Multimorbidity and health-related quality of life among people 55 years and up: results of a longitudinal study in New Zealand

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Abstract

Background: This study aimed to examine the association of Health-Related Quality of Life (HRQOL) and multimorbidity (MM) and its correlates over time in New Zealand.

Methods: People aged 55 years and over were invited to participate in a nationally representative population-based longitudinal study in 2006 and followed up biennially until 2016. Generalized Estimating Equations (GEE) with an exchangeable correlation matrix and robust standard errors adjusted for both time-constant and time-varying factors using baseline and five subsequent waves of data were used, to compare a range of factors related to changes in MM and HRQOL.

Results: Of 2632 participants at baseline, 957 of the participants were classified as “MM participants”; 570 had two, and the rest had three chronic conditions. The results of the GEE regression models demonstrated that SF12-PCS decreased over time, and there was a significant difference in SF12-PCS between MM and Non-MM participants. Having MM was negatively associated with HRQOL-PCS -3.00 (95 %CI -3.60, -2.49); p <0.001). Although the results showed an increase in SF12-MCS over time, the score of the mental dimension of HRQOL was lower among MM participants compared to Non-MM participants -2.60, 95 %CI -3.09, -2.11. Conclusions: According to this longitudinal study, there is an inverse association between MM and one of the most important health outcomes; HRQOL, in older adults.

Background

Multimorbidity (MM) is defined as “coexistence of two or more chronic diseases within an individual” (1). It is an emerging health problem due to the ageing of the population and the high prevalence and burden of chronic diseases (2, 3). The prevalence of MM in the general population worldwide ranges from 13.1% to 71.8% (4).

Health-Related Quality of Life (HRQOL) is the dominant outcome measure in clinical research for assessment of the burden of illness as well as the evaluation of care and treatment effectiveness (5). Cross-sectional studies have shown an inverse association between Quality of Life (QOL) and MM. Fortin et al. (6) conducted a systematic review to clarify the association between MM and HRQOL in the primary care setting. They screened published manuscripts from 1993 to 2003 to confirm the
negative impact of MM on HRQOL. A systematic review of published studies from South Asian countries (7) also reported a lower quality of life among people with MM. Results of a large and nationally representative study in the US (8) showed that individuals with MM had a poorer performance in HRQOL compared to those without MM which was significantly more remarkable in those with three or more chronic conditions. A more recent systematic review (9) including studies conducted in the general population aged 45-64 years old confirmed the association of MM with poorer HRQOL.

Despite cross-sectional support for the impact of multiple chronic illnesses on HRQOL, longitudinal data examining the change in HRQOL among people with MM is rare. Only one recent publication was found using a longitudinal approach. Gu et al. (10) conducted a 24-month longitudinal study among 437 individuals aged 60 years and over in China to show that MM was associated with lower HRQOL. Certain patterns of MM impacted on different dimensions of HRQOL. However, the duration of the study and the small sample size limited the conclusions of this study.

Because HRQOL varies over time, longitudinal analysis can contribute to improved understanding of the impact of multiple illnesses on QOL. This study aimed to examine the HRQOL changes related to MM over time and to identify potential epidemiological and clinical correlates of these differences.

Data from six waves of the New Zealand Health, Work and Retirement Study (HWR) were used.

Methods And Materials

Study Population

The HWR is a prospective cohort study of community-dwelling older adults. It commenced in 2006 as a postal survey of a representative national sample aged 55-70, randomly selected from the New Zealand electoral roll. Of the original cohort (N=6662), 2632 consented to be invited to participate in subsequent waves. Of these, 1069 (41%) were lost to follow up over the five waves of the study (212 to death, and remaining unknown). Data has been collected biennially. The core questionnaire assesses domains of health and well-being; family and social support; work and retirement; financial well-being; and cultural identity.

Measures
Multimorbidity

Participants with MM were selected based on their response to a question ‘Has a doctor, nurse or other healthcare worker told you that you have any of the following health problems (a list of conditions was provided)? We selected nine groups of diseases for this analysis according to the availability of data in all waves including heart disease, stroke, other neurologic diseases (epilepsy, Parkinson, migraine headache, Alzheimer/dementia), musculoskeletal (arthritis, osteoporosis, hip/knee replacement), diabetes mellitus, respiratory diseases (Chronic Obstructive Pulmonary Disease (COPD), asthma), chronic liver conditions (cirrhosis), cancer, and mental disorder (depression, anxiety and other mental diseases). Participants were classified as 1) “MM participants”; those who answered “yes” to at least two conditions in this list, 2) “Non-MM participants” defined as participants who were without MM in any of the study waves and the baseline. MM was also categorised as no. of chronic diseases (up to 3+). We also analysed the HRQOL over time according to the number of chronic diseases (0, 1, 2, 3+).

Health-Related Quality of Life

HRQOL was assessed using the SF12, a short version of the 36-items HRQOL measures developed within the framework of the Medical Outcome Study (11). It consists of fewer questions but covers the same eight health domains as the SF-36 including General Health (GH), Physical Functioning (PF), Role Physical (RP), and Body Pain (BP). Vitality (VT), Social Functioning (SF), Role Emotional (RE), and Mental Health (MH). SF-12 yields two summary measures; physical and mental health, using the weighted means of the eight domains. The Physical Component Score (PCS) which was calculated by combining and normalising RP, GH, BP, and PF scales and the Mental Component Score (MCS) which was calculated by combining and normalizing RE, MH, RE, SF, and VT scales (12). Generated normalised summary scores range from 0 to 100, where higher values represent a higher QOL.

Demographic Variables

Age, provided as a continuous variable, was categorised as 55-64 years and 65 and over. Marital status was considered as two groups: married/living with a partner, divorced/ separated/single/ widow; ethnicity was classified as, Māori and non-Māori (Europeans, Asians, Pacific people and other
ethnicities). Socioeconomic status indicators included educational qualification categorised as no secondary, secondary, post-secondary and tertiary; and annual personal income (0-25000, 25001-50000, 50001-70000, >70000 NZ$). Smoking was defined by asking respondents to identify themselves as a regular smoker or not.

**Behavioural Variables**

Alcohol consumption was assessed by the frequency of drinking, from never, through up to four times a month, to two or more times a week, and then classified into two groups; regular consumption (2 or more drink per week) and occasional consumption (less than two drinks) per week. Physical activity was measured by the number of moderate activities including brisk walking, and vigorous activity in the last seven days that were categorised into two levels: two or more times per week, and once per week/none. Body Mass Index (BMI, kg/m$^2$) was measured only in 2008 and categorised as healthy weight (<25), overweight (25-29.9), obese ($\geq$30).

**Clinical variables**

Hypertension and eye problems (including cataracts, glaucoma and blindness) were included as dichotomous variables (yes/no), based on the responses to a question about doctor-diagnosed health problems. Vision problems were also measured by asking about the ability to see an ordinary newspaper (with glasses or contact lenses if worn).

**Statistical analysis**

For continuous variables, Student’s t-test determined differences in the characteristics of people with and without MM at baseline and the chi-square test for categorical variables. Generalized Estimating Equations (GEE) with an exchangeable correlation matrix and robust standard errors were used to analyse the data. The results are presented as estimates (with 95 per cent confidence intervals) of the difference between the two groups (those with/without MM). The difference of two components of the HRQOL; PCS, MCS, between groups was estimated after adjusting for baseline values in the first model and baseline values plus age, sex, ethnicity, education, marital status, hypertension, alcohol consumption, smoking, and physical activity in the second model. Besides, we repeated the analysis according to the number of chronic conditions (without chronic conditions, 1, 2, $\geq$3 chronic
conditions) separately to assess the difference in SF12-PCS mean scores according to the number of chronic diseases.

Data were analysed using the STATA statistical package Version14, all estimates were reported with 95% confidence interval and a significance level 0.05.

Results
At baseline, 957 of the participants were classified as “MM participants”, of whom 570 had two chronic conditions, and the remainder had three chronic conditions. Figure 1 shows that the prevalence of MM increased over time from about 34% in 2006 to about 62% in 2016.

Table 1 displays the range of epidemiological and clinical variables within the two study groups. Relative to Non-MM participants, MM participants were older (61.8±4.5 vs 60.7±4.5 respectively, \( P <0.001 \)), less educated, had lower annual income (\( P<0.001 \)), and identified as Māori, (\( P<0.001 \)). The frequency of overweight/obesity, irregular alcohol consumption, insufficient physical activity (less than two times moderate/vigorous activity per week), was higher among MM participants compared to Non-MM participants. The frequency of hypertension and sight problems were higher among MM participants relative to Non-MM participants (\( P <0.001 \)).

Figure 2 shows the changes in both physical and mental dimensions of SF12 over time. The mean score of the physical dimension decreased over time in both MM and Non-MM participants. The mean SF12-PCS was lower in the MM group than in the Non-MM group at every time point (Figure 2a). In contrast, the SF12-MCS mean score showed a steady increase over time in both groups. However, MM participants had significantly poorer performance on the SF12-MCS than Non-MM participants at every time point (Figure 2b). The mean scores of both SF12 dimensions over time, according to the number of chronic conditions are also shown. Those with a higher number of chronic conditions recorded lower scores of both components of SF12 at every time point (p<0.001) (Figure 2c and 2d).

Table 2 shows the results of the GEE modelling which demonstrates that SF12-PCS decreased over time \([\beta=-0.23 \ (SE=0.03), \ p<0.001] \) for all, while there was a significant difference in SF12-PCS between MM and Non-MM participants. Having MM was negatively associated with HRQOL-PCS \([\text{(difference, (95 percent confidence interval, -3.00 (-3.60, -2.49); } p <0.001)\)\); individuals with MM, on
average, had a score 3 points lower on the HRQOL-PCS than those without MM. Further adjustment for other variables (age, sex, ethnicity, education, income, marital status, BMI, hypertension, alcohol consumption, smoking, physical activity, and sight problem) had little effect on the difference, reducing it to -2.21.

The results showed an increase in SF12-MCS (\(\beta=0.17\) (SE=0.03, \(p<0.001\)) over time, however, the score of the mental dimension of HRQOL was lower among MM participants compared to Non-MM participants [difference, 95 %CI, -2.60 (-3.09, -2.11)]. After adjustment for all other variables, the effect size decreased but remained significant (difference, 95%CI, -1.85 (-2.44, -1.27).

This analysis was repeated according to the number of chronic diseases. The difference in SF12-PCS means scores increased as the number of chronic diseases increased from an average -2.29 for those with one chronic condition compared to individuals without chronic conditions, to -6.29 for those with three and more chronic conditions. Adjustment for other variables had little effect on the effect size.

The difference in the mean score of SF12-MCS increased as the number of chronic diseases increased from -0.79 in those with one chronic condition to -4.61 in those with three and more chronic conditions compared to individuals without chronic conditions. The difference did not remain significant among those with one chronic condition after adjustment for other variables.

Discussion
This study examined the impact of MM on HRQOL using data from a longitudinal study in New Zealand. The prevalence of the MM at the baseline was lower than the Gu et al. study (10) (34% vs 56.5%) which can be partly explained by the age group of the participants; our participants were, on average, five years younger than those in the Gu et al. study.

We found that physical quality of life scores decreased over time for all; however, individuals with MM had a lower mean score on HRQOL-PCS than those without MM, in both crude and adjusted statistical models. Moreover, the results showed an increase in mental health-related quality of life over time in both groups, while the score of the mental health dimension of HRQOL was lower among MM participants compared to Non-MM participants. These findings are similar to the results of the study by Gu et al. (10) among community-dwelling older adults in China, which reported an inverse
association of MM with HRQOL. Our study had a higher number of participants (2632 vs 437 at the baseline), and longer duration of follow-up (10 years vs two years) which provides more robust support for these relationships.

When this analysis was repeated according to the number of chronic diseases reported by participants, the difference in mean scores of both physical and mental dimensions of HRQOL increased as the number of chronic diseases increased. This negative association of a number of chronic conditions with mental and physical HRQOL has been observed in other cross-sectional studies (13). Our participants were classified at baseline, and the analysis shows how the initial incidence of multiple conditions continues to impact negatively on HRQOL over time. Future longitudinal studies will be able to follow the trajectories of those whose MM status changes across time.

The strength of the present study is the longitudinal nature. However, an important issue, the consistent definition of MM, must be resolved before developing complex longitudinal designs. In our study, as in others, we used a list of chronic diseases developed for general health research purposes. The wide variation in the reported incidence of MM worldwide is probably due to heterogeneity in data collection methods and the operational definition of MM (4). Fortin et al. (6) concluded their systematic review by suggesting that the heterogeneity in the definition and measurement of MM must be addressed to help clarify the impact of MM on HRQOL. Others (7) have also commented on the heterogeneity in the operational definition of MM, and a Canadian cross-sectional study (14) showed how this impacts findings; the length of the list of conditions has an impact on the estimated prevalence of MM and the level of the physical component of HRQOL. These authors recommend the use of a comprehensive list. Certainly, a more focussed approach to the assessment of MM is required in future research. Another issue was the missing values due to death or other reasons is another limitation of this study. We used GEE regression modeling to address the problem however, future research may usefully employ different methods, such as multiple imputations.

In conclusion, this longitudinal study has supported the importance of understanding the long term effects of MM on HRQOL for older adults and raised questions about possible trajectories. These
findings can contribute useful information for health policy. The present study supports further research in this area with an initial focus on better definitions of MM.

**Abbreviations**

MM: Multimorbidity; HRQOL: Health-Related Quality of Life; HWR: Work and Retirement Study; BMI: Body Mass Index; GEE: Generalized Estimating Equations; Physical Component Scale (PCS); Mental Component Scale (MCS); COPD: Chronic Obstructive Pulmonary Diseases; CI: Confidence Intervals; OR: Odds Ratio; ORadj: Adjusted Odds Ratio; ORcrude: Crude Odds Ratio

**Declarations**

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**Ethics approval and consent to participate**

The study was conducted in accordance with the declaration of Helsinki and had ethics approval from the Massey University Human Ethics Committee (MUHEC Southern B 09/70). At the beginning of the study, informed consent was obtained in written forms from all of the participants after a thorough explanation of the procedures involved.

**Consent for publication**

Not applicable.

**Availability of data and materials**

The data or analysis generated during this study is available upon request.

**Competing interests**

Authors have no conflict of interest to declare.

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Authors’ contributions

All authors were involved in the design of the protocol and all drafts of the manuscript. NA and SMS were responsible for data preparation and analysis and CS, FA supervised and supported data collection. All authors reviewed and contributed to all drafts of the manuscript.

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Tables

| Characteristics (2006) | Group | P val |
|-----------------------|-------|-------|
|                       | without MM | with MM |
|                       | N       | %     |
| Age group    | 55-64 | 76.8 | 647 | 67.6 | <0.001 |
|--------------|-------|------|-----|------|--------|
| 64+          | 398   | 23.3 | 310 | 32.4 |        |

**Sex**

| Male     | 868   | 51.9 | 536 | 56.0 | 0.041 |
|-----------|-------|------|-----|------|-------|
| Female    | 805   | 48.1 | 421 | 44.0 |       |

**Education**

| No secondary | 441   | 26.6 | 313 | 33.0 | 0.002 |
|--------------|-------|------|-----|------|-------|
| Secondary    | 471   | 28.4 | 245 | 25.8 |       |
| Post-secondary/tertiary | 747   | 45.0 | 391 | 41.2 |       |

**Marital status**

| Married/partner | 1238 | 75.2 | 634 | 67.0 | <0.001 |
|-----------------|------|------|-----|------|--------|
| Divorced/separated/single/Widowed | 408 | 24.8 | 313 | 33.1 |       |

**Personal income (Annual)**

| 0-25000   | 489   | 34.8 | 414 | 53.8 | <0.001 |
|-----------|-------|------|-----|------|--------|
| 25001-50000 | 523 | 37.2 | 220 | 28.6 |        |
| 50001-70000 | 205 | 14.6 | 83  | 10.8 |        |
| >70000    | 190   | 13.4 | 52  | 6.8  |        |

**Ethnicity**

| European/others | 1006 | 61.2 | 488 | 56.7 | <0.001 |
|-----------------|------|------|-----|------|--------|
| Maori           | 637  | 38.8 | 463 | 49.3 |       |

**Current smoker**

| No     | 881   | 93.8 | 445 | 92.3 | 0.357 |
|--------|-------|------|-----|------|-------|
| Yes    | 60    | 6.4  | 37  | 7.7  |       |

**Alcohol consumption**

| No     | 259   | 26.6 | 100 | 21.6 | 0.012 |
|--------|-------|------|-----|------|-------|
| Yes    | 716   | 73.4 | 386 | 79.4 |       |

**BMI**

| Normal weight (<25) | 496 | 35.3 | 183 | 22.4 | <0.001 |
|---------------------|-----|------|-----|------|--------|
| Overweight (25-29.9)| 523 | 37.2 | 291 | 35.6 |       |
| Obese (≥30)         | 386 | 27.5 | 344 | 42.1 |       |

**Physical activity**

| insufficient | 211   | 13.0 | 148 | 16.0 | <0.001 |
|--------------|-------|------|-----|------|--------|
| sufficient   | 1411  | 87.0 | 779 | 84.0 |       |
### Hypertension

|                | Baseline | Average follow-up | Difference adjusted for baseline value (95% CI) | P value |
|----------------|----------|-------------------|-----------------------------------------------|---------|
| No             | 455      | 45.0              | 135                                          | 25.6    | <0.001 |
| Yes            | 556      | 55.0              | 392                                          | 74.4    |         |

### Sight problem

|                | Baseline | Average follow-up | Difference adjusted for baseline value (95% CI) | P value |
|----------------|----------|-------------------|-----------------------------------------------|---------|
| No             | 1442     | 91.2              | 763                                          | 84.0    | <0.001 |
| Yes            | 139      | 8.8               | 392                                          | 16.0    |         |

*MM: Multimorbidity; ≥ 2 chronic conditions (heart, neurological, respiratory, musculoskeletal, and mental diseases, cancer, diabetes, chronic liver conditions)

Table 2. Scores of SF12 dimensions and differences between groups during the study period, adults 55 years and up, New Zealand

| Group                              | Baseline score | Average follow-up score | Difference adjusted for baseline value (95% CI) | P value |
|------------------------------------|----------------|-------------------------|-----------------------------------------------|---------|
| **SF12 -Physical dimension score**|                |                        |                                               |         |
| Less than two chronic conditions (Without MM*) | 49.98± 7.95 | 47.55± 7.92             | -3.00 (-3.60, -2.49)                            | <0.001 |
| ≥ two chronic conditions (With MM)   | 41.94± 11.03  | 39.81± 10.01            |                                               |         |
| **SF12 -Mental dimension score**    |                |                        |                                               |         |
| Less than two chronic conditions (Without MM*) | 51.20± 9.38 | 51.06± 7.66             | -2.60 (-3.09, -2.11)                            | <0.001 |
| ≥ two chronic conditions (With MM)   | 45.68± 11.77  | 45.85± 10.11            |                                               |         |
| **SF12 -Physical dimension score**  |                |                        |                                               |         |
| Without chronic conditions          | 52.27± 6.03   | 49.65± 6.54             | ref                                           |         |
| 1                                  | 48.06± 8.80   | 45.73± 8.55             | - 2.29 (-2.84, -1.75)                          | <0.001 |
| 2                                  | 44.66± 9.97   | 42.46± 9.07             | -3.96 (-4.58, -3.34)                          | <0.001 |
| 3+                                 | 37.84± 11.30  | 35.91± 10.07            | -6.39 (-7.14, -5.69)                          | <0.001 |
| **SF12 -Mental dimension score**    |                |                        |                                               |         |
| Without chronic conditions          | 52.67± 8.39   | 52.08± 7.17             | ref                                           |         |
| 1                                  | 49.96± 9.97   | 50.18± 8.32             | -0.76 (-1.32, -0.20)                          | 0.00    |
| 2                                  | 48.49± 10.13  | 48.44± 8.62             | -2.33 (-2.97, 1.68)                           | <0.001 |
| 3+                                 | 41.45±12.77   | 42.02± 10.91            | -4.61 (-5.41, -3.81)                          | <0.001 |

* MM: Multimorbidity; ≥ 2 chronic conditions (heart, neurological, respiratory, musculoskeletal, and mental diseases, cancer, diabetes, chronic liver conditions)

** fully adjusted for age, sex, ethnicity, education, income, marital status, BMI, hypertension, alcohol consumption, smoking, physical activity, and sight problem

Figures
Flowchart of study participants and the prevalence of multimorbidity, 2006-2016

Changes in physical and mental dimensions of SF12 over time. Figure 2a changes in the mean SF-PCS in people with/without MM; Figure 2b changes in the mean SF12-MCS in people with/without; Figure 2c changes in the mean SF12-PCS by number of chronic conditions, Figure 2d changes in the mean SF12-MCS by number of chronic conditions