conditions) by including disease pairs (two-way interactions) in the model.

Here, disability burden refers to the disability prevalence, as our analysis is based on cross-sectional data. Also, for simplification, the cause-specific disability hazard rates will be labeled "disability rates" or "disabling impacts," and they represent the rate of disability in individuals reporting a given condition (1). Likewise, the background disability hazard rate will be labeled "background rate."

### Calculation of the Contribution of Chronic Conditions to the Disability Prevalence

The prevalence of disability by cause was obtained by calculating the total disability probability for each individual, defined as the sum of the disability probability due to condition $d\left(\left(\beta_d X_d/\eta\right)\times\hat{y}\right)$ and the disability probability due to background $\left((\alpha/\eta)\times\hat{y}\right)$.

The total number of individuals with reported disability by each condition, disease pairs, and background was obtained by the sum of cause-specific probabilities in the sample. Finally, the contribution of each chronic disease and disease pairs to the disability burden (disability prevalence by cause) was obtained by dividing the number of individuals with reported disability for each cause by the total number individuals in the sample.

Confidence intervals (CIs) for the disease prevalence, disabling impacts, and contributions were obtained via bootstrapping using 1,000 replicates of the same size of the original data (30). Disease combinations were selected via backward-stepwise selection procedure.

All analysis were carried out in R, version 3.2.1 (31). The R code developed by Nusselder and Looman (13,29) was used to fit the multiple additive hazards model and to assess the attribution of disability to chronic conditions.

## Results

Most of the individuals with reported disability were women (58%), old (74% aged 65 years or older), and with low education level (more than one third reported primary school as the highest education attainment). Only 3% of the participants who reported disability had a proxy interview, and 5% lived in institutions (these proportions were two times higher in the individuals with disability compared with the individuals without disability). The proportion of hospitalization in the year preceding the survey was 2.6 times higher in individuals with disability compared with individuals without disabilities, reaching 25% in the former group (Table 1).

The proportion of older participants without any reported chronic condition was more than three times higher in individuals without disability (53%) compared with individuals with disability (16%). However, the occurrence of one chronic disease was similar among individuals with (31%) and without (30%) disability. The proportion of individuals with two or more chronic conditions was much larger among individuals with disability. Also, ADL and mobility limitations were more common in individuals with disability than in individuals without disability (Table 1).

**Table 1.** Characteristics of the Study Population by Disability Status. Health Interview Survey, Belgium, 2001, 2004, and 2008

| | Disability* | | | | |
|---|---|---|---|---|---|
| | No | | Yes | | |
| Characteristic | *n* | % | *n* | %‡ | *p* Value† |
| Survey year | | | | | .721 |
| 2001 | 1,821 | 31.6 | 1,179 | 31.7 | |
| 2004 | 2,261 | 39.3 | 1,433 | 38.5 | |
| 2008 | 1,679 | 21.1 | 1,109 | 29.8 | |
| Gender | | | | | <.001 |
| Male | 2,743 | 47.6 | 1,583 | 42.5 | |
| Female | 3,018 | 52.4 | 2,138 | 57.5 | |
| Age group (years) | | | | | <.001 |
| 55–64 | 2,500 | 43.4 | 970 | 26.1 | |
| 65–74 | 1,872 | 32.5 | 1,090 | 29.3 | |
| 75–84 | 944 | 16.4 | 969 | 26.0 | |
| ≥ 80 | 445 | 7.7 | 692 | 18.6 | |
| Education level | | | | | <.001 |
| No diploma | 106 | 1.8 | 116 | 3.1 | |
| Primary | 1,384 | 24.0 | 1,283 | 34.5 | |
| Secondary | 2,504 | 43.5 | 1,515 | 40.7 | |
| Tertiary | 1,601 | 27.8 | 706 | 19.0 | |
| Missing information | 166 | 2.9 | 101 | 2.7 | |
| Proxy interview | 75 | 1.3 | 103 | 2.8 | <.001 |
| Living in institution§ | 77 | 2.4 | 133 | 4.8 | <.001 |
| Hospitalization rate‖ | 374 | 9.5 | 631 | 24.8 | <.001 |
| Number of chronic conditions¶ | | | | | <.001 |
| 0 | 3,048 | 52.9 | 580 | 15.6 | |
| 1 | 1,735 | 30.1 | 1,166 | 31.3 | |
| 2 | 682 | 11.8 | 959 | 25.8 | |
| 3 | 246 | 4.3 | 613 | 16.5 | |
| 4 | 42 | 0.7 | 285 | 7.6 | |
| ≥5 | 8 | 0.1 | 118 | 3.2 | |
| ADL limitations# | 291 | 5.1 | 1,343 | 36.1 | <.001 |
| Mobility limitations** | 360 | 6.2 | 1,515 | 40.7 | <.001 |

*Notes:* ADL = activity of daily living.

*Disability measured by the Global Activity Limitation Indicator, which measures difficulties in performing usual activities.

†The *p* values were obtained by the $\chi^2$ test.

‡The percentages are not weighted; they represent the proportion of each characteristic in the study population and not the prevalence.

§Restricted to the individuals aged 65 years and older (*N* = 6,012)

‖Hospitalization in the year preceding the interview. Information is available only for the 2004 and 2008 surveys (*N* = 6,482)

¶Chronic conditions included: chronic respiratory diseases, diabetes, cancer, depression, ischemic heart diseases, stroke, osteoporosis, back pain, osteoarthritis, rheumatoid arthritis, Parkinson's disease, and epilepsy.

#ADL considered: getting in and out of bed, getting in and out of chair, dressing and undressing, washing hands and face, feeding and cutting up food, and using the toilet. ADL limitations were considered present if the respondent reported having any degree of difficulty in performing at least one ADL task.

**Ability to walk without stopping and severe discomfort less than 200 m.

The disability prevalence increased with the number of chronic conditions, reaching almost 100% in the individuals with five or more chronic conditions (Figure 1).

The overall disability prevalence was 35.6% (CI = 35.0; 36.2%) in the older population in Belgium. The contribution of chronic diseases/conditions to the disability prevalence depends on the prevalence of the condition and its disability rate. Table 2 shows the prevalence of chronic conditions/groups (main diagonal) and disease pairs (off-diagonal) in the study population. Musculoskeletal conditions were by far the most prevalent condition (45.3%), followed by chronic respiratory diseases (11.8%), cardiovascular diseases (10.2%), diabetes (8.4%), and depression (6.5%). The most common disease combinations were musculoskeletal and chronic respiratory diseases (7%) and the co-occurrence of musculoskeletal and cardiovascular diseases (5.6%). A low prevalence of neurological diseases (<2%) was observed.

Figure 2 shows the disability rates and the contribution of the background, chronic conditions, and disease pairs to the disability burden. The most disabling diseases (largest values in the x axis) were the co-occurrence of chronic respiratory diseases and depression (1.48), followed by the combination of diabetes and cardiovascular diseases (1.45), cardiovascular diseases (0.71), neurological diseases (0.65), and cancer (0.64). Background (0.14) and the occurrence of diabetes without other diseases (0.24) were the least disabling conditions.

Musculoskeletal conditions (11.8%; CI = 11.4; 12.1%) were the most important contributor to the total disability prevalence, followed by the background (11.3%; CI = 11.3; 11.4%), cardiovascular diseases (4%; CI = 3.7; 4.4%), chronic respiratory diseases (3.2%; CI = 2.9; 3.4%), and depression (1.5%; CI = 1.3; 1.7%). The disease pairs were not important contributors to the total disability burden, as each disease combination contributed 0.3% to the disability prevalence (Figure 2).

## Discussion

Beyond the contribution of single diseases to the disability burden, this study was the first to apply the attribution method to investigate the role of disease co-occurrence in the disability prevalence. The increased disability prevalence observed with the cumulative effect of chronic conditions highlights the importance of taking into account multimorbidity when investigating the disability burden (1,8,12).

The main contributors to the disability burden in the population aged 55 years and older in Belgium were musculoskeletal, cardiovascular, and chronic respiratory diseases. The attribution results were very similar to a previous study, which also used the Belgian HIS data, but with a different disability definition (22).

Both the disease prevalence and disease-specific disability rate determine the contribution of chronic conditions and disease pairs to the disability burden (13,18,22). Thus, the most important contributors to the disability burden are not necessarily the most common conditions or the conditions that result in high disability (1,18,22). For example, the high contribution of musculoskeletal conditions was a result of its very high prevalence (45.3%) and moderate disability rate (0.37). In other words, the risk of disability is not very high in individuals with musculoskeletal conditions (moderate disabling impact), but because it is so common in the population (high prevalence), the sum of individual moderate risks resulted in a large contribution to the total disability prevalence.

High contribution of musculoskeletal conditions to the disability burden was also found in other countries (18,19,21,32). The large contribution of cardiovascular diseases and chronic respiratory diseases to the disability prevalence might be associated with modifiable lifestyle risk factors, such as physical inactivity, smoking, obesity, and harmful alcohol use (33,34). However, future studies are needed to better investigate the role of risk factors in the disability burden. The large background contribution observed might indicate that important disability causes were not included in the analysis, such as mental disorders (35) and consequences of accidents (18).

The information obtained by the disabling impacts is also relevant, especially for the development of disability prevention strategies in the clinical practice (2). Both disease pairs that were significant in the models presented a positive disabling impact, indicating a synergistic effect, that is, the co-occurrence of chronic respiratory diseases and depression or diabetes and cardiovascular diseases results in a higher

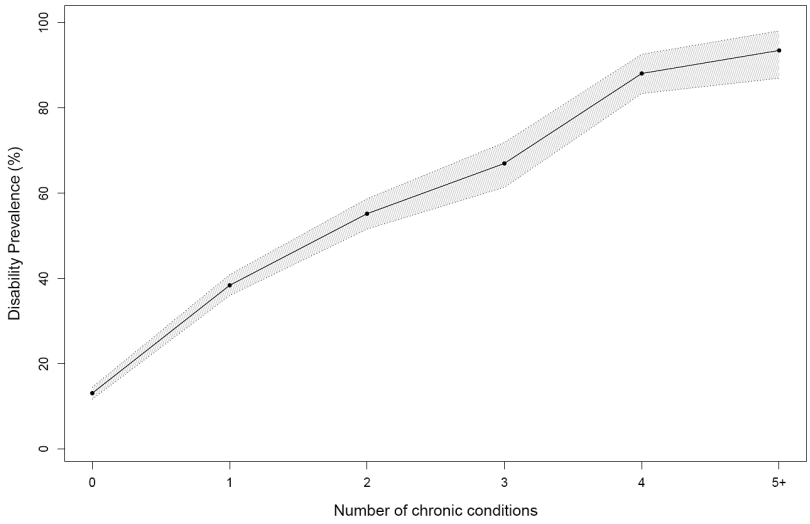


**Figure 1.** Disability prevalence according to the number of chronic conditions, Health Interview Survey, Belgium, 2001, 2004, and 2008. Eleven chronic conditions included: chronic respiratory diseases (asthma and chronic pulmonary diseases), diabetes, cancer, depression, ischemic heart diseases, stroke, osteoporosis, back pain, arthritis (osteoarthritis and rheumatoid arthritis), Parkinson's disease, and epilepsy. The shaded area corresponds to the bootstrap percentile confidence intervals.

**Table 2.** Prevalence of Chronic Conditions and Percentile Bootstrap Confidence Intervals, Health Interview Survey, Belgium, 2001, 2004, and 2008

| Diseases/Conditions | Chronic Respiratory Diseases | Diabetes | Cancer | Depression | Cardiovascular Diseases | Musculoskeletal Conditions | Neurological Diseases |
|---|---|---|---|---|---|---|---|
| Chronic Respiratory Diseases | 11.8 (10.9; 12.6) | | | | | | |
| Diabetes | 1.6 (1.3; 1.9) | 8.4 (7.7; 9.1) | | | | | |
| Cancer | 0.7 (0.4; 1.0) | 0.3 (0.2; 0.5) | 3.5 (2.9; 4.1) | | | | |
| Depression | 1.3 (1.1; 1.6) | 0.9 (0.7; 1.2) | 0.4 (0.2; 0.6) | 6.5 (5.8; 7.3) | | | |
| Cardiovascular Diseases | 2.5 (2.1; 2.9) | 1.5 (1.3; 1.8) | 0.6 (0.4; 1.0) | 1.0 (0.7; 1.2) | 10.2 (9.4; 11.1) | | |
| Musculoskeletal Conditions | 7.0 (6.4; 7.7) | 4.2 (3.7; 4.7) | 1.9 (1.4; 2.3) | 4.6 (3.9; 5.3) | 5.6 (5.1; 6.2) | 45.3 (43.9; 46.7) | |
| Neurological Diseases | 0.3 (0.2; 0.4) | 0.3 (0.1; 0.4) | 0.1 (0.0; 0.1) | 0.2 (0.1; 0.4) | 0.2 (0.1; 0.4) | 0.7 (0.5; 0.9) | 1.3 (1.0; 1.6) |

*Note:* Weighted prevalence is presented; Chronic respiratory diseases: asthma, chronic bronchitis, and chronic obstructive pulmonary disease; Cardiovascular diseases: stroke and ischemic heart diseases; Musculoskeletal conditions: low back pain, arthritis, and osteoporosis; Neurological diseases: epilepsy and Parkinson's disease.

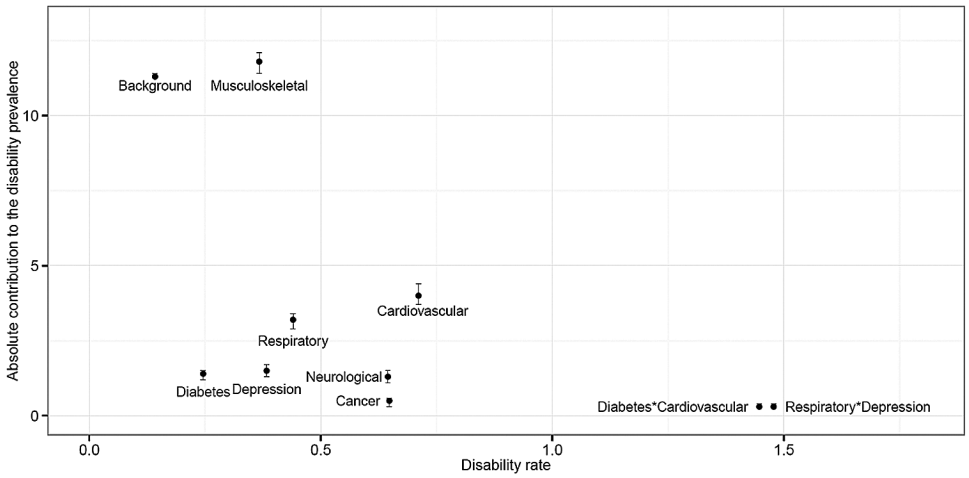


**Figure 2.** Disability rate and absolute contribution of chronic conditions to the disability burden, Health Interview Survey, Belgium, 2001, 2004, and 2008. The bars correspond to the bootstrap percentile confidence intervals for the contributions. Respiratory: chronic respiratory diseases; Cardiovascular: cardiovascular diseases; Musculoskeletal: Musculoskeletal conditions; Neurological: Neurological diseases. Background: disability causes that were not included in the analysis. The disability rates represent the rate of disability among diseased individuals. The contribution of each chronic condition and the background sum to the total disability prevalence.

risk of disability than is expected by the combination of the separate disease effects (2). For example, the disability rate in individuals with diabetes only is 0.38 [0.14 (background disability rate) + 0.24 (diabetes disability rate)]; for individuals with cardiovascular diseases only, the total disability rate is 0.85 [0.14 (background disability rate) + 0.71 (cardiovascular diseases disability rate)]; and the total disability rate for individuals with both diabetes and cardiovascular diseases is 1.58 [0.14 (background disability rate) + 0.24 (diabetes disability rate) + 0.71 (cardiovascular diseases disability rate) + 0.49 (interaction between diabetes and cardiovascular diseases)]. Using the exponential function to convert the disability rate to a probability, we obtain the disability probability due to diabetes only is 0.32 (1 – exp(–0.38)); due to cardiovascular diseases only is 0.57(1 – exp(–0.85)); and due to diabetes and cardiovascular diseases is 0.79 (1 – exp(–1.58)).

Despite the low contribution of these disease combinations to the total disability prevalence, mainly because of their low frequency in the population, multimorbidity also deserves attention. As an example, individuals with diabetes can be screened for cardiovascular diseases to prevent among other complications, also disability.

Although the individual effects of chronic respiratory diseases and depression showed a moderate impact on disability, the co-occurrence of these two diseases showed a high disability rate. Depression has been associated with chronic respiratory diseases, especially with chronic obstructive pulmonary disease (36–38). It has also been shown that depression is related to chronic obstructive pulmonary disease severity, and the co-occurrence of these diseases impacts quality of life by restricting social participation (36).

In contrast with previous findings (1,2,9–12), the combination of diabetes and cardiovascular diseases was associated with a high disability rate in the present study. Cardiovascular diseases are the main cause of morbidity and mortality in individuals with diabetes (39). The results of the National Health and Nutrition Examination Survey (NHANES) in the United States from 1999 to 2006 showed that, among the diabetes-related comorbidities, cardiovascular diseases showed the highest association with functional limitations in older adults (40).

It is also interesting to note that the high impact caused by cancer on disability was not found in a previous study conducted in Belgium, which used the attribution method, but disability was defined based on ADL and mobility limitations (22). Although cancer is a major cause of mortality, it is also strongly related to disability among cancer survivors (41). The difference between the two studies using the Belgian HIS might be related to the broader

disability concept captured by the GALI, which is beyond functional limitations, including also participation restriction (25).

The comparison of the present results with previous studies is limited due to differences in the target population, the definition of disability, the chronic conditions included in the analysis, the model used to assess the impact of chronic conditions and multimorbidity on the disability burden, how multimorbidity was taken into account, and the method used to select disease interactions. One drawback of most of the studies that included multimorbidity in the analysis (1,9–11) is related to multiple testing. Different from the present study, most of these studies assessed the effect of multimorbidity by fitting several models for two individual diseases and their combination separately. However, a correction for multiple statistical testing should be used in this case, as multiple null hypotheses are being tested (42). Therefore, these results should be interpreted carefully, as the null hypothesis of no interaction effect may be incorrectly rejected.

Some limitations should be considered in the present study. The low response rates observed in the three HIS and the exclusion of individuals without information about chronic conditions or the GALI may have resulted in selection bias. In the last case, individuals with missing information showed characteristics that are associated with higher disability risk (43) (Supplementary File 1), which underestimates the prevalence of chronic conditions and disability. Also, causality cannot be assessed with cross-sectional data, that is, we are not certain that disease caused disability, as assumed by the attribution method used here. As a result, disability was wrongly attributed to diseases in cases that the disability onset occurred prior to the onset of disease. Despite the plausibility of the causality assumption between diseases and disability, this association is based on a statistical model, which does not necessarily imply causal or clinical association. The attribution method was developed as an attempt to attribute the self-reported disability cases in a survey to self-reported chronic conditions. Therefore, incorrect attributions might also have occurred as a consequence of possible violations of the assumptions of the method.

Additionally, the changes in the heart attack and back pain questions over the successive HIS resulted in a higher prevalence of back pain and lower prevalence of heart attack in 2008, as shown previously (44). Furthermore, the use of self-reported chronic conditions might have underestimated their prevalence, because the validity of self-reports is disease specific (44). In addition, the use of only six chronic conditions/groups in the current analysis may have underestimated multimorbidity. The classification of conditions using disease/conditions groups (musculoskeletal conditions, cardiovascular, and neurological diseases) does not allow the assessment of individual diseases (12). Also, no stratification of the disability rates was applied by age, gender, and education level although some studies previously showed a difference in the disability rates according to these covariates (17–20,22). The use of a simplified approach in the present study was preferred due to the limited sample size to detect disease/condition interactions. Although the chronic conditions considered here are strongly associated with disability (43), important causes for older individuals, such as mental disorders (8) and injuries (18), were not included in the models, because they were not systematically available in the three successive HIS. Despite the identification of different contributors to the disability burden according to the level of disability in a previous study conducted in Belgium (45), the present study did not distinguish between disability severity due to the limited sample size to detect interaction between diseases by fitting separate models for each disability severity level. Also, the GALI showed a small misclassification, as individuals who reported no limitations in the GALI question, reported ADL ($n$ = 291; 5.1%) and/or mobility limitations ($n$ = 360; 6.2%). Most of these misclassified cases were individuals with moderate levels of ADL ($n$ = 260) and mobility limitations ($n$ = 967), suggesting that the GALI can better capture dependence or severe limitations in ADL and mobility.

Moreover, the fact that only two disease interactions showed an impact on disability should be carefully interpreted, as the low number of significant disease pairs can be related to the low power to detect interactions due to the low frequency of most diseases combinations. Finally, although higher order disease interactions, such as the combination of three diseases, might be of importance and also associated with increased disability burden, they were not considered in this study due to the limited sample size to detect these interactions.

Nonetheless, this study had the advantage of using a representative data from the older Belgian population, including individuals living in institutions. Another added value was the use of disability defined based on the GALI, which incorporates participation restriction on the definition of disability and allows better comparability with other large-scale international studies using the same instrument, such as the Survey of Health, Ageing and Retirement in Europe (SHARE) (28). It is also important to mention the inclusion of depression in the analysis, which was among the main contributors to the disability prevalence. In addition, the inclusion of multimorbidity in the analysis allowed the assessment of the contribution of disease pairs to the disability prevalence.

The present findings provide a deeper insight of the impact of chronic conditions on the disability burden in the older adults in Belgium. The increase in life expectancy accompanied by the disability burden poses severe challenges to the health care system and the society. Thus, the present results emphasize the need for policy makers to define prevention strategies to tackle disability, targeting musculoskeletal, cardiovascular, and chronic respiratory diseases at the population level. In addition to the main contributors, clinicians should also be aware of the co-occurrence of chronic respiratory diseases and depression, and the combination of diabetes and cardiovascular diseases, at the individual level, as these combinations result in increased disability probability. Our results support the inclusion of multimorbidity when assessing the disability burden.

## Supplementary Material

Please visit the article online at http://gerontologist.oxfordjournals.org/ to view supplementary material.

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## Conflict of Interest

The authors declare no conflict of interest.

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