Somatic Multimorbidity and Self-rated Health in the Older Population

Henrike Galenkamp, Arjan W. Braam, Martijn Huisman, and Dorly J.H. Deeg

Department of Epidemiology and Biostatistics, EMGO Institute for Health and Care Research, VU University Medical Center, Amsterdam, The Netherlands.

Department of Emergency Psychiatry, Altrecht Mental Health Care, Utrecht, The Netherlands.

Department of Sociology, VU University, Amsterdam, The Netherlands.

Department of Psychiatry, EMGO Institute for Health and Care Research, VU University Medical Center, Amsterdam, The Netherlands.

Objectives. Chronic diseases are important predictors of self-rated health (SRH). This study investigated whether multimorbidity has a synergistic or cumulative impact on SRH. Moderation by gender and age was examined.

Methods. Data originated from the Longitudinal Aging Study Amsterdam (N = 2,046, aged 57–98 years). We assessed the presence of lung disease, cardiac disease, peripheral atherosclerosis, stroke, diabetes mellitus, arthritis, and cancer. SRH was measured with the question “How is your health in general?” including 5 response categories. Generalized ordered probit models were applied; possible synergism was examined by testing for nonlinearity of the association.

Results. The association between multimorbidity and SRH was non-linear in that the effect of having a single disease was larger than the added effects of co-occurring diseases. However, from the second disease onward, each additional co-occurring disease caused cumulative declines in SRH. Only in the oldest old (85+), the impact of a single disease was similar to that of co-occurring diseases. Results were similar for men and women.

Discussion. Our findings help to improve understanding of the impact multimorbidity has on SRH: Having a single disease increases the chance of poor health more than each co-occurring disease, indicating some overlap between diseases or adaptation to declining health.

Key Words: Aged—Aged 80 years and older (MeSH)—Comorbidity—Health status—Health status indicators.
MULTIMORBIDITY AND SELF-RATED HEALTH

the added effect of having multiple diseases. The second study found a dampening effect on SRH with increasing scores on a comorbidity index. This effect may be explained either by the fact that some diseases manifest themselves with similar symptoms showing overlapping effects on SRH or by the occurrence of adaptation to a declining health state.

As previous studies have provided no definite answer, the goal of this study was to investigate in a population-based sample of older adults whether multimorbidity has an exacerbating effect, a simple cumulative effect, or a dampening effect on SRH. To that end, the linearity of the association between a count of total number of chronic diseases and SRH was examined. We applied ordinal regression analysis that enables the assessment of the impact of multimorbidity for all categories of SRH and avoids information loss, which arises from using a dichotomy to represent the ordered categories of SRH.

We further examined whether multimorbidity has a different impact on SRH according to gender and age. First, chronic conditions are distributed differently between men and women (Molarius & Janson, 2002), and given comparable health status, Dutch men were shown to report worse SRH than women (Crimmins, Kim, & Solé-Auró, 2010). We expected a weakening association between chronic diseases and SRH with age because chronic disease may be viewed more as on-time events in older old than in younger old (Hoeymans et al., 1999; Pinquart, 2001; Wurm, Tomasik, & Tesch-Römer, 2008). On the other hand, the impact of diseases may increase with age because the prospect of disability, dependency on others, and dying is increased only further.

METHODS

Sample

Our sample was derived from the Longitudinal Aging Study Amsterdam (LASA), an ongoing multidisciplinary study focusing on predictors and consequences of changes in well-being and autonomy in the older population. Details on the sampling and data collection procedures have been described elsewhere (Huisman et al., 2011). In short, a random sample of older adults (age 55–85 years), stratified by age and gender according to expected 5-year mortality, was drawn from the population registries of 11 municipalities in three geographical regions of The Netherlands in 1992. Sample members were approached first for the program “Living arrangements and Social Networks of older Adults” by the Netherlands Program for Research on Aging (N = 3,805; response rate 62%; Broese van Groenou, van Tilburg, de Leeuw, & Liefbroer, 1995), and after an average of 10 months, the participants were approached for the LASA baseline measurement (N = 3,107; response rate 82%). The Medical Ethics Committee of the VU University Medical Center approved the LASA study; informed consent was obtained from all respondents. Respondents were examined in their homes by trained and supervised interviewers once every three years. In 2002, a group of 1,002 new respondents (aged 55–65 years; response rate 57%), sampled from the same sampling frame as the original cohort, was added to the sample.

Data from the fifth LASA cycle (conducted in 2005/2006) were used in this study. An advantage of using this recent measurement is that there is a wide range in the age of the respondents (57–98 years). Excluded respondents were those for whom questions were answered by a proxy (N = 117) and those with missing data on either chronic diseases or SRH (N = 2). In total, the number of respondents included in the current analyses was 2,046.

Of the participants who completed the previous interview in 2001/2002 (N = 2,693), 377 (14.0%) had died before 2005 and 151 (5.6%) were lost to follow-up because of refusal, frailty, or other reasons. Excluded respondents and nonresponders who were still alive in 2005 were older and had worse SRH at the previous measurement (p < .01), reported lower income and education levels (p < .01), were less often married (p < .01), and more often suffered from diabetes (p < .05) and stroke (p < .01).

Measures

SRH was assessed by the question: “How is your health in general?” Response categories were (1) very good, (2) good, (3) fair, (4) sometimes good, sometimes poor, and (5) poor (van Sonsbeek, 1991). Categories 4 and 5 were merged to avoid a large number of empty cells.

The presence of chronic diseases was determined by means of explicitly asking respondents whether they currently or previously had any of the following seven chronic diseases or disease events: chronic nonspecific lung disease (asthma, chronic bronchitis, or pulmonary emphysema), cardiac disease, peripheral atherosclerosis, stroke, diabetes mellitus, arthritis (rheumatoid arthritis and osteoarthritis), and cancer. The selection of these seven major chronic diseases was based on their prevalence (>5%) in the 55+ age group in The Netherlands (Kriegsman, Penninx, van Eijk, Boeke, & Deeg, 1996). In addition, respondents were asked to report a maximum of two other diseases, which were present for three months or longer for which they were being treated or regularly examined by a physician.

Included as possible confounders were marital status (married vs. unmarried) and income and education level as indicators of socioeconomic position because they were shown to be independently associated with SRH (Hays, Schoenfeld, & Blazer, 1996). Income level comprised three categories: low (< 935), intermediate (935–1,560), and high (> 1,560). The income of respondents living with a partner was multiplied by 0.7 to make their income comparable to that of one-person households (Koster et al., 2006). Persons with missing income data (N = 389) were assigned...
the category “missing.” During the baseline interview, respondents were asked about their highest level of education, expressed in years.

### Statistical Analyses

After describing basic characteristics of the sample, we applied generalized ordered regression analysis, using Stata 10 (Williams, 2006). Because SRH response categories follow an ordinal ranking. The probit link function was used, appropriate for the normally distributed outcome SRH. A disadvantage of the probit link function is that there is no straightforward interpretation of the generated regression coefficients. However, because our main interest was in the shape of the association between number of diseases and SRH, we chose the link function that best describes the data. As the assumption of parallel lines was violated, we applied a partial proportional odds model (Long & Freese, 2005; Williams, 2006). Constrained estimation of coefficients was applied for those categories of SRH where estimating equal coefficients was allowed (i.e., where the assumption of parallel lines was met).

A synergistic or cumulative impact of multimorbidity on SRH was defined as a nonlinear or linear association, respectively, between number of diseases and SRH. Linearity was examined with a generalized ordered probit model including SRH as the outcome measure and a variable for number of chronic diseases and its quadratic term as predictor variables. In case this quadratic term was significant, we concluded that a nonlinear association exists and dummy variables were then reported for each number of diseases, with no diseases as the reference category.

To examine significant effect modification by age and gender, we added product terms of these variables with the number of diseases to the model. In addition, product terms of age or gender with the quadratic term for number of diseases were added to examine whether nonlinearity was moderated by age or gender. In case there was evidence of effect modification we stratified the analyses and assessed the effects in different gender or age strata by applying the method proposed by Figueiras et al. (Figueiras, Domenech-Massons, & Cadarso, 1998). We recoded all age or gender categories into dummy variables such that the categories that were designated as reference groups were assigned zero, and we included product terms of these dummy variables with the independent predictor into the model. These models were estimated sequentially while alternating between all possible age and gender categories as reference groups.

Potential confounders were required to be associated both with the number of chronic diseases and SRH ($p < .20$). In case the regression coefficient of the predictor variable changed with more than 10% after adding the confounder, the confounder was retained in the final model.

The level of statistical significance was $p < .05$ for main effects. Because the power of statistical tests for higher order terms is generally lower than for first-order terms (Aiken & West, 1991), we chose $p < .10$ for interaction effects to reduce the chance that we would dismiss relevant modification effects. All analyses were adjusted for age in years and gender, in case gender was not an effect modifier, and were weighted to the age and gender distribution of the Dutch population at January 1, 2006.

### Results

Sample characteristics, weighted to the Dutch population, are presented in Table 1. Chi-square tests and Pearson’s correlations revealed that female gender ($p < .05$) as well as higher age, being unmarried, lower education, and lower income ($p < .001$) were associated with worse SRH (data not shown).

The association between number of chronic diseases and SRH was nonlinear. Therefore, the effects are shown for dummy variables indicating the number of diseases (Table 2). Because only 1.9% of the respondents had more than four

---

**Table 1. Characteristics of the Study Sample, Unweighted $N = 2,046$**

<table>
<thead>
<tr>
<th>Age (years)</th>
<th>Number of chronic diseases</th>
<th>Female gender</th>
<th>Married</th>
<th>Education (years)</th>
<th>Income</th>
<th>Self-rated health</th>
<th>Weighted mean ($SD/N$)</th>
</tr>
</thead>
<tbody>
<tr>
<td>69.2 (8.6)</td>
<td>1.5 (1.2)</td>
<td>54.3%</td>
<td>67.9%</td>
<td>10.0 (3.4)</td>
<td>4</td>
<td>1.2%</td>
<td>Average of $N=2,046$</td>
</tr>
<tr>
<td>1 = Very good</td>
<td>1 = Poor</td>
<td>3 = Fair</td>
<td>4 = Sometimes good, sometimes poor</td>
<td>5 = Poor</td>
<td>0</td>
<td>1</td>
<td>0</td>
</tr>
<tr>
<td>3 = Fair</td>
<td>2 = Good</td>
<td>3 = Fair</td>
<td>4 = Sometimes good, sometimes poor</td>
<td>5 = Poor</td>
<td>0</td>
<td>1</td>
<td>0</td>
</tr>
<tr>
<td>4 = Sometimes good, sometimes poor</td>
<td>1 = Very good</td>
<td>3 = Fair</td>
<td>4 = Sometimes good, sometimes poor</td>
<td>5 = Poor</td>
<td>0</td>
<td>1</td>
<td>0</td>
</tr>
<tr>
<td>5 = Poor</td>
<td>2 = Good</td>
<td>3 = Fair</td>
<td>4 = Sometimes good, sometimes poor</td>
<td>5 = Poor</td>
<td>0</td>
<td>1</td>
<td>0</td>
</tr>
</tbody>
</table>
MULTIMORBIDITY AND SELF-RATED HEALTH

The strongest effect of multimorbidity on SRH was found within dichotomization #2. In general, the increase in the positive coefficients indicates a decline in SRH with each increase in number of co-occurring diseases. However, the significant \( p \) values, reflecting negative nonlinear effects, indicate that the impact on SRH decreases with each increment in number of diseases. When persons without any disease were excluded (data not shown) and linearity was tested again with the continuous disease variable and its quadratic term, the quadratic term was not significant anymore. This indicates that nonlinearity was caused by the relatively large impact of having a single disease compared with co-occurring diseases, which showed cumulative declines in SRH.

There was no confounding effect of income level, education level, or marital status. In addition, gender or age in years did not moderate the association or the linearity of the association between number of diseases and SRH. However, when introducing four age categories, we found differences between the oldest old (aged 85+) and the other age groups, both in the shape \( (p < .05) \) and in the strength \( (p < .10) \) of the association. This effect was most pronounced in dichotomization #2. Therefore, Figure 1 displays the percentages with fair or poor SRH in each age group according to the number of diseases.

A linear association was found only in the oldest old, indicating a cumulative impact of diseases. Nonlinear associations in the other age groups again indicated a relatively large effect of having a single disease. A large effect of having a single disease was also found in persons aged 57–64 years and was not affected by the relatively large impact of having more than three compared with three diseases (Figure 1). This large effect of having more than three diseases also was not statistically significant from the effect in other age groups.

The impact of having one disease in the oldest old was smaller than in other age groups and was not significantly

Table 2. Generalized Ordered Regression Models for Predicting Self-rated Health With Number of Chronic Diseases in Total Sample

<table>
<thead>
<tr>
<th>N = 2,046</th>
<th>Dichotomization #1a, Good/fair/poor vs. very good</th>
<th>Dichotomization #2, Fair/poor vs. good/very good</th>
<th>Dichotomization #3a, Poor vs. fair/good/very good</th>
</tr>
</thead>
<tbody>
<tr>
<td>Number of diseases</td>
<td>Coeff (95% CI)</td>
<td>Coeff (95% CI)</td>
<td>Coeff (95% CI)</td>
</tr>
<tr>
<td>0</td>
<td>—</td>
<td>—</td>
<td>—</td>
</tr>
<tr>
<td>1</td>
<td>0.59 (0.43-0.76)</td>
<td>0.89 (0.67-1.11)</td>
<td>0.59 (0.43-0.76)</td>
</tr>
<tr>
<td>2</td>
<td>1.11 (0.93-1.30)</td>
<td>1.51 (1.29-1.73)</td>
<td>1.11 (0.93-1.30)</td>
</tr>
<tr>
<td>3</td>
<td>1.53 (1.30-1.77)</td>
<td>1.96 (1.71-2.21)</td>
<td>1.53 (1.30-1.77)</td>
</tr>
<tr>
<td>≥4</td>
<td>1.91 (1.65-2.18)</td>
<td>2.48 (2.17-2.78)</td>
<td>1.91 (1.65-2.18)</td>
</tr>
</tbody>
</table>

Notes: Link function used: Probit. Bold printed coefficients are significant at \( p < .05 \) (i.e., the null hypothesis that coefficients are equal to zero is rejected). The model is adjusted for age and gender.

\( a \)Coefficients for dichotomizations # 1 and # 3 in an unconstrained model were not statistically different \( (p > .05) \), therefore, they were equally estimated.

\( b \)Nonlinearity was tested in an ordinal regression model with a count variable of number of diseases together with its quadratic term.

Figure 1. Weighted percentages with less than good self-rated health (SRH) in the total sample and in each age group according to the number of chronic diseases.

*Nonlinearity was significant at \( p < .05 \), tested in an ordinal regression model with a count variable of number of diseases together with its quadratic term. *The nonlinear effect in this age group concerns the relatively large impact of having one disease, not the large impact of having more than three diseases.
different from the effect of having no diseases ($p = .285$). This might be caused by the fact that in this age group, the prevalence of poor SRH is already higher in those without any chronic diseases.

**Discussion**

In this study, the association between multimorbidity and SRH was investigated. The main finding was that multiple diseases did not have an exacerbating synergistic effect on SRH. In contrast, having a single disease increased the chance of having poorer health to a larger extent than each co-occurring disease, suggesting a synergistic dampening effect of multimorbidity, which was moderated by age. Nonetheless, the results showed that from the first disease onward, multimorbidity has a cumulative negative impact on SRH.

Although it is well known that having more diseases results in poorer SRH, in this study, we focused on the shape of the association between a count of the number of chronic diseases and SRH. Previous studies have shown that the individual impact of diseases on either a dichotomization of SRH (Hoeymans et al., 1999) or a decline in SRH (Heller et al., 2009) decreased with each increase in the number of conditions. Our results refine this finding in that having one disease showed a greater negative impact on SRH than co-occurring diseases. Co-occurring diseases were associated with smaller cumulative declines in SRH. Thus, when persons already have a chronic disease, the smaller added impact of having a second or third disease suggests that some extent of adaptation occurs. To some degree, symptoms associated with different diseases may show overlap; however, the fact that the impact does not further decrease with a third or fourth disease contradicts this hypothesis. Furthermore, it is likely that the severity of the already present symptoms increases when a second disease is accompanied by similar symptoms. A more likely explanation for our results is that the impact of having a first disease on SRH is of a different kind, for instance, with respect to the onset of disability or the need for health care. This hypothesis should be confirmed longitudinally in further research.

Significant associations, although weaker, were found when dichotomizing between the more extreme categories of SRH (e.g., poor vs. better than poor). Clearly, the number of diseases better differentiates between “good” and “less than good” health than between other categories of SRH. However, the results also show that chronic diseases still affect SRH, even when it is already less than good.

In contrast with our hypothesis and with the study by Crimmins and colleagues (2010), men did not rate their health worse than women. It might be that worse SRH in men is compensated for by more disability in women, which in this study we have not controlled for. Differential effects arising from different types of diseases—women more often suffer from disabling diseases and men from fatal diseases (Crimmins et al., 2010)—may be masked by the cumulation of different diseases. Future research may show whether there are gender effects in how the cumulation of specific diseases leads to worse SRH.

We found no evidence for a gradually decreasing impact of diseases on SRH with age, which is in contrast with other studies (Damian, Ruigomez, Pastor, & Martin-Moreno, 1999; Heller et al., 2009; Hoeymans et al., 1999). Thus, the hypothesis that the older old expect declining health and thus evaluate new diagnoses as “on-time” events was not confirmed (Wurm et al., 2008). We did find a large impact of having more than three diseases on SRH in persons aged 57–64 years. This might indicate that younger persons evaluate multimorbidity as an “off-time” event; however, the impact was not significantly different from that in other age groups. Duration since diagnosis was not included in our study, and it is possible, although not likely, that diseases were diagnosed a longer time ago in the younger old than in the older old, complicating the on-time/off-time theory. Having a single disease did show a smaller impact in the oldest old (85+) than in the younger groups. This may be due to the relatively poor SRH in those without diseases among the oldest old as compared with those without diseases in the younger groups. Both the expectation of deteriorating health and a worse health state without chronic diseases may play a role in this finding. A possible explanation is that frailty, which does not necessarily co-occur with chronic diseases (Fried, Ferrucci, Darer, Williamson, & Anderson, 2004), leads to a poor SRH in the oldest old.

A strong aspect of this study is that the results provide new information about the shape of the association between the number of chronic diseases and SRH in a population-based sample. A proportional odds model was used for SRH as the outcome measure. In such a model, more information about SRH categories could be obtained than from using a simple dichotomy to represent the ordered SRH categories. In addition, in a partially constrained model, different coefficients are estimated only if necessary.

Some limitations of this study should be addressed. Although it was shown that self-reports about chronic diseases are fairly accurate as compared with general practitioner reports (Kriegsman et al., 1996), studying the association between self-reported diseases and self-reported health might introduce response bias, which leads to artificially inflated associations between chronic diseases and SRH. However, we do not see how such bias could account for the finding that first diseases have a relatively large impact on SRH. Loss to follow-up is an inevitable consequence of a longitudinal study among older persons. However, we do not expect that the results are affected by attrition to a large extent because nonresponse analysis did not show an effect of multimorbidity on attrition and also because it was shown earlier that prevalences are, but associations are not necessarily affected by attrition.
MULTIMORBIDITY AND SELF-RATED HEALTH

(Keinpen & van Sonderen, 2002). The response rate in the younger cohort may be seen as relatively low, but compared with, for example, the Survey of Health, Ageing and Retirement in Europe (SHARE) study (Börsch-Supan, Hank, & Jurges, 2005), response rate in this age group seems to be in the middle range of what can be reached in European countries. Furthermore, our experience is that especially the active young old are overrepresented among refusers rather than the unhealthy.

In sum, our findings help to improve the understanding of the impact of multimorbidity on SRH. Multimorbidity did not show exacerbating effects on SRH; however, it does lead to significant decline in SRH in all age groups. The results showed that having a single disease increases the chance of poor health to a larger extent relative to each additional co-occurring disease, indicating that either adaptation to worse health or symptom overlap occurs. However, each second, third, or fourth co-occurring disease did lead to cumulative declines in SRH. Further research, preferably on longitudinal data, may focus more specifically on the adaptation process and on health consequences, which accompany in particular the diagnosis of a first chronic disease as potential explanation for this finding.

Acknowledgments
This study is based on data collected in the context of the LASA, which is funded largely by the Ministry of Welfare, Health, and Sports of the Netherlands.

Study concept and design: H. Galenkamp, A. W. Braam, M. Huisman, and D. J. H. Deeg
Analysis of data: H. Galenkamp
Drafting of the manuscript: H. Galenkamp
Critical revision of the manuscript for important intellectual content: H. Galenkamp, A. W. Braam, M. Huisman, and D. J. H. Deeg.

Correspondence
Correspondence should be addressed to H. Galenkamp, MSc, EMGO/Longitudinal Aging Study Amsterdam, VU University Medical Centre, Van der Boechorststraat 7, 1081 BT Amsterdam, The Netherlands. E-mail: h.galenkamp@vumc.nl.

References


