

BMJ Open Complex multimorbidity and mortality in Japan: a prospective propensity-matched cohort study

Daisuke Kato ¹, Ichiro Kawachi,² Junko Saito ³, Naoki Kondo⁴

To cite: Kato D, Kawachi I, Saito J, *et al.* Complex multimorbidity and mortality in Japan: a prospective propensity-matched cohort study. *BMJ Open* 2021;**11**:e046749. doi:10.1136/bmjopen-2020-046749

► Prepublication history and additional supplemental material for this paper are available online. To view these files, please visit the journal online. (<http://dx.doi.org/10.1136/bmjopen-2020-046749>).

Received 09 November 2020
Accepted 22 July 2021



© Author(s) (or their employer(s)) 2021. Re-use permitted under CC BY-NC. No commercial re-use. See rights and permissions. Published by BMJ.

¹Department of Family Medicine, Mie University Graduate School of Medicine Faculty of Medicine, Tsu, Mie, Japan

²Department of Social & Behavioral Sciences, Harvard T.H. Chan School of Public Health, Boston, Massachusetts, USA

³Behavioral Science Division, Center for Public Health Sciences, National Cancer Center Japan, Chuo-ku, Tokyo, Japan

⁴Department of Social Epidemiology, Graduate School of Medicine and School of Public Health, Kyoto University, Kyoto, Japan

Correspondence to

Dr Daisuke Kato;
d.kato0417@gmail.com

ABSTRACT

Objectives There are limitations to defining multimorbidity (MM) based on a simple count of diseases. To address these limitations, the concept of complex MM (CMM) focuses on how many body systems are affected in a single patient, rather than counting comorbid conditions. This study compared the prediction of mortality among older Japanese adults between CMM and conventional MM.

Design A population-based prospective cohort study.

Setting The Japan Gerontological Evaluation Study, a nationwide longitudinal cohort study, which ran from 2010 to 2016.

Participants Functionally independent individuals who were older than 65 and had complete illness data at the time of baseline survey were eligible.

Outcomes measure CMM was defined as the coexistence of 3 or more body system disorders at baseline. We calculated the propensity for each individual to develop CMM based on a wide array of characteristics, including socioeconomic status and health behaviours. Individuals with and without CMM were then matched on their propensity scores before we estimated overall survival using a log-rank test.

Results Our 6-year follow-up included 38 889 older adults: 20 233 (52.0%) and 7565 (19.5%) adults with MM and CMM, respectively. In the MM-matched cohort (n=15 666 pairs), the presence of MM was significantly associated with increased mortality (HR 1.07; 95% CI 1.01 to 1.14; p=0.02 by the log-rank test). A similar mortality association was found in the CMM-matched cohort (n=7524 pairs, HR, 1.07; 95% CI 0.99 to 1.16; p=0.08 by the log-rank test).

Conclusion This is the first study to report the association between CMM and mortality among older adults in Japan. MM and CMM predict mortality in older adults to a similar degree. This finding needs to be replicated with more precision in larger samples.

INTRODUCTION

There are limitations in defining multimorbidity (MM; the co-occurrence of diseases in the same person) based on a simple count of diseases,¹ and a new concept of ‘complex MM’ (CMM) has thus been proposed.² CMM focuses on the impact across the different body systems rather than counting comorbid conditions.

Strengths and limitations of this study

- This is the first study to directly compare the associations between two alternative formulations of multimorbidity—conventional multimorbidity and complex multimorbidity—and survival in a nationwide cohort of older Japanese adults.
- We used propensity score matching to minimise confounding bias when comparing the survival of individuals with and without multimorbidity.
- One limitation is that we did not take into account the severity of disease at baseline, which may have underestimated the impact of comorbid conditions.

In CMM, diseases are categorised by the body system they affect. Because impairments of the same body system often have similar interventions, their impacts on patient prognosis are expected to be similar. Therefore, it makes biological sense to combine closely related diseases (eg, osteoporosis and fractures) as affecting a single body system (ie, musculoskeletal and connective disorders) rather than counting them as two separate diseases when evaluating the impact of multiple comorbid conditions. In turn, disorders of different body systems should be counted separately because they need more complex and extensive treatment, and the treatment of one disease may adversely affect another. Furthermore, from a methodological perspective, focusing on body system disorders may be more reliable method for collecting patient self-report data as patients are apt to misclassify individual conditions (eg, osteoarthritis vs rheumatoid arthritis or asthma vs COPD (chronic obstructive pulmonary disease)) but they are unlikely to mistake the affected body system. CMM is also likely to be a more reliable method as it may avoid issues of whether a clinician sees two very similar diseases as distinct and thereby avoids the issue of some clinicians recording a single condition while others record two.

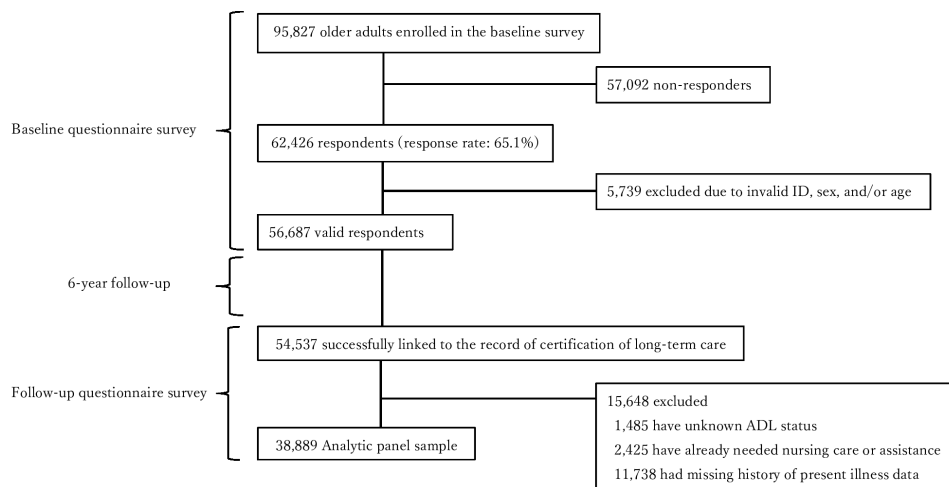


Figure 1 Flow diagram of the sample group. ADL, activities of daily living.

A growing number of studies have demonstrated the negative impact of MM on patient outcomes, showing that MM is associated with mortality, reduced quality of life, lower physical functioning and so on.^{13–6} In many reports claiming these associations, researchers have attempted to weight diseases according to severity. Although the MM approach is better than conventional medical care that tends to focus on a single disease at a time, the new concept of CMM that focuses on multiple body system disorders is expected to result in stronger predictions of patient outcomes.

There is little evidence on the impact of CMM on mortality.⁷ Although functional disability is associated with mortality, no previous studies have evaluated the impact of CMM by considering baseline activities of daily

living status. Furthermore, previous reports that include both MM and CMM mainly performed descriptive statistics, not inferential statistics.^{8–11} Against this background, we used CMM and conventional MM to compare the predictions of mortality among older Japanese adults.

METHODS

Data sources

We conducted this study using the longitudinal nationwide cohort data from the Japan Gerontological Evaluation Study (JAGES),¹² which was established in 2010. This study focuses on adults in Japan over 65 years of age and aims to establish a society of healthy longevity.

Study population

Self-administered questionnaires for the baseline survey were mailed to 95 827 older adults in Japan between August 2010 and January 2012. Adults were sampled from 13 municipalities in 7 of the 47 prefectures in Japan. All adults were functionally independent, which was defined as not receiving public long-term care (LTC) insurance. The municipalities were from three of the four major islands of Japan (Hokkaido, Honshu, Kyushu).

Among the target population, 62 426 individuals responded to the survey (response rate, 65.1%). We included individuals who were functionally independent and not receiving any nursing care or home care assistance to avoid reverse causality between MM and functional disability, which is a key factor in mortality. We included individuals who had valid ID, sex, and age information, and who were linked to LTC insurance certification registers. We excluded individuals whose functional disability status at baseline was unknown, or who were already receiving nursing care or home care assistance, or whose data on the history of present illness was missing. Finally, we identified a cohort of 38 889 individuals. Further details of the cohort flow diagram are shown in [figure 1](#).

Table 1 Definition of body system categories in CMM and diseases surveyed in JAGES

Category	Disease
Circulation disorder	▶ Heart disease (including arrhythmia) ▶ Stroke ▶ High blood pressure
Endocrine-metabolic disorder (general system)	▶ Diabetes (including mild type) ▶ Obesity ▶ Dyslipidaemia
Eye disorder	▶ Impaired vision
Gastrointestinal disorder	▶ Gastrointestinal disease ▶ Liver disease
Hearing disorder	▶ Impaired hearing
Mental and behavioural disorder	▶ Mental disease ▶ Sleep problem
Musculoskeletal and connective disorder	▶ Osteoporosis ▶ Joint disease/neuralgia ▶ Injury/fracture
Neoplasm	▶ Cancer
Respiratory disorder	▶ Respiratory disease

CMM, complex multimorbidity; JAGES, the Japan Gerontological Evaluation Study

Table 2 Demographic characteristics of the cohort study

Characteristic	With MM		Without MM		With CMM		Without CMM	
Sample size	20 233		18 656		7565		31 324	
Age								
65–69	4087	43.4	5328	56.6	1205	12.8	8210	87.2
70–74	5673	49.7	5745	50.3	1955	17.1	9463	82.9
75–79	5413	56.7	4134	43.3	2162	22.6	7385	77.4
80–84	3418	59.2	2352	40.8	1485	25.7	4285	74.3
85–89	1322	60.3	870	39.7	605	27.6	1587	72.4
90+	320	58.5	227	41.5	153	28.0	394	72.0
Missing	0		0		0		0	
Sex								
Male	8803	49.3	9038	50.7	3051	17.1	14 790	82.9
Female	11 430	54.3	9618	45.7	4514	21.4	16 534	78.6
Missing	0		0		0		0	
No of natural teeth								
20 or more	5979	48.6	6313	51.4	2020	16.4	10 272	83.6
10–19	4946	51.3	4686	48.7	1807	18.8	7825	81.2
1–9	5478	54.5	4582	45.5	2170	21.6	7890	78.4
No natural teeth	3174	56.1	2484	43.9	1311	23.2	4347	76.8
Missing	656	52.6	591	47.4	257	20.6	990	79.4
Formal education years								
Less than 6 years	582	58.6	412	41.4	296	29.8	698	70.2
6–9 years	9812	54.2	8297	45.8	3818	21.1	14 291	78.9
10–12 years	6234	49.9	6250	50.1	2247	18.0	10 237	82.0
13 years or more	3091	49.1	3208	50.9	997	15.8	5302	84.2
Other	125	50.6	122	49.4	52	21.1	195	78.9
Missing	389	51.5	367	48.5	155	20.5	601	79.5
Marital status								
Married	13 555	50.4	13 328	49.6	4772	17.8	22 111	82.2
Widowed	5124	56.5	3944	43.5	2171	23.9	6897	76.1
Divorced	652	52.3	594	47.7	255	20.5	991	79.5
Never married	413	55.5	331	44.5	157	21.1	587	78.9
Other	108	50.2	107	49.8	48	22.3	167	77.7
Missing	381	52.0	352	48.0	162	22.1	571	77.9
Living arrangement								
Live alone	17 195	51.5	16 169	48.5	6300	18.9	27 064	81.1
Not alone	2730	56.1	2138	43.9	1159	23.8	3709	76.2
Missing	308	46.9	349	53.1	106	16.1	551	83.9
Financial insecurity (worries about unexpected expenses)								
None at all	1858	47.9	2018	52.1	608	15.7	3268	84.3
Slight	8218	49.6	8357	50.4	2817	17.0	13 758	83.0
Moderate	5556	54.2	4701	45.8	2144	20.9	8113	79.1
Severe	3431	57.9	2494	42.1	1554	26.2	4371	73.8
Missing	1170	51.9	1086	48.1	442	19.6	1814	80.4
Receiving pension								

Continued



Table 2 Continued

Characteristic	With MM		Without MM		With CMM		Without CMM	
No	19 191	51.9	17 779	48.1	7162	19.4	29 808	80.6
Yes	277	57.0	209	43.0	109	22.4	377	77.6
Missing	765	53.4	668	46.6	294	20.5	1139	79.5
Current employment status								
Has a paid job	3259	44.6	4055	55.4	952	13.0	6362	87.0
Retired	11 344	53.0	10 040	47.0	4315	20.2	17 069	79.8
Never had a job	2623	56.2	2043	43.8	1125	24.1	3541	75.9
Missing	3007	54.4	2518	45.6	1173	21.2	4352	78.8
Alcohol consumption								
Yes	5640	47.8	6164	52.2	1868	15.8	9936	84.2
Used to drink	840	57.2	628	42.8	354	24.1	1114	75.9
No	12 498	53.8	10 733	46.2	4844	20.9	18 387	79.1
Missing	1255	52.6	1131	47.4	499	20.9	1887	79.1
Smoking status								
Never smoked	10 990	52.8	9842	47.2	4195	20.1	16 637	79.9
Stopped smoking 5 or more years ago	4499	52.4	4086	47.6	1609	18.7	6976	81.3
Stopped smoking within the past 4 years	913	50.4	899	49.6	334	18.4	1478	81.6
Current smoker	1632	46	1918	54	546	15.4	3004	84.6
Missing	2199	53.5	1911	46.5	881	21.4	3229	78.6

CMM, complex multimorbidity; MM, multimorbidity

MM and CMM

At baseline, 19 diseases were surveyed in the JAGES. Among them, as noted in table 1, we analysed the following 17 diseases to calculate MM and CMM: heart disease (including arrhythmia), stroke, high blood pressure, diabetes (including mild type), obesity, dyslipidaemia, impaired vision, gastrointestinal disease, liver disease, impaired hearing, mental disease, sleep problems, osteoporosis, joint disease/neuralgia, injury/fracture, cancer and respiratory disease. The remaining two symptoms, difficulty swallowing and difficulty with bowel movements, were excluded from the disease list in this study because they have aspects of dysfunction not disease. The JAGES did not survey diseases of the nervous system.

MM was defined as having two or more of the aforementioned diseases concurrently. For CMM, the diseases surveyed were categorised according to the body system they affected.^{2 13} For example, heart disease and diabetes were individually categorised into disorders of the circulatory system and endocrine system. Next, CMM was defined as the coexistence of 3+ body system disorders at baseline (see table 1).

Outcome

The outcome of this study was the 6-year incidence of mortality. We ascertained vital status from 2010 to 2016

by linking the cohort participants to the mortality records of the national LTC insurance database (follow-up rate=96.2%). The mean follow-up period was 5.6 years, and we observed 5183 (13.3%) deaths during the period.

Statistical analysis

Estimation of missing data

Given that the missing data was missing at random, we conducted multiple imputations using a bootstrapping Expectation-Maximisation algorithm.¹⁴ We analysed 20 multiply imputed datasets, taking the low missing rate of the cohort (approximately 5%) into consideration.¹⁵ Lastly, we combined all estimators by Rubin's rule.¹⁶

Propensity score matching

We used propensity score matching to compare overall survival among individuals with and without MM/CMM. To address potential confounding bias, we conducted propensity score matching within a logistic regression framework. The participant information included in estimating the propensity score consisted of 44 variables: age, sex, smoking status, alcohol consumption, marital status, pension, dental health, employment status, consumption of meat of fish/fruits or vegetable, education, city code and so on (see online supplemental table S1).

We performed a 1:1 matching between individuals with and without MM/CMM using the nearest-neighbour

Table 3 Standardised mean differences with or without MM/CMM, before and after propensity score matching

Characteristic	MM		CMM	
	SMD in multiply imputed data	SMD in matching data	SMD in multiply imputed data	SMD in matching data
Age	0.24	0.002	0.327	0.025
Sex	0.099	0.001	0.139	0.004
Previous health check-up	0.01	0.015	0.02	0.005
No of natural teeth	0.11	0.019	0.16	0.005
Consumption of meat and fish	0.009	0.017	0.017	0.016
Consumption of fruits and vegetables	0.003	0.006	0.035	0.012
Formal educational years	0.093	0.045	0.151	0.004
Marital status	0.072	0.015	0.118	0.002
Living arrangement	0.06	0.033	0.1	0.011
Residence type	0.025	0.055	0.058	0.008
Architectural type of home	0.005	0.086	0.02	0.006
Financial insecurity	0.123	0.004	0.21	0.012
Receiving pension	0.023	0.022	0.022	0.006
Current working status	0.147	0.002	0.225	0.004
Eats meals alone	0.089	0.02	0.17	0.014
Alcohol consumption	0.107	0.015	0.145	0.013
Smoking status	0.079	0.014	0.098	0.016
Falls	0.223	0.004	0.307	0.013
Worries about falls	0.266	0.001	0.396	0.005
Goes upstairs without support	0.265	0.009	0.348	0.005
Gets up out of a chair without support	0.251	0.02	0.343	0.01
Average time to walk	0.16	<0.001	0.203	0.001
Frequency of going out	0.151	0.015	0.207	0.003
Decrease in the frequency of going out	0.243	0.001	0.352	0.006
Engagement in leisure activities	0.105	0.016	0.145	0.008
Trust in neighbours	0.079	0.027	0.135	0.009
Support from neighbours	0.074	0.015	0.109	0.002
Attachment to residence	0.053	0.036	0.086	0.002
Contribution to residence	0.095	0.009	0.129	0.007
Uneasiness about safety in residence	0.073	0.011	0.105	0.01
Participation in local events	0.085	0.009	0.114	0.008
Interactions with neighbourhood	0.02	0.031	0.049	0.007
Residential environment:				
Presence of graffiti or garbage	0.009	0.02	0.019	0.014
Parks or footpaths	0.059	0.045	0.097	<0.001
Locations difficult for walking	0.076	0.012	0.132	0.007
Risky roads or crossroads for traffic accidents	0.044	0.005	0.061	0.002

Continued

Table 3 Continued

	MM		CMM	
	SMD in multiply imputed data	SMD in matching data	SMD in multiply imputed data	SMD in matching data
Aesthetic views or buildings	0.04	<0.001	0.074	0.004
Shops selling fresh fruits and vegetables	0.074	0.023	0.091	0.001
Dangerous place to walk alone at night	0.013	0.019	0.016	<0.001
Comfortable house or facilities	0.066	0.024	0.107	0.011
Someone who listens to your concerns	0.019	0.01	0.075	0.007
Someone to provide care in case of illness	0.049	0.023	0.094	0.026
Attendance				
Sports group or club	0.063	0.008	0.117	0.031
Leisure activity group	0.06	0.006	0.088	0.007

CMM, complex multimorbidity; MM, multimorbidity; SMD, standardised mean difference

method within a calliper (0.2 of the SD of the logit of the propensity score).^{17 18} We evaluated the covariate balance after matching using standardised differences. An absolute standardised difference of less than 0.1 was considered negligible in the groups (see tables 2 and 3).

Survival data analysis

We estimated the overall survival using Kaplan-Meier curves.¹⁸ We also compared overall survival between matched with and without MM/CMM groups using a log-rank test.

Sensitivity analysis

While the definition of MM we adopted in this study is one of the most commonly used definitions in previous studies,² we analysed this cohort data with a more sensitive approach. Specifically, we analysed the association between the number of diseases or body system disorders and the mortality by multivariate analysis with the

covariates used in the propensity score calculation. The results of this analysis did not change the direction or significance of the MM/CMM effect (data not shown).

We used R software packages (V.4.0.1) for all statistical analyses, and the statistical significance level was 0.05 for all analyses.

Patient and public involvement

This was a nationwide cohort study focusing on community-dwelling individuals. No patients and the public were involved in this research.

RESULTS

Baseline population characteristics

Among the current cohort study, 20 233 (52.0%) participants out of 38 889 had MM and 7565 (19.5%) had CMM. Table 2 presents the demographic characteristics of the

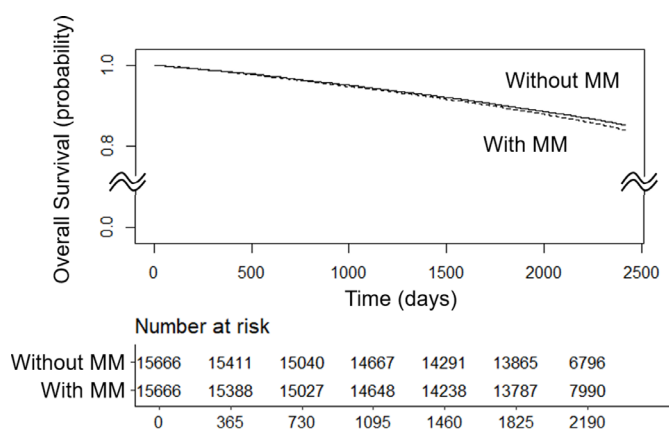


Figure 2 Kaplan-Meier curve for overall survival comparing patients with and without MM. MM, multimorbidity.

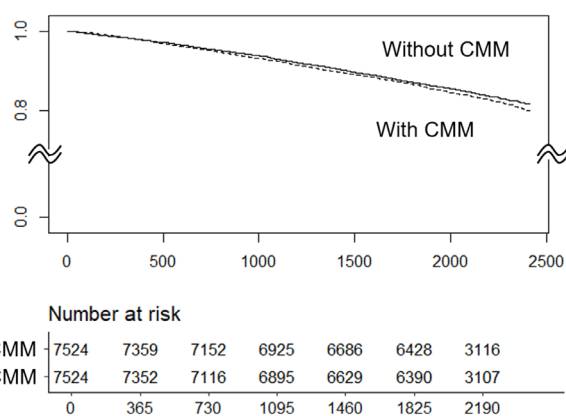


Figure 3 Kaplan-Meier curve for overall survival comparing patients with and without CMM. CMM, complex multimorbidity.

cohort study. **Table 3** summarises the background characteristics of the participants between the two groups before and after matching. Populations with MM/CMM were more likely to be older, were more likely to have fewer teeth, and were more vulnerable to financial insecurity (worries about unexpected expenses) compared with those without MM/CMM. Furthermore, compared with populations with MM, populations with CMM were more likely to be female, to have lower education, to eat meals alone and to be unmarried.

MM outcome

After the 1:1 propensity score matching, 31 332 patients were recruited and evenly classified into propensity-matched MM and propensity-matched non-MM groups. The C-statistics before matching for evaluation of the discriminatory ability of the propensity score model was 0.64 (95% CI 0.63 to 0.64).¹⁹ The two matched cohorts were well balanced (see **table 3**). The populations with MM had a 7% higher mortality than those without MM as shown in **figure 2** (HR 1.07; 95% CI 1.01 to 1.14; $p=0.02$ by the log-rank test).

CMM outcome

After the 1:1 propensity score matching, 15 048 patients were recruited and evenly classified into propensity-matched CMM and propensity-matched non-CMM groups. The C-statistics before matching for evaluation of the discriminatory ability of the propensity score model was 0.69 (95% CI 0.68 to 0.69).¹⁹ The two matched cohorts were well balanced (see **table 3**). The populations with CMM had slightly higher mortality than those without CMM as shown in **figure 3** (HR, 1.07; 95% CI 0.99 to 1.16; $p=0.08$ by the log-rank test).

DISCUSSION

To the best of our knowledge, this is the first study to report the association between CMM and mortality among older adults in Japan. MM and CMM predict mortality in older adults to a similar degree.

MM is both an individual and a social issue. Low socioeconomic status (SES) individuals develop MM roughly 10–15 years earlier compared with high SES individuals.²⁰ Therefore, to evaluate whether the presence of MM/CMM is causally related to mortality, SES should be considered as a confounding factor. There were larger intergroup differences in baseline variables for the CMM-matched cohort compared with the MM-matched cohort. Although CMM was already known to be associated with lower SES,²¹ the current findings indicate that CMM may be more closely related to social factors than MM.

We found that the impact of MM and CMM on mortality was similar. Furthermore, CMM was marginally statistically significantly associated with mortality. This may be partly because the current study did not consider disease severity or disease status except in the baseline survey. That is, it may not sufficiently represent body

system disorders in terms of the number of disease groups affected. This finding needs to be replicated with more precision in larger samples.

There are several limitations to this study. First, the self-administered questionnaire was the basis for disease information, which may have led to recall bias. This reporting error may lead to bias in either direction because its extent depends on the type of disease and age.²² Second, although the results are based on a nationwide cohort study, the participants were not nationally representative, and hence external generalisability is not assured. The response rate (around 65%) was comparable to that of other cohort studies for community-dwelling individuals. Third, because this study was observational, our findings cannot be interpreted as indicating causality. Nonetheless, we attempted to minimise confounding bias through the use of propensity score matching.¹⁸

CONCLUSION

Both MM and CMM predicted future mortality among older adults in Japan. These findings indicate the importance of the interactive effects of multiple diseases.

Acknowledgements The authors are grateful to all of the staff who conducted the baseline and follow-up surveys, all survey participants, and JAGES group members.

Contributors All authors (DK, IK, JS and NK) made contributions to the conception and design of this study. DK analysed the data and authored the paper. IK checked the results and advised edits. All authors agreed on the final version of this manuscript.

Funding This study used data from JAGES (the Japan Gerontological Evaluation Study). This study was supported by the Japan Society for the Promotion of Science, KAKENHI Grant (JP15H01972), Health Labour Sciences Research Grant (H28-Choju-Ippan002), Japan Agency for Medical Research and Development (JP17dk0110017, JP18dk0110027, JP18Is0110002, JP18Ie0110009, JP20dk0110034, JP20dk0110037), Open Innovation Platform with Enterprises, Research Institute and Academia (OPERA, JPMJOP1831) from the Japan Science and Technology (JST), a grant from Innovative Research Program on Suicide Countermeasures(1-4), a grant from Sasakawa Sports Foundation, a grant from Japan Health Promotion & Fitness Foundation, a grant from Chiba Foundation for Health Promotion & Disease Prevention, the 8020 Research Grant for fiscal 2019 from the 8020 Promotion Foundation (adopted number: 19-2-06), a grant from Niimi University (1915010), grants from Meiji Yasuda Life Foundation of Health and Welfare and the Research Funding for Longevity Sciences from National Center for Geriatrics and Gerontology (29-42, 30-22).

Competing interests None declared.

Patient consent for publication Not required.

Ethics approval JAGES participants were informed that participation was voluntary and that their consent to participate in the study was shown by returning the questionnaire via mail. The Nihon Fukushi University Ethics Committee (no. 10-5), National Center for Geriatrics and Gerontology (no. 992-2), and Chiba University Ethics Committee (no. 2493) approved the parent JAGES protocol.

Provenance and peer review Not commissioned; externally peer reviewed.

Data availability statement Data are available on reasonable request. Data are from the JAGES study. All inquiries are to be addressed to the data management committee via email: dataadmin.ml@jages.net. All JAGES datasets have ethical and legal restrictions for public deposition due to the inclusion of sensitive information from human participants.

Supplemental material This content has been supplied by the author(s). It has not been vetted by BMJ Publishing Group Limited (BMJ) and may not have been peer-reviewed. Any opinions or recommendations discussed are solely those of the author(s) and are not endorsed by BMJ. BMJ disclaims all liability and responsibility arising from any reliance placed on the content. Where the content



includes any translated material, BMJ does not warrant the accuracy and reliability of the translations (including but not limited to local regulations, clinical guidelines, terminology, drug names and drug dosages), and is not responsible for any error and/or omissions arising from translation and adaptation or otherwise.

Open access This is an open access article distributed in accordance with the Creative Commons Attribution Non Commercial (CC BY-NC 4.0) license, which permits others to distribute, remix, adapt, build upon this work non-commercially, and license their derivative works on different terms, provided the original work is properly cited, appropriate credit is given, any changes made indicated, and the use is non-commercial. See: <http://creativecommons.org/licenses/by-nc/4.0/>.

ORCID iDs

Daisuke Kato <http://orcid.org/0000-0002-2449-0548>

Junko Saito <http://orcid.org/0000-0002-6923-7298>

REFERENCES

- 1 Violan C, Foguet-Boreu Q, Flores-Mateo G, *et al*. Prevalence, determinants and patterns of multimorbidity in primary care: a systematic review of observational studies. *PLoS One* 2014;9:e102149.
- 2 Johnston MC, Crilly M, Black C, *et al*. Defining and measuring multimorbidity: a systematic review of systematic reviews. *Eur J Public Health* 2019;29:182–9.
- 3 Wei MY, Mukamal KJ. Multimorbidity, mortality, and long-term physical functioning in 3 prospective cohorts of community-dwelling adults. *Am J Epidemiol* 2018;187:103–12.
- 4 John PDS, Tyas SL, Menec V. Multimorbidity, disability, and mortality in community-dwelling older adults. *Can Fam Physician* 2014;60:272–80.
- 5 Tooth L, Hockey R, Byles J, *et al*. Weighted multimorbidity indexes predicted mortality, health service use, and health-related quality of life in older women. *J Clin Epidemiol* 2008;61:151–9.
- 6 Nunes BP, Flores TR, Mielke GI, *et al*. Multimorbidity and mortality in older adults: a systematic review and meta-analysis. *Arch Gerontol Geriatr* 2016;67:130–8.
- 7 Storeng SH, Vinjerui KH, Sund ER, *et al*. Associations between complex multimorbidity, activities of daily living and mortality among older Norwegians. A prospective cohort study: the HUNT study, Norway. *BMC Geriatr* 2020;20:1–8.
- 8 Harrison C, Henderson J, Miller G, *et al*. The prevalence of diagnosed chronic conditions and multimorbidity in Australia: a method for estimating population prevalence from general practice patient encounter data. *PLoS One* 2017;12:e0172935.
- 9 Singer L, Green M, Rowe F, *et al*. Social determinants of multimorbidity and multiple functional limitations among the ageing population of England, 2002–2015. *SSM - Popul Heal* 2019;8:1–9.
- 10 Harrison C, Henderson J, Miller G, *et al*. The prevalence of complex multimorbidity in Australia. *Aust N Z J Public Health* 2016;40:239–44.
- 11 Lujic S, Simpson JM, Zwar N, *et al*. Multimorbidity in Australia: comparing estimates derived using administrative data sources and survey data. *PLoS One* 2017;12:e0183817.
- 12 Kondo K. Progress in aging epidemiology in Japan: the JAGES project. *J Epidemiol* 2016;26:331–6.
- 13 Linn BS, Linn MW, Gurel L. Cumulative illness rating scale. *J Am Geriatr Soc* 1968;16:622–6.
- 14 Honaker J, King G, Blackwell M. A program for missing data. *J Stat Softw* 2011;45:1–47.
- 15 Graham JW, Olchowski AE, Gilreath TD. How many imputations are really needed? some practical clarifications of multiple imputation theory. *Prev Sci* 2007;8:206–13.
- 16 Rubin DB. Multiple imputation after 18+ years. *J Am Stat Assoc* 1996;91:473–89.
- 17 Rosenbaum PR, Rubin DB. The central role of the propensity score in observational studies for causal effects. *Biometrika* 1983;70:41–55.
- 18 Austin PC. The use of propensity score methods with survival or time-to-event outcomes: reporting measures of effect similar to those used in randomized experiments. *Stat Med* 2014;33:1242–58.
- 19 Westreich D, Cole SR, Funk MJ, *et al*. The role of the c-statistic in variable selection for propensity score models. *Pharmacoepidemiol Drug Saf* 2011;20:317–20.
- 20 Barnett K, Mercer SW, Norbury M, *et al*. Epidemiology of multimorbidity and implications for health care, research, and medical education: a cross-sectional study. *Lancet* 2012;380:37–43.
- 21 Vinjerui KH, Bjerkeset O, Bjorngaard JH, *et al*. Socioeconomic inequalities in the prevalence of complex multimorbidity in a Norwegian population: findings from the cross-sectional HUNT study. *BMJ Open* 2020;10:e036851.
- 22 Fortin M, Haggerty J, Sanche S, *et al*. Self-Reported versus health administrative data: implications for assessing chronic illness burden in populations. A cross-sectional study. *CMAJ Open* 2017;5:E729–33.

Table S1. 44 variables used for the propensity score calculation

- Age

- Sex

- Have you ever had a check-up at a health center, your workplace, a medical institution, or another place?

1. I had one within a year
 2. I had one within 2 to 3 years
 3. I had one more than 4 years ago
 4. I've never had one
-

- What is the status of your dental health? teeth4_10

1. I have 20 or more natural teeth
 2. I have 10 to 19 natural teeth
 3. I have 1 to 9 natural teeth
 4. I have no natural teeth
-

- How often did you eat meat or fish over the past month?

1. Twice a day or more
 2. Once a day
 3. Four to six times a week
 4. Two or three times a week
 5. Once a week
 6. Less than once a week
 7. None
-

- How often do you eat fruits and vegetables over the past month?

1. Twice a day or more
2. Once a day
3. Four to six times a week
4. Two or three times a week
5. Once a week
6. Less than once a week
7. None

- How many years of formal education have you had?

1. Less than 6 years
2. 6 to 9 years
3. 10 to 12 years
4. 13 years or more
5. Other

- What is your marital status?

1. Married
2. Widowed
3. Divorced
4. Never married
5. Other

- Who do you live with?

1. I live alone
2. I live with someone

- What type of residence do you live in?

1. Owned house
2. Privately-rented house
3. Municipally-managed house
4. Company-owned house
5. Other

- What is the architectural type of your home?

1. Detached house
2. Row house
3. Apartment building
4. Other

- How worried are you if you have to deal with an unexpected expense?

1. Not at all
2. Slightly
3. Moderately
4. Very

- Are you receiving a pension?

1. Yes
2. No

- What is your current working status?

1. I have a paid job.
2. I am retired from my job.
3. I have never had a job

- Who do you usually have meals with?

1. I eat meals alone.

2. I eat meals with someone.

- Do you currently drink alcohol?

1. Yes

2. I used to drink

3. No

- Do you smoke cigarettes?

1. I have never smoked

2. I stopped smoking 5 or more years ago

3. I stopped smoking within the past 4 years

4. I am currently a smoker

- Have you had any falls over the past year?

1. Many times

2. Once

3. None

- Are you very worried about falls?

1. Yes

2. No

- Do you go up stairs without holding onto the handrail or the wall?

1. Yes

2. No

- Do you get up out of chairs without holding anything?

1. Yes

2. No

- How long do you walk a day on average?

1. Less than 30 minutes
2. 30 to 59 minutes
3. 60 to 89 minutes
4. 90 minutes or more

- How often do you go out?

1. Almost everyday
2. Two or three times a week
3. Once a week
4. Once or twice a month
5. Several times a year
6. Rarely

- Has the frequency of your going out decreased since last year?

1. Yes
2. No

- Do you engage in any leisure activities at the moment?

1. Yes
2. No

- Do you think people living in your area can be trusted in general?

1. Very
2. Moderately
3. Neutral

4. Slightly

5. Not at all

- Do you think people living in your area try to help others in most situations?

1. Very

2. Moderately

3. Neutral

4. Slightly

5. Not at all

- How attached are you to the area you live?

1. Very

2. Moderately

3. Neutral

4. Slightly

5. Not at all

- Do you agree with making it a rule to offer half a day for the interests of the whole area but not for your own interests?

1. I agree

2. Neutral

3. I disagree

- How uneasy do you feel about safety in your community?

1. Very uneasy

2. More or less uneasy

3. Slightly uneasy

4. Not uneasy at all

- Do you want to participate in local events or festivals positively?

1. Yes
2. No

- What kind of interactions do you have with people in your neighborhood?

1. Mutual consultation, lending and borrowing daily commodities, cooperation in daily life
2. Standing and chatting frequently
3. No more than exchanging greetings
4. None, not even greetings

- Are the following present within 1 km of your home?

Locations with noticeable graffiti or undisposed garbage

1. Many
2. Some
3. Few
4. None
5. I don't know

- Are the following present within 1 km of your home?

Parks or foot paths suitable for exercise or walking

1. Many
2. Some
3. Few
4. None
5. I don't know

- Are the following present within 1 km of your home?

Locations difficult for walking, such as hills or steps

1. Many
 2. Some
 3. Few
 4. None
 5. I don't know
-

- Are the following present within 1 km of your home?

Roads or crossroads with a great risk of traffic accidents

1. Many
 2. Some
 3. Few
 4. None
 5. I don't know
-

- Are the following present within 1 km of your home?

Fascinating views or buildings

1. Many
 2. Some
 3. Few
 4. None
 5. I don't know
-

- Are the following present within 1 km of your home?

Shops or facilities selling fresh fruits and vegetables

1. Many

2. Some
3. Few
4. None
5. I don't know

- Are the following present within 1 km of your home?

Dangerous places when walking alone at night

1. Many
2. Some
3. Few
4. None
5. I don't know

- Are the following present within 1 km of your home?

Houses or facilities you feel free to drop in

1. Many
2. Some
3. Few
4. None
5. I don't know

- Do you have someone who listens to your concerns and complaints?

1. Yes
2. No

- Do you have someone who looks after you when you are sick and confined to a bed for a few days?

1. Yes

2. No

- How often do you attend activities for the following groups?

Sports group or club

1. Almost everyday

2. Two or three times a week

3. Once a week

4. Once or twice a month

5. A few times a year

6. Never

- How often do you attend activities for the following groups?

Leisure activity group

1. Almost everyday

2. Two or three times a week

3. Once a week

4. Once or twice a month

5. A few times a year

6. Never

Table S2. Basement Characteristics of populations with or without MM

With MM (n=20,233)	Without MM (n=18,656)
--------------------	-----------------------

Characteristic	Care need	No care need	Care need	No care need
Sample size. No	5,588	14,645	3,580	15,076
Age				
65-69	377 (7)	3,710 (25)	313 (9)	5,015 (33)
70-74	910 (16)	4,763 (33)	641 (18)	5,104 (34)
75-79	1,571 (28)	3,842 (26)	1,013 (28)	3,121 (21)
80-84	1,660 (30)	1,758 (12)	961 (27)	1,391 (9)
85-89	837 (15)	485 (3)	495 (14)	375 (2)
90-	233 (4)	87 (1)	157 (4)	70 0
missing	0 0	0 0	0 0	0 0
Sex				
male	2,234 (40)	6,569 (45)	1,662 (46)	7,376 (49)
female	3,354 (60)	8,076 (55)	1,918 (54)	7,700 (51)
missing	0 0)	0 0	0 0	0 0
Previous health check-up				
I had one within a year	2,838 (51)	8,888 (61)	1,696 (47)	9,204 (61)
I had one within 2 to 3 years	672 (12)	1,757 (12)	424 (12)	1,808 (12)

I had one more than 4 years ago	632 (11)	1,426 (10)	379 (11)	1,527 (10)
I've never had one	1,054 (19)	1,962 (13)	815 (23)	2,053 (14)
missing	392 (7)	612 (4)	266 (7)	484 (3)
The number of natural teeth				
20 or more	1,127 (20)	4,852 (33)	787 (22)	5,526 (37)
10 to 19	1,153 (21)	3,793 (26)	756 (21)	3,930 (26)
1 to 9	1,758 (31)	3,720 (25)	1,071 (30)	3,511 (23)
no natural teeth	1,312 (23)	1,862 (13)	796 (22)	1,688 (11)
missing	238 (4)	418 (3)	170 (5)	421 (3)
Consumption of meat and fish				
Twice a day or more	411 (7)	1,114 (8)	264 (7)	1,130 (7)
Once a day	1,652 (30)	4,465 (30)	1,090 (30)	4,636 (31)

Four to six times a week	1,147 (21)	3,347 (23)	733 (20)	3,382 (22)
Two or three times a week	1,517 (27)	3,856 (26)	916 (26)	3,963 (26)
Once a week	305 (5)	752 (5)	215 (6)	763 (5)
Less than once a week	136 (2)	248 (2)	77 (2)	266 (2)
None	38 (1)	42 0	13 0	35 0
missing	382 (7)	821 (6)	272 (8)	901 (6)
Consumption of fruits and vegetables				
Twice a day or more	2,366 (42)	6,641 (45)	1,464 (41)	6,796 (45)
Once a day	1,762 (32)	4,604 (31)	1,156 (32)	4,651 (31)
Four to six times a week	618 (11)	1,583 (11)	415 (12)	1,757 (12)

Two or three times a week	386 (7)	878 (6)	275 (8)	883 (6)
Once a week	63 (1)	122 (1)	32 (1)	115 (1)
Less than once a week	46 (1)	46 0	16 0	52 0
None	10 0	21 0	5 0	11 0
missing	337 (6)	750 (5)	217 (6)	811 (5)
Formal educational year				
Less than 6 years	297 (5)	285 (2)	200 (6)	212 (1)
6 to 9 years	2,821 (50)	6,991 (48)	1,688 (47)	6,609 (44)
10 to 12 years	1,527 (27)	4,707 (32)	1,028 (29)	5,222 (35)
13 years or more	719 (13)	2,372 (16)	492 (14)	2,716 (18)
Other	49 (1)	76 (1)	29 (1)	93 (1)
missing	175 (3)	214 (1)	143 (4)	224 (1)
Marital status				
Married	3,182 (57)	10,373 (71)	2,137 (60)	11,191 (74)

Widowed	1,948 (35)	3,176 (22)	1,125 (31)	2,819 (19)
Divorced	178 (3)	474 (3)	106 (3)	488 (3)
Never married	118 (2)	295 (2)	67 (2)	264 (2)
Other	23 0	85 (1)	22 (1)	85 (1)
missing	139 (2)	242 (2)	123 (3)	229 (2)
Someone living with				
live alone	4,515 (81)	12,680 (87)	2,956 (83)	13,213 (88)
not alone	944 (17)	1,786 (12)	507 (14)	1,631 (11)
missing	129 (2)	179 (1)	117 (3)	232 (2)
Residence type				
Owned house	4,722 (85)	12,740 (87)	3,039 (85)	13,172 (87)
Privately-rented house	240 (4)	597 (4)	177 (5)	619 (4)
Municipally-managed house	309 (6)	748 (5)	166 (5)	744 (5)
Company-owned house	5 0	25 0	3 0	24 0

Other	77 (1)	176 (1)	32 (1)	159 (1)
missing	235 (4)	359 (2)	163 (5)	358 (2)
Architectural type of home				
Detached house	4,490 (80)	12,200 (83)	2,932 (82)	12,586 (83)
Row house	126 (2)	312 (2)	90 (3)	282 (2)
Apartment building	528 (9)	1,416 (10)	316 (9)	1,507 (10)
Other	60 (1)	131 (1)	25 (1)	123 (1)
missing	384 (7)	586 (4)	217 (6)	578 (4)
Worries about unexpected expenses				
Not at all	584 (10)	1,274 (9)	480 (13)	1,538 (10)
Slightly	2,190 (39)	6,028 (41)	1,467 (41)	6,890 (46)
Moderately	1,443 (26)	4,113 (28)	835 (23)	3,866 (26)
Very	974 (17)	2,457 (17)	461 (13)	2,033 (13)
missing	397 (7)	773 (5)	337 (9)	749 (5)

Receiving pension

no	5,237 (94)	13,954 (95)	3,361 (94)	14,418 (96)
yes	84 (2)	193 (1)	44 (1)	165 (1)
missing	267 (5)	498 (3)	175 (5)	493 (3)

Current working status

having a paid job	497 (9)	2,762 (19)	398 (11)	3,657 (24)
retired	3,060 (55)	8,284 (57)	1,941 (54)	8,099 (54)
never having a job	956 (17)	1,667 (11)	525 (15)	1,518 (10)
missing	1,075 (19)	1,932 (13)	716 (20)	1,802 (12)

Persons to have meal
with

No one	3,676 (66)	10,781 (74)	2,492 (70)	11,461 (76)
With someone	1,569 (28)	3,136 (21)	859 (24)	2,781 (18)
missing	343 (6)	728 (5)	229 (6)	834 (6)

Alcohol

Yes	1,173 (21)	4,467 (31)	893 (25)	5,271 (35)
-----	------------	------------	----------	------------

Used to drink	259 (5)	581 (4)	163 (5)	465 (3)
No	3,728 (67)	8,770 (60)	2,262 (63)	8,471 (56)
missing	428 (8)	827 (6)	262 (7)	869 (6)
Smoking				
I have never smoked	3,042 (54)	7,948 (54)	1,824 (51)	8,018 (53)
I stopped smoking 5 or more years ago	1,158 (21)	3,341 (23)	727 (20)	3,359 (22)
I stopped smoking within the past 4 years	214 (4)	699 (5)	163 (5)	736 (5)
I am currently a smoker	452 (8)	1,180 (8)	390 (11)	1,528 (10)
missing	722 (13)	1,477 (10)	476 (13)	1,435 (10)
Falling over				
Many times	866 (15)	1,224 (8)	397 (11)	708 (5)
Once	1,609 (29)	3,676 (25)	913 (26)	3,085 (20)
None	2,806 (50)	9,119 (62)	2,078 (58)	10,673 (71)

missing	307 (5)	626 (4)	192 (5)	610 (4)
Worries about falls				
Yes	3,626 (65)	7,053 (48)	1,882 (53)	5,579 (37)
No	1,556 (28)	6,721 (46)	1,373 (38)	8,569 (57)
missing	406 (7)	871 (6)	325 (9)	928 (6)
Going up stairs without support				
Yes	1,953 (35)	7,801 (53)	1,586 (44)	9,740 (65)
No	3,332 (60)	6,217 (42)	1,808 (51)	4,706 (31)
missing	303 (5)	627 (4)	186 (5)	630 (4)
Get up out of chairs without support				
Yes	3,192 (57)	11,492 (78)	2,449 (68)	12,902 (86)
No	2,098 (38)	2,553 (17)	949 (27)	1,598 (11)
missing	298 (5)	600 (4)	182 (5)	576 (4)
Average time to walk				

Less than 30 minutes	2,553 (46)	4,877 (33)	1,496 (42)	4,256 (28)
30 to 59 minutes	1,570 (28)	4,894 (33)	1,041 (29)	5,020 (33)
60 to 89 minutes	565 (10)	2,085 (14)	400 (11)	2,386 (16)
90 minutes or more	402 (7)	1,879 (13)	328 (9)	2,539 (17)
missing	498 (9)	910 (6)	315 (9)	875 (6)
Frequency of going out				
Almost everyday	1,885 (34)	7,301 (50)	1,417 (40)	8,424 (56)
Two or three times a week	1,779 (32)	4,261 (29)	1,067 (30)	3,910 (26)
Once a week	719 (13)	1,349 (9)	393 (11)	1,177 (8)
Once or twice a month	525 (9)	718 (5)	269 (8)	519 (3)
Several times a year	112 (2)	133 (1)	76 (2)	128 (1)
Rarely	182 (3)	129 (1)	94 (3)	98 (1)

missing	386 (7)	754 (5)	264 (7)	820 (5)
Decrease in the frequency of going out				
Yes	2,459 (44)	3,637 (25)	1,222 (34)	2,516 (17)
No	2,696 (48)	10,145 (69)	2,083 (58)	11,601 (77)
missing	433 (8)	863 (6)	275 (8)	959 (6)
Engagement in leisure activities				
Yes	2,197 (39)	7,959 (54)	1,483 (41)	8,776 (58)
No	2,892 (52)	5,587 (38)	1,766 (49)	5,177 (34)
missing	499 (9)	1,099 (8)	331 (9)	1,123 (7)
Trust in neighbors				
Very	752 (13)	1,834 (13)	565 (16)	2,089 (14)
Moderately	2,804 (50)	7,913 (54)	1,827 (51)	8,415 (56)
Neutral	1,358 (24)	3,467 (24)	800 (22)	3,316 (22)
Slightly	222 (4)	537 (4)	120 (3)	423 (3)
Not at all	57 (1)	130 (1)	30 (1)	97 (1)

missing	395 (7)	764 (5)	238 (7)	736 (5)
Support from neighbors				
Very	438 (8)	968 (7)	332 (9)	1,043 (7)
Moderately	2,371 (42)	6,586 (45)	1,574 (44)	7,305 (48)
Neutral	1,796 (32)	4,867 (33)	1,074 (30)	4,731 (31)
Slightly	408 (7)	1,120 (8)	248 (7)	1,006 (7)
Not at all	110 (2)	244 (2)	66 (2)	164 (1)
missing	465 (8)	860 (6)	286 (8)	827 (5)
Attachment to residence				
Very	1,732 (31)	4,355 (30)	1,162 (32)	4,553 (30)
Moderately	2,492 (45)	7,195 (49)	1,664 (46)	7,550 (50)
Neutral	786 (14)	1,877 (13)	448 (13)	1,914 (13)
Slightly	258 (5)	629 (4)	109 (3)	523 (3)
Not at all	53 (1)	119 (1)	29 (1)	73 0
missing	267 (5)	470 (3)	168 (5)	463 (3)
Contribution to residence				

I agree	1,864 (33)	6,070 (41)	1,254 (35)	6,875 (46)
Neutral	2,927 (52)	7,188 (49)	1,790 (50)	6,839 (45)
I disagree	303 (5)	568 (4)	171 (5)	500 (3)
missing	494 (9)	819 (6)	365 (10)	862 (6)
Uneasiness about safety in residence				
Very uneasy	410 (7)	1,125 (8)	224 (6)	988 (7)
More or less uneasy	2,471 (44)	7,095 (48)	1,443 (40)	6,942 (46)
Slightly uneasy	1,940 (35)	5,141 (35)	1,341 (37)	5,747 (38)
Not uneasy at all	350 (6)	611 (4)	267 (7)	704 (5)
missing	417 (7)	673 (5)	305 (9)	695 (5)
Participation in local events				
Yes	1,881 (34)	5,953 (41)	1,260 (35)	6,680 (44)
No	3,160 (57)	7,656 (52)	1,882 (53)	7,303 (48)

missing	547 (10)	1,036 (7)	438 (12)	1,138 (8)
Interactions with neighborhood				
Daily Mutual consultation and cooperation	844 (15)	2,365 (16)	557 (16)	2,499 (17)
Standing and chatting frequently	2,831 (51)	8,080 (55)	1,789 (50)	8,425 (56)
No more than exchanging greetings	1,250 (22)	2,910 (20)	795 (22)	2,977 (20)
None, not even greetings	111 (2)	179 (1)	88 (2)	156 (1)
missing	552 (10)	1,111 (8)	351 (10)	1,019 (7)

Near to residence

Locations with graffiti
or garbage

Many	201 (4)	592 (4)	123 (3)	539 (4)
Some	1,209 (22)	3,673 (25)	680 (19)	3,672 (24)
Few	2,442 (44)	7,165 (49)	1,643 (46)	7,644 (51)
None	815 (15)	1,750 (12)	546 (15)	1,874 (12)
I don't know	590 (11)	938 (6)	352 (10)	816 (5)
missing	331 (6)	527 (4)	236 (7)	531 (4)

Parks or foot paths

Many	691 (12)	1,968 (13)	438 (12)	2,218 (15)
Some	2,830 (51)	7,903 (54)	1,812 (51)	8,257 (55)
Few	1,169 (21)	3,219 (22)	757 (21)	3,138 (21)
None	350 (6)	791 (5)	208 (6)	737 (5)
I don't know	292 (5)	365 (2)	169 (5)	325 (2)
missing	256 (5)	399 (3)	196 (5)	401 (3)

Locations difficult for
walking

Many	441 (8)	997 (7)	250 (7)	872 (6)
Some	1,872 (34)	4,276 (29)	1,048 (29)	3,933 (26)
Few	2,412 (43)	7,429 (51)	1,633 (46)	8,158 (54)
None	410 (7)	1,233 (8)	329 (9)	1,455 (10)
I don't know	206 (4)	359 (2)	141 (4)	278 (2)
missing	247 (4)	351 (2)	179 (5)	380 (3)

Risky roads or
crossroads for traffic
accidents

Many	666 (12)	1,911 (13)	374 (10)	1,752 (12)
Some	2,960 (53)	7,979 (54)	1,797 (50)	8,048 (53)
Few	1,402 (25)	3,839 (26)	1,014 (28)	4,335 (29)
None	77 (1)	180 (1)	67 (2)	213 (1)
I don't know	250 (4)	356 (2)	146 (4)	340 (2)
missing	233 (4)	380 (3)	182 (5)	388 (3)

Fascinating views or
buildings

Many	312 (6)	856 (6)	169 (5)	870 (6)
Some	1,719 (31)	4,702 (32)	1,103 (31)	4,994 (33)
Few	2,247 (40)	6,416 (44)	1,463 (41)	6,703 (44)
None	536 (10)	1,477 (10)	329 (9)	1,418 (9)
I don't know	441 (8)	688 (5)	260 (7)	583 (4)
missing	333 (6)	506 (3)	256 (7)	508 (3)

Shops selling fresh
fruits and vegetables

Many	639 (11)	2,145 (15)	468 (13)	2,393 (16)
Some	3,050 (55)	8,478 (58)	1,968 (55)	8,872 (59)
Few	1,134 (20)	2,630 (18)	691 (19)	2,541 (17)
None	402 (7)	864 (6)	204 (6)	776 (5)
I don't know	135 (2)	157 (1)	82 (2)	124 (1)
missing	228 (4)	371 (3)	167 (5)	370 (2)

Dangerous places
walking alone at night

Many	616 (11)	1,615 (11)	310 (9)	1,415 (9)
Some	2,540 (45)	7,371 (50)	1,523 (43)	7,442 (49)
Few	1,371 (25)	3,997 (27)	1,103 (31)	4,656 (31)
None	105 (2)	202 (1)	88 (2)	219 (1)
I don't know	672 (12)	1,018 (7)	352 (10)	893 (6)
missing	284 (5)	442 (3)	204 (6)	451 (3)

Comfortable houses
or facilities

Many	88 (2)	282 (2)	78 (2)	324 (2)
Some	1,789 (32)	5,140 (35)	1,219 (34)	5,523 (37)
Few	2,256 (40)	6,322 (43)	1,442 (40)	6,456 (43)
None	574 (10)	1,423 (10)	314 (9)	1,284 (9)
I don't know	603 (11)	1,046 (7)	336 (9)	1,007 (7)
missing	278 (5)	432 (3)	191 (5)	482 (3)

Someone listening to
your concerns

None	4,758 (85)	13,067 (89)	3,026 (85)	13,504 (90)
Yes	398 (7)	782 (5)	250 (7)	771 (5)
missing	432 (8)	796 (5)	304 (8)	801 (5)

Someone looking after
in case of ill

None	4,870 (87)	13,246 (90)	3,141 (88)	13,724 (91)
Yes	337 (6)	688 (5)	176 (5)	585 (4)
missing	381 (7)	711 (5)	263 (7)	767 (5)

Attendance

Sports group or club

Almost everyday	57 (1)	270 (2)	34 (1)	320 (2)
Two or three times a week	227 (4)	1,039 (7)	144 (4)	1,146 (8)
Once a week	181 (3)	826 (6)	124 (3)	884 (6)

Once or twice a month	108 (2)	539 (4)	88 (2)	681 (5)
A few times a year	94 (2)	514 (4)	94 (3)	611 (4)
Never	3,483 (62)	8,383 (57)	2,108 (59)	8,423 (56)
missing	1,438 (26)	3,074 (21)	988 (28)	3,011 (20)
Leisure activity group				
Almost everyday	53 (1)	249 (2)	40 (1)	265 (2)
Two or three times a week	260 (5)	1,216 (8)	217 (6)	1,253 (8)
Once a week	410 (7)	1,354 (9)	250 (7)	1,575 (10)
Once or twice a month	468 (8)	1,741 (12)	303 (8)	1,902 (13)
A few times a year	262 (5)	1,081 (7)	197 (6)	1,263 (8)
Never	2,809 (50)	6,302 (43)	1,691 (47)	6,268 (42)
missing	1,326 (24)	2,702 (18)	882 (25)	2,550 (17)

Data are given as No. (%) unless otherwise noted.

Abbreviations: MM, multimorbidity;

Table S3. Basement Characteristics of populations with or without CMM

Characteristic	With CMM (n=7,565)		Without CMM (n=31,324)	
	Care need	No care need	Care need	No care need
Sample size. No	2,508	5,057	6,660	24,664
Age				
65-69	146(6)	1,059(21)	544(8)	7,666(31)
70-74	376(15)	1,579(31)	1,175(18)	8,288(34)
75-79	714(28)	1,448(29)	1,870(28)	5,515(22)
80-84	758(30)	727(14)	1,863(28)	2,422(10)
85-89	398(16)	207(4)	934(14)	653(3)
90-	116(5)	37(1)	274(4)	120(0)
missing	0(0)	0(0)	0(0)	0(0)
Sex				
male	937(37)	2,114(42)	2,959(44)	11,831(48)
female	1,571(63)	2,943(58)	3,701(73)	12,833(52)

missing	0(0)	0(0)	0(0)	0(0)
Previous health check-up				
I had one within a year	1,253(50)	3,024(60)	3,281(65)	15,068(61)
I had one within 2 to 3 years	312(12)	613(12)	784(16)	2,952(12)
I had one more than 4 years ago	260(10)	497(10)	751(15)	2,456(10)
I've never had one	489(19)	683(14)	1,380(27)	3,332(14)
missing	194(8)	240(5)	464(9)	856(3)
The number of natural teeth				
20 or more	485(19)	1,535(30)	1,429(28)	8,843(36)
10 to 19	502(20)	1,305(26)	1,407(28)	6,418(26)
1 to 9	818(33)	1352(27)	2011(40)	5879(24)

no natural teeth	592(24)	719(14)	1,516(30)	2,831(11)
missing	111(4)	146(3)	297(6)	693(3)
Consumption of meat and fish				
Twice a day or more	193(8)	384(8)	482(10)	1,860(8)
Once a day	734(29)	1,526(30)	2,008(40)	7,575(31)
Four to six times a week	525(21)	1,142(23)	1,355(27)	5,587(23)
Two or three times a week	656(26)	1,343(27)	1,777(35)	6,476(26)
Once a week	145(6)	261(5)	375(7)	1,254(5)
Less than once a week	68(3)	93(2)	145(3)	421(2)
None	15(1)	20(0)	36(1)	57(0)
missing	172(7)	288(6)	482(10)	1,434(6)

Consumption of fruits and vegetables				
Twice a day or more	1054(42)	2,240(44)	2,776(55)	11,197(45)
Once a day	805(32)	1,602(32)	2,113(42)	7,653(31)
Four to six times a week	264(11)	563(11)	769(15)	2,777(11)
Two or three times a week	158(6)	306(6)	503(10)	1,455(6)
Once a week	35(1)	46(1)	60(1)	191(1)
Less than once a week	31(1)	21(0)	31(1)	77(0)
None	8(0)	11(0)	7(0)	21(0)
missing	153(6)	268(5)	401(8)	1,293(5)

Formal educational year

Less than 6 years	155(6)	141(3)	342(7)	356(1)
-------------------	--------	--------	--------	--------

6 to 9 years	1,301(52)	2,517(50)	3,208(63)	11,083(45)
10 to 12 years	662(26)	1,585(31)	1,893(37)	8,344(34)
13 years or more	294(12)	703(14)	917(18)	4,385(18)
Other	22(1)	30(1)	56(1)	139(1)
missing	153(6)	81(2)	244(5)	357(1)
Marital status				
Married	1,356(54)	3,416(68)	3,963(78)	18,148(74)
Widowed	928(37)	1,243(25)	2,145(42)	4,752(19)
Divorced	92(4)	163(3)	192(4)	799(3)
Never married	57(2)	100(2)	128(3)	459(2)
Other	11(0)	37(1)	34(1)	133(1)

missing	74(3)	98(2)	198(4)	373(2)
Someone living with				
live alone	1,992(79)	4,308(85)	5,479(108)	21,585(88)
not alone	468(19)	691(14)	983(19)	2,726(11)
missing	64(3)	58(1)	198(4)	353(1)
Residence type				
Owned house	2,104(84)	4,336(86)	5,657(112)	21,576(87)
Privately-rented house	118(5)	208(4)	299(6)	1,008(4)
Municipally-managed house	149(6)	292(6)	326(6)	1,200(5)
Company-owned house	1(0)	8(0)	7(0)	41(0)
Other	38(2)	75(1)	71(1)	260(1)
missing	48(2)	138(3)	300(6)	579(2)

Architectural type of home

Detached house	1,987(79)	4,184(83)	5,435(107)	20,602(84)
Row house	60(2)	121(2)	156(3)	473(2)
Apartment building	245(10)	502(10)	599(12)	2,421(10)
Other	30(1)	43(1)	55(1)	211(1)
missing	98(4)	207(4)	415(8)	957(4)

Worries about unexpected expenses

Not at all	235(9)	373(7)	829(16)	2,439(10)
Slightly	929(37)	1,888(37)	2,728(54)	11,030(45)
Moderately	666(27)	1,478(29)	1,612(32)	6,501(26)
Very	500(20)	1,054(21)	935(18)	3,436(14)
missing	186(7)	264(5)	556(11)	1,258(5)

Receiving pension

no	2,351(94)	4,811(95)	6,247(124)	23,561(96)
yes	41(2)	68(1)	87(2)	290(1)
missing	116(5)	178(4)	326(6)	813(3)

Current working status

having a paid job	190(8)	762(15)	705(14)	5,657(23)
retired	1,379(55)	2,936(58)	3,622(72)	13,447(55)
never having a job	478(19)	647(13)	1,003(20)	2,538(10)
missing	116(5)	712(14)	1,330(26)	3,022(12)

Persons to have meal with

No one	1,568(63)	3,542(70)	4,600(91)	18,700(76)
With someone	788(31)	1,259(25)	1,640(32)	4,658(19)

missing	152(6)	256(5)	420(8)	1306(5)
Alcohol				
Yes	479(19)	1,389(27)	1,587(31)	8,349(34)
Used to drink	118(5)	236(5)	304(6)	810(3)
No	1,701(68)	3,143(62)	4,289(85)	14,098(57)
missing	210(8)	289(6)	480(9)	1,407(6)
Smoking				
I have never smoked	1,400(56)	2,795(55)	3,466(69)	13,171(53)
I stopped smoking 5 or more years ago	510(20)	1,099(22)	1,375(27)	5,601(23)
I stopped smoking within the past 4 years	89(4)	245(5)	288(6)	1,190(5)
I am currently a smoker	174(7)	372(7)	668(13)	2,336(9)

missing	335(13)	546(11)	863(17)	2,366(10)
Falling over				
Many times	470(19)	567(11)	793(16)	1,365(6)
Once	724(29)	1,432(28)	1,798(36)	5,329(22)
None	1,180(47)	2,813(56)	3,704(73)	16,979(69)
missing	134(5)	245(5)	365(7)	991(4)
Worriees about falls				
Yes	1,751(70)	2,867(57)	3,757(74)	9,765(40)
No	579(23)	1,861(37)	2,350(46)	13,429(54)
missing	178(7)	329(7)	553(11)	1,470(6)
Going up stairs without support				

Yes	790(31)	2,314(46)	2,749(54)	15,227(62)
No	1,586(63)	2,507(50)	3,554(70)	8,416(34)
missing	132(5)	236(5)	357(7)	1,021(4)
Get up out of chairs without support				
Yes	1,300(52)	3,678(73)	4,341(86)	20,716(84)
No	1,066(43)	1,154(23)	1,981(39)	2,997(12)
missing	142(6)	225(4)	338(7)	951(4)
Average time to walk				
Less than 30 minutes	1,186(47)	1,857(37)	2,863(57)	7,276(30)
30 to 59 minutes	675(27)	1,629(32)	1,936(38)	8,285(34)
60 to 89 minutes	251(10)	653(13)	714(14)	3,818(15)

90 minutes or more	167(7)	565(11)	563(11)	3,853(16)
missing	229(9)	353(7)	584(12)	1432(6)

Frequency of going out

Almost everyday	756(30)	2,349(46)	2,546(50)	13,376(54)
Two or three times a week	853(34)	1,526(30)	1,993(39)	6,645(27)
Once a week	331(13)	506(10)	781(15)	2,020(8)
Once or twice a month	245(10)	297(6)	549(11)	940(4)
Several times a year	53(2)	60(1)	135(3)	201(1)
Rarely	89(4)	53(1)	187(4)	174(1)
missing	181(7)	266(5)	469(9)	1,308(5)

Decrease in the frequency of going out

Yes	1,222(49)	1,596(32)	2,459(49)	4,557(18)
No	1,095(44)	3,162(63)	3,684(73)	18,584(75)
missing	191(8)	299(6)	517(10)	1,523(6)
Engagement in leisure activities				
Yes	938(37)	2,611(52)	2,742(54)	14,124(57)
No	1,351(54)	2,042(40)	3,307(65)	8,722(35)
missing	219(9)	404(8)	611(12)	1,818(7)
Trust in neighbors				
Very	306(12)	597(12)	1,011(20)	3,326(13)
Moderately	1,212(48)	2,592(51)	3,419(68)	13,736(56)
Neutral	653(26)	1,300(26)	1,505(30)	5,483(22)

Slightly	120(5)	212(4)	222(4)	748(3)
Not at all	33(1)	61(1)	54(1)	166(1)
missing	184(7)	295(6)	449(9)	1,205(5)

Support from neighbors

Very	177(7)	338(7)	593(12)	1,673(7)
Moderately	1,043(42)	2,143(42)	2,902(57)	1,1748(48)
Neutral	823(33)	1,714(34)	2,047(40)	7,884(32)
Slightly	198(8)	436(9)	458(9)	1,690(7)
Not at all	58(2)	107(2)	118(2)	301(1)
missing	209(8)	319(6)	542(11)	1,368(6)

Attachment to residence

Very	735(29)	1,467(29)	2,159(43)	7,441(30)
Moderately	1,110(44)	2,428(48)	3,046(60)	12,317(50)
Neutral	381(15)	699(14)	853(17)	3,092(13)
Slightly	125(5)	232(5)	242(5)	920(4)
Not at all	32(1)	58(1)	50(1)	134(1)
missing	125(5)	173(3)	310(6)	760(3)

Contribution to residence

I agree	783(31)	1,977(39)	2,335(46)	10,968(44)
Neutral	1,358(54)	2,552(50)	3,359(66)	11,475(47)
I disagree	144(6)	220(4)	330(7)	848(3)
missing	223(9)	308(6)	636(13)	1,373(6)

Uneasiness about safety in residence				
Very uneasy	218(9)	441(9)	416(8)	1,672(7)
More or less uneasy	1,122(45)	2,520(50)	2,792(55)	11,517(47)
Slightly uneasy	824(33)	1,649(33)	2,457(49)	9,239(37)
Not uneasy at all	159(6)	199(4)	458(9)	1,116(5)
missing	185(7)	248(5)	537(11)	1,120(5)
Participation in local events				
Yes	787(31)	1,951(39)	2,354(47)	10,682(43)
No	1,478(59)	2,722(54)	3,564(70)	12,237(50)
missing	243(10)	384(8)	742(15)	1,745(7)
Interactions with neighborhood				

Daily Mutual consultation and cooperation	359(14)	805(16)	1,042(21)	4,059(16)
Standing and chatting frequently	1,249(50)	2,679(53)	3,371(67)	13,826(56)
No more than exchanging greetings	582(23)	1,052(21)	1,463(29)	4,835(20)
None, not even greetings	54(2)	70(1)	145(3)	265(1)
missing	264(11)	451(9)	639(13)	1,679(7)

Near to residence

Locations with graffiti or garbage

Many	99(4)	229(5)	225(4)	902(4)
Some	552(22)	1,281(25)	1,337(26)	6,064(25)
Few	1,071(43)	2,389(47)	3,014(60)	12,420(50)

None	334(13)	590(12)	1,027(20)	3,034(12)
I don't know	302(12)	363(7)	640(13)	1391(6)
missing	150(6)	205(4)	417(8)	853(3)

Parks or foot paths

Many	284(11)	684(14)	845(17)	3,502(14)
Some	1,255(50)	2,665(53)	3,387(67)	13,495(55)
Few	532(21)	1,106(22)	1,394(28)	5,251(21)
None	173(7)	296(6)	385(8)	1,232(5)
I don't know	154(6)	163(3)	307(6)	527(2)
missing	110(4)	143(3)	342(7)	657(3)

Locations difficult for walking

Many	225(9)	434(9)	466(9)	1,435(6)
Some	865(34)	1,606(32)	2,055(41)	6,603(27)
Few	1,024(41)	2,395(47)	3,021(60)	13,192(53)
None	166(7)	363(7)	573(11)	2325(9)
I don't know	116(5)	132(3)	231(5)	505(2)
missing	112(4)	127(3)	314(6)	604(2)

Risky roads or
crossroads for traffic
accidents

Many	337(13)	736(15)	703(14)	2,927(12)
Some	1,348(54)	2,730(54)	3,409(67)	13,297(54)
Few	562(22)	1,274(25)	1,854(37)	6,900(28)

None	25(1)	51(1)	119(2)	342(1)
I don't know	130(5)	128(3)	266(5)	568(2)
missing	106(4)	138(3)	309(6)	630(3)
Fascinating views or buildings				
Many	138(6)	308(6)	343(7)	1,418(6)
Some	756(30)	1,574(31)	2,066(41)	8,122(33)
Few	970(39)	2,185(43)	2,740(54)	10,934(44)
None	263(10)	530(10)	602(12)	2,365(10)
I don't know	225(9)	278(5)	476(9)	993(4)
missing	156(6)	182(4)	433(9)	832(3)
Shops selling fresh fruits and vegetables				

Many	275(11)	715(14)	832(16)	3,823(16)
Some	1,363(54)	2,880(57)	3,655(72)	14,470(59)
Few	513(20)	937(19)	1,312(26)	4,234(17)
None	186(7)	320(6)	420(8)	1,320(5)
I don't know	69(3)	66(1)	148(3)	215(1)
missing	102(4)	139(3)	293(6)	602(2)
Dangerous places walking alone at night				
Many	329(13)	658(13)	597(12)	2,372(10)
Some	1,138(45)	2,494(49)	2,925(58)	12,319(50)
Few	533(21)	1283(25)	1941(38)	7,370(30)
None	36(1)	64(1)	157(3)	357(1)

I don't know	344(14)	389(8)	680(13)	1,522(6)
missing	128(5)	169(3)	360(7)	724(3)
Comfortable houses or facilities				
Many	30(1)	98(2)	136(3)	508(2)
Some	766(31)	1,712(34)	2,242(44)	8,951(36)
Few	982(39)	2,179(43)	2,716(54)	10,599(43)
None	298(12)	524(10)	590(12)	2,183(9)
I don't know	304(12)	388(8)	635(13)	1,665(7)
missing	128(5)	156(3)	341(7)	758(3)
Someone listening to your concerns				
None	2,094(83)	4,469(88)	5,690(113)	22,102(90)
Yes	224(9)	303(6)	424(8)	1,250(5)

missing	190(8)	285(6)	546(11)	1,312(5)
---------	--------	--------	---------	----------

Someone looking after in case of ill				
--------------------------------------	--	--	--	--

None	2,134(85)	4,526(89)	5,877(116)	22,444(91)
------	-----------	-----------	------------	------------

Yes	194(8)	276(5)	319(6)	997(4)
-----	--------	--------	--------	--------

missing	180(7)	255(5)	464(9)	1,223(5)
---------	--------	--------	--------	----------

Attendance

Sports group or club

Almost everyday	19(1)	84(2)	72(1)	506(2)
-----------------	-------	-------	-------	--------

Two or three times a week	85(3)	319(6)	286(6)	1,866(8)
---------------------------	-------	--------	--------	----------

Once a week	86(3)	263(5)	219(4)	1,447(6)
-------------	-------	--------	--------	----------

Once or twice a month	39(2)	150(3)	157(3)	1,070(4)
-----------------------	-------	--------	--------	----------

A few times a year	36(1)	150(3)	152(3)	975(4)
--------------------	-------	--------	--------	--------

Never	1,590(63)	2,920(58)	4,001(79)	13,886(56)
missing	653(26)	1,171(23)	1,773(35)	4,914(20)
Leisure activity group				
Almost everyday	17(1)	78(2)	76(2)	436(2)
Two or three times a week	115(5)	398(8)	362(7)	2,071(8)
Once a week	171(7)	445(9)	489(10)	2,484(10)
Once or twice a month	204(8)	571(11)	567(11)	3,072(12)
A few times a year	113(5)	364(7)	346(7)	1980(8)
Never	1,293(52)	2,168(43)	3,207(63)	10,402(42)
missing	595(24)	1,033(20)	1613(32)	4,219(17)

Data are given as No. (%) unless otherwise noted.

Abbreviations: CMM, complex multimorbidity;