# Chronic Physical Conditions, Multimorbidity, and Mild Cognitive Impairment in Low- and Middle-Income Countries

*Ai Koyanagi, MD,[ab] Elvira Lara, PhD,[bc] Brendon Stubbs, PhD,[def] Andre F. Carvalho, PhD,[g] Hans Oh, PhD,[h] Andrew Stickley, PhD,[i] Nicola Veronese, PhD,[jk] and Davy Vancampfort, PhD[lm]*

**OBJECTIVES:** To assess the association between chronic physical conditions and multimorbidity and mild cognitive impairment (MCI) in low- and middle-income countries (LMICs).
**DESIGN:** Nationally representative, cross-sectional, community-based study.
**SETTING:** Six countries that participated in the World Health Organization Study on Global Ageing and Adult Health.
**PARTICIPANTS:** Individuals aged 50 and older (N=32,715; mean age 62.1 ± 15.6; 51.7% female).
**MEASUREMENTS:** The definition of MCI was based on the recommendations of the National Institute on Ageing and Alzheimer's Association. Ten chronic conditions were assessed (angina pectoris, arthritis, asthma, cataract, chronic lung disease, diabetes mellitus, edentulism, hearing problems, hypertension, stroke). Multivariable logistic regression analysis was conducted to assess the association between chronic physical conditions, multimorbidity (≥2 chronic conditions), and MCI.
**RESULTS:** The prevalence of multimorbidity was 49.8% (95% confidence interval (CI)=48.1–51.5%) and of MCI was 15.3% (95% CI=14.4–16.3%). After adjustment for potential confounders, edentulism (odds ratio (OR)=1.24), arthritis (OR=1.24), chronic lung disease (OR=1.29), cataract (OR=1.33), stroke (OR=1.94), hearing problems (OR=2.27), and multimorbidity (OR=1.40) were significantly associated with MCI. There was a gradual increase in the likelihood of MCI (1 condition: OR=1.21, 95% CI=1.03–1.42; ≥4 conditions: OR=2.07, 95% CI=1.70–2.52).
**CONCLUSION:** These results highlight the need to investigate the underlying mechanisms linking chronic conditions and MCI and whether prevention or treatment of chronic conditions or multimorbidity can reduce the onset of cognitive decline and subsequent dementia, especially in LMICs. **J Am Geriatr Soc 66:721–727, 2018.**

**Key words: mild cognitive impairment; chronic physical conditions; multimorbidity; low- and middle-income countries**

The world population is aging at an unprecedented speed because of increasing life expectancy. The number of individuals aged 65 and older is projected to increase from 524 million in 2010 to 1.5 billion by 2050, with most of the increase occurring in low- and middle-income countries (LMICs).[1] Increases in noncommunicable diseases (NCDs) such as heart disease, cancer, and diabetes mellitus[1] and neuropsychiatric disorders such as dementia[2] will inevitably accompany this demographic change. In particular, dementia is projected to increase sharply because the incidence of dementia doubles with every 6.3-year increase in age in the older population.[3] The number of people living with dementia is projected to increase from current figures of 46 million to 131.5

From the [a]Research and Development Unit, Parc Sanitari Sant Joan de Déu, Universitat de Barcelona, Fundació Sant Joan de Déu, Barcelona, Spain; [b]Instituto de Salud Carlos III, Centro de Investigación Biomédica en Red de Salud Mental, Madrid, Spain; [c]Department of Psychiatry, Universidad Autónoma de Madrid, Madrid, Spain; [d]Physiotherapy Department, South London and Maudsley National Health Service Foundation Trust, Denmark Hill, London, United Kingdom; [e]Health Service and Population Research Department, Institute of Psychiatry, Psychology and Neuroscience, King's College London, London, United Kingdom; [f]Faculty of Health, Social Care and Education, Anglia Ruskin University, Chelmsford, United Kingdom; [g]Department of Clinical Medicine and Translational Psychiatry Research Group, Faculty of Medicine, Federal University of Ceará, Fortaleza, Brazil; [h]School of Social Work, University of Southern California, Los Angeles, California; [i]Stockholm Center for Health and Social Change, Södertörn University, Huddinge, Sweden; [j]Geriatrics Unit, Department of Geriatric Care, OrthoGeriatrics and Rehabilitation, E.O. Galliera Hospital, National Relevance and High Specialization Hospital, Genova, Italy; [k]National Research Council, Neuroscience Institute, Aging Branch, Padova, Italy; [l]Department of Rehabilitation Sciences, Katholieke Universiteit Leuven, Leuven, Belgium; and the [m]University Psychiatric Center, Katholieke Universiteit Leuven, Leuven-Kortenberg, Belgium.

Address correspondence to Ai Koyanagi, MD, MSc, PhD, Research and Development Unit, Parc Sanitari Sant Joan de Déu, Universitat de Barcelona, Fundació Sant Joan de Déu, Dr. Antoni Pujadas, 42, Sant Boi de Llobregat, Barcelona, Spain. E-mail: a.koyanagi@pssjd.org

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million by 2050.[3] The proportion of people with dementia residing in LMICs is expected to increase from current rates of 58% to 68% in 2050.[3]

Dementia is one of the major causes of disability and dependency in older adults and has significant social and economic effects,[4] but there are no drugs to cure dementia or to modify its clinical course, and symptomatic medication has only modest effects.[5,6] Thus, identifying modifiable risk factors of the precursory stage of dementia to establish interventions to prevent or delay the onset of dementia is a priority. Specifically, mild cognitive impairment (MCI) is considered to be a preclinical transitional state of dementia[7] for which targeted interventions may be feasible. The conversion rate of MCI to dementia has been estimated to be 12% at 1 year, 20% at 3 years, and 50% at 5 years.[8] Previously reported potentially modifiable risk factors for MCI include factors such as low physical activity, obesity, diabetes mellitus, and hypertension.[9]

In terms of single chronic physical diseases, most previous studies have focused on cardiometabolic diseases,[10] but studies of other chronic conditions are limited. Furthermore, there is a notable paucity of data on the association between multimorbidity (coexistence of $\geq$2 chronic conditions) and MCI. Multimorbidity is highly prevalent in the older population and is an important risk concept because it is associated with greater disability, poorer quality of life, polypharmacy, premature mortality, and higher healthcare costs.[11,12]

To our knowledge, only a few studies have specifically focused on the association between multimorbidity and MCI in the general population.[13,14] One U.S. longitudinal study found that individuals aged 70 and older with multimorbidity had a risk of MCI or dementia that was 1.38 (95% confidence interval (CI)=1.05–1.82) times as high than in those without multimorbidity (N=2,176). Another cross-sectional study from Sweden found that individuals aged 75 and older with 2 or 3 chronic conditions are 3.03 (95% CI=1.20–7.64) times as likely to have MCI as those with no conditions (N=1,435).[14] These studies were conducted in limited locations in single high-income countries with a focus on elderly adults. Thus, it is unknown whether these results are applicable to other age groups or settings. Assessment of cognitive function and its risk factors at earlier ages is important from the point of view of prevention of dementia because cognitive dysfunction appears up to 10 years before dementia diagnosis,[15] and it is important to intervene in midlife.[16–18] Also, data on this topic from LMICs are particularly important given that increasing trends in cardiovascular diseases coupled with epidemics of obesity and increasing hypertension can result in upward trends in dementia prevalence and incidence in this setting.[3] Furthermore, the association between multimorbidity and MCI may differ in LMICs because of different disease profiles, population age structure, and healthcare systems, as well as higher prevalence of poverty and low education and suboptimal treatment of chronic conditions.[19]

Thus, the main aim of the current study was to assess the association between multimorbidity and MCI in adults aged 50 and older in 6 LMICs using data from the World Health Organization (WHO) Study on Global Ageing and Adult Health (SAGE).

## METHODS

### The Survey

Data from the SAGE survey were analyzed. This survey was undertaken in China, Ghana, India, Mexico, Russia, and South Africa between 2007 and 2010. Based on the World Bank classification at the time of the survey, all of these countries were LMICs. Details of the survey methodology have been published elsewhere.[20] In brief, to obtain nationally representative samples, a multistage clustered sampling design method was used. The sample consisted of adults aged 18 and older, with oversampling of those aged 50 and older. Trained interviewers conducted face-to-face interviews using a standard questionnaire. Standard translation procedures were undertaken to ensure comparability between countries. Those who were unable to undertake the interview because of limited cognitive function were not included in the current study. Survey response rates were: 93% for China, 81% for Ghana, 68% for India, 53% for Mexico, 83% for Russia, and 75% for South Africa. Sampling weights were constructed to adjust for the population structure as reported by the United Nations Statistical Division. Ethical approval was obtained from the WHO Ethical Review Committee and local ethics research review boards. Written informed consent was obtained from all participants.

### MCI (Outcome)

MCI was ascertained based on the recommendations of the National Institute on Aging and Alzheimer's Association.[21] We applied algorithms identical to those used in previous publications using a dataset with the same survey questions to identify MCI.[9,22] Briefly, individuals fulfilling all of the following conditions were considered to have MCI.

#### *Concern about a change in cognition*

Individuals who replied "bad" or "very bad" to the question, "How would you best describe your memory at present?" and those who answered "worse" to the question, "Compared with 12 months ago, would you say your memory is now better, the same, or worse then it was then?" were considered to have this condition.

#### *Objective evidence of impairment in one or more cognitive domains*

This was based on a cut-off of 1 standard deviation or more below the mean after adjustment for level of education, age, and country. Cognitive function was assessed according to word list immediate and delayed verbal recall from the Consortium to Establish a Registry for Alzheimer's Disease,[23] which assessed learning and episodic memory; digit span forward and backward from the Weschler Adult Intelligence Scale,[24] which evaluated attention and working memory; and the animal naming task,[23] which assessed verbal fluency.

### *Preservation of independence in select functional abilities (absence of severe or extreme activity of daily living difficulties)*

This was assessed using questions on self-reported difficulties with basic activities of daily living (ADLs) in the past 30 days.[25] Specific questions were: "How much difficulty did you have in getting dressed?" and "How much difficulty did you have with eating (including cutting up your food)?" Answer options were none, mild, moderate, severe, and extreme (cannot do). Those who answered none, mild, or moderate to both of these questions were considered to have preservation of independence in ADLs. Although these questions were about difficulty with ADLs rather than dependence, we assumed that those with severe or extreme levels of difficulty performing these tasks were highly unlikely to be independent in functional abilities. All other individuals were deleted from the analysis (935 individuals aged ≥50).

### *No dementia*

Individuals with a level of cognitive impairment severe enough that they could not take the survey were not included in the study.

## Chronic Conditions and Multimorbidity (Exposures)

We included all 10 chronic physical conditions (angina pectoris, arthritis, asthma, cataract, chronic lung disease, diabetes mellitus, edentulism, hearing problems, hypertension, stroke), assessed according to self-report of diagnosis, symptoms, interviewer observation, and blood pressure measurement (see Supplementary Table S1 for details), for which data were available in SAGE. These conditions have been reported to be associated with poor cognitive performance.[9,26–33] The total number of chronic conditions was calculated and categorized as 0, 1, 2, 3, and 4 or more. Multimorbidity was defined as 2 or more chronic conditions.[34]

## Control Variables

The analysis adjusted for a number of potential confounders that have been reported to be linked with MCI and chronic physical conditions.[9,35,36] Sociodemographic control variables included age, sex, education (no formal, some primary, ≥secondary completed), and wealth quintiles based on country-specific income. Other variables included health behavior (smoking (never, current, former), alcohol consumption (never, nonheavy, heavy), physical activity), body mass index (BMI) based on measured weight and height (<18.5, 18.5–24.9, 25.0–29.9, ≥30 kg/m$^2$), and depression. (See Supplementary Table S2 for details on these variables.)

## Statistical Analysis

Statistical analysis was performed using Stata version 14.1 (Stata Corp LP, College Station, TX). The analysis was restricted to those aged 50 and older. The difference in the prevalence of multimorbidity or MCI according to sample characteristics was tested using chi-square tests. Tetrachoric correlations between each chronic condition were calculated in those with MCI.

We conducted multivariable logistic regression analysis to assess the association between number of chronic conditions, including multimorbidity (≥2 chronic conditions), or each of the 10 individual chronic conditions (exposure variables) and MCI (outcome) using the overall sample (aged ≥50) and according to age group (50–64, ≥65) because previous studies have shown that risk factors for MCI may differ between mid- and late life.[9,37] Finally, to assess the degree of between-country heterogeneity in the association between multimorbidity and MCI, based on country-wise estimates, we calculated Higgin's $I^2$, which represents the degree of heterogeneity that sampling error does not explain; a value of 25% is often considered as a low level of heterogeneity, 50% as moderate, and 75% as high.[38]

The regression analyses were all adjusted for age, sex, education, wealth, smoking, alcohol consumption, physical activity, BMI, depression, and country, with the exception of the country-wise analysis, which did not adjust for country. When the individual chronic conditions were the exposure variable, the models were also adjusted for the presence of other chronic illnesses to account for comorbid chronic conditions. This variable included information on whether the individual had any of the other 9 chronic conditions. Country adjustment was done by including dummy variables for each country. Less than 5% of the data was missing for the variables used in the analysis. All variables were included in the models as categorical variables, with the exception of age when used as a continuous variable. Complete-case analysis was performed. Sample weighting and the complex study design were taken into account in the analyses. Results from the regression analyses are presented as odds ratios (ORs) with 95% confidence intervals (CIs). The level of statistical significance was set at $P<.05$.

# RESULTS

The final analytical sample consisted of 32,715 individuals aged 50 and older (China, n=12,815; Ghana, n=4,201; India, n=6,191; Mexico, n=2,070; Russia, n=3,766; South Africa, n=3,672). Mean age was 62.1, and 51.7% were female. The prevalence (95% CI) of multimorbidity was 49.8% (95% CI=48.1–51.5%) and of MCI was 15.3% (95% CI=14.4–16.3%). The country-wise prevalence of individual chronic physical conditions is provided in Supplementary Table S3. Older age, female sex, lower levels of education and wealth, former smoking, low physical activity, BMI of 30 kg/m$^2$ or more, and depression were associated with greater prevalence of multimorbidity (Table 1).

All single chronic conditions assessed were significantly associated with higher prevalence of MCI with the exception of angina pectoris, cataract, and diabetes mellitus (Table 2). There was a linear increase in the prevalence of MCI with increasing number of chronic conditions. In individuals with MCI, there was a particularly strong correlation between angina pectoris and asthma, angina

**Table 1. Prevalence of Multimorbidity According to Sample Characteristic**

| Characteristic | %[a] | With Multimorbidity, % | P-Value |
|---|---|---|---|
| Age | | | <.001 |
| 50–59 | 47.3 | 37.6 | |
| 60–69 | 30.2 | 53.1 | |
| 70–79 | 17.7 | 70.2 | |
| ≥80 | 4.8 | 74.6 | |
| Sex | | | <.001 |
| Female | 51.7 | 54.9 | |
| Male | 48.3 | 44.4 | |
| Education | | | <.001 |
| No formal | 28.5 | 54.3 | |
| Primary | 28.2 | 46.6 | |
| ≥Secondary completed | 43.3 | 49.0 | |
| Wealth | | | .005 |
| Poorest | 16.9 | 53.2 | |
| Poorer | 18.9 | 53.1 | |
| Middle | 19.4 | 50.0 | |
| Richer | 21.5 | 48.0 | |
| Richest | 23.3 | 46.3 | |
| Smoking | | | <.001 |
| Never | 58.7 | 51.0 | |
| Current | 34.9 | 46.4 | |
| Former | 6.4 | 57.4 | |
| Alcohol consumption | | | <.001 |
| Never | 66.7 | 49.0 | |
| Nonheavy | 29.1 | 52.6 | |
| Heavy | 4.2 | 39.8 | |
| Low physical activity | | | <.001 |
| No | 77.6 | 47.8 | |
| Yes | 22.4 | 56.8 | |
| Body mass index, kg/m$^2$ | | | |
| <18.5 | 16.2 | 52.1 | <.001 |
| 18.5–24.9 | 47.8 | 44.2 | |
| 25.0–29.9 | 24.5 | 51.4 | |
| ≥30 | 11.5 | 67.5 | |
| Depression | | | <.001 |
| No | 94.5 | 48.3 | |
| Yes | 5.5 | 76.5 | |

Percentage is based on weighted sample.
[a]Denominator ranges from 31,179 to 32,715.

**Table 2. Prevalence of Chronic Conditions and Proportion of Individuals with Mild Cognitive Impairment (MCI) According to Presence of Chronic Conditions**

| Characteristic | %[a] | With MCI, % | P-Value |
|---|---|---|---|
| Angina pectoris | | | .29 |
| No | 82.8 | 15.1 | |
| Yes | 17.2 | 16.3 | |
| Arthritis | | | <.001 |
| No | 71.0 | 14.2 | |
| Yes | 29.0 | 17.9 | |
| Asthma | | | .03 |
| No | 92.5 | 15.1 | |
| Yes | 7.5 | 17.9 | |
| Cataract | | | .07 |
| No | 73.6 | 14.9 | |
| Yes | 26.4 | 16.5 | |
| Chronic lung disease | | | <.001 |
| No | 85.0 | 14.5 | |
| Yes | 15.0 | 19.6 | |
| Diabetes mellitus | | | .70 |
| No | 93.3 | 15.3 | |
| Yes | 6.7 | 15.8 | |
| Edentulism | | | <.001 |
| No | 87.8 | 14.7 | |
| Yes | 12.2 | 20.0 | |
| Hearing problems | | | <.001 |
| No | 94.7 | 14.2 | |
| Yes | 5.3 | 32.0 | |
| Hypertension | | | <.001 |
| No | 45.2 | 13.3 | |
| Yes | 54.8 | 17.0 | |
| Stroke | | | <.001 |
| No | 97.3 | 15.0 | |
| Yes | 2.7 | 27.6 | |
| Number of chronic conditions | | | <.001 |
| 0 | 19.2 | 10.7 | |
| 1 | 31.0 | 14.0 | |
| 2 | 23.6 | 15.4 | |
| 3 | 13.8 | 18.0 | |
| ≥4 | 12.5 | 21.2 | |

Percentage is based on weighted sample.
[a]Denominator ranges from 31,940 to 32,662.

pectoris and chronic lung disease, asthma and chronic lung disease, diabetes mellitus and hypertension, edentulism and hearing problems, and stroke and hypertension (Supplementary Table S4).

In the overall sample, multivariable regression analysis showed that all individual chronic conditions are associated with higher odds of MCI, but statistical significance was reached only for arthritis (OR=1.24), cataract (OR=1.33), chronic lung disease (OR=1.29), edentulism (OR=1.24), hearing problems (OR=2.27), and stroke (OR=1.94). The OR for multimorbidity was 1.40 (95% CI=1.23–1.58) (Table 3). These associations were similar in the two age groups with the exception of angina pectoris and chronic lung disease, which were significantly associated with MCI only in the younger group. The association between MCI and multimorbidity showed a moderate level of between-country heterogeneity (Higgin's $I^2$=64%, 95% CI=12%–85%) (Supplementary Figure S1). There was a gradual increase in the odds of MCI with increasing number of conditions in the overall sample (1 condition: OR=1.21, 95% CI=1.03–1.42; ≥4 conditions: OR=2.07, 95% CI=1.70–2.52) (Table 4). In terms of other potentially modifiable risk factors for MCI, in the overall sample, smoking, low physical activity, and obesity (BMI ≥30.0 kg/m$^2$) were also associated with higher odds of MCI independent of the number of chronic conditions, although some of these factors were not significantly associated with MCI in one of the age groups (Table 4).

## DISCUSSION

Several chronic conditions and multimorbidity were significantly associated with higher odds of MCI. There was also a gradual increase in the odds of MCI with increasing number of chronic conditions. The strength of the study includes the large sample size and the use of nationally representative samples from 6 countries, which comprise nearly half of the world population.[20] Our study results expand understanding of the effects of modifiable risk factors on development of MCI and

**Table 3. Associations Between Physical Health Conditions and Multimorbidity and Mild Cognitive Impairment, Estimated Using Multivariable Logistic Regression**

| Chronic Physical Condition | Odds Ratio (95% Confidence Interval) | | |
|---|---|---|---|
| | Overall | Aged 50–64 | Aged ≥65 |
| Angina pectoris | 1.14 (0.98–1.33) | 1.34 (1.09–1.63)[b] | 0.98 (0.77–1.24) |
| Arthritis | 1.24 (1.10–1.40)[c] | 1.24 (1.06–1.44)[b] | 1.30 (1.09–1.54)[b] |
| Asthma | 1.18 (0.96–1.45) | 1.13 (0.85–1.50) | 1.22 (0.91–1.63) |
| Cataract | 1.33 (1.15–1.55)[c] | 1.44 (1.15–1.79)[b] | 1.28 (1.06–1.55)[b] |
| Chronic lung disease | 1.29 (1.10–1.52)[b] | 1.46 (1.17–1.83)[c] | 1.14 (0.91–1.44) |
| Diabetes mellitus | 1.13 (0.90–1.42) | 1.32 (0.93–1.89) | 1.05 (0.80–1.38) |
| Edentulism | 1.24 (1.03–1.48)[a] | 1.23 (0.95–1.58) | 1.21 (0.95–1.55) |
| Hearing problems | 2.27 (1.84–2.78)[c] | 2.86 (2.10–3.89)[c] | 1.91 (1.50–2.43)[c] |
| Hypertension | 1.08 (0.96–1.20) | 1.04 (0.91–1.19) | 1.15 (0.97–1.37) |
| Stroke | 1.94 (1.49–2.53)[c] | 2.35 (1.57–3.52)[c] | 1.65 (1.14–2.39)[b] |
| Multimorbidity[d] | 1.40 (1.23–1.58)[c] | 1.43 (1.25–1.64)[c] | 1.42 (1.16–1.73)[c] |

Models were adjusted for age, sex, education, wealth, body mass index, smoking, alcohol consumption, physical activity, depression, other physical illness, and country, with the exception of multimorbidity, which was not adjusted for other physical illness.
p<[a].05, [b].01, [c].001.
[d]≥2 physical health conditions.

dementia by showing for the first time that multimorbidity is associated with MCI in midlife and in LMICs. This is an important finding because previous studies have suggested that strategies to address risk factors for dementia should take place in midlife.[16–18] Furthermore, our study has important implications for public health in LMICs, where MCI and dementia are often underdiagnosed,[39] health care is suboptimal,[19] and there is urgent need for strategies to address and manage the growing epidemic of chronic diseases,[40] which are also risk factors for MCI and dementia.

Angina pectoris (only in those aged 50–64), edentulism, arthritis, chronic lung disease, cataract, stroke, and hearing problems were significantly associated with higher odds of MCI. All these conditions have been observed to be associated with poor cognitive performance, even in study populations from LMICs,[26,28–30,32,33,41–43] although with mixed results for some conditions.[32,44,45] Similar to some previous studies, we did not observe a significant association between diabetes mellitus or hypertension and MCI.[46,47] These two conditions have been recognized as potentially modifiable risk factors for dementia.[16] Thus, further studies from LMICs are warranted to assess whether our results are corroborated. In particular, the results on diabetes mellitus may have differed if objective data such as blood glucose had been available.

**Table 4. Association Between Number of Chronic Physical Conditions and Other Modifiable Factors and Mild Cognitive Impairment, Estimated Using Multivariable Logistic Regression**

| Characteristic | Odds Ratio (95% Confidence Interval) | | |
|---|---|---|---|
| | Overall | Aged 50–64 | Aged ≥65 |
| Number of chronic conditions (reference 0) | | | |
| 1 | 1.21 (1.03–1.42)[a] | 1.23 (1.02–1.48)[a] | 1.14 (0.83–1.55) |
| 2 | 1.37 (1.14–1.63)[c] | 1.40 (1.14–1.73)[b] | 1.33 (0.91–1.95) |
| 3 | 1.75 (1.43–2.14)[c] | 1.91 (1.45–2.51)[c] | 1.66 (1.21–2.27)[b] |
| ≥4 | 2.07 (1.70–2.52)[c] | 2.41 (1.76–3.29)[c] | 1.85 (1.36–2.50)[c] |
| Smoking (reference never) | | | |
| Current | 1.20 (1.01–1.43)[a] | 1.23 (1.00–1.50)[a] | 1.24 (0.91–1.69) |
| Former | 1.20 (0.97–1.50) | 1.16 (0.86–1.58) | 1.22 (0.88–1.69) |
| Alcohol consumption (reference never) | | | |
| Non-heavy | 0.97 (0.82–1.15) | 1.03 (0.85–1.26) | 0.95 (0.73–1.23) |
| Heavy | 1.22 (0.93–1.61) | 1.18 (0.81–1.72) | 1.31 (0.86–2.00) |
| Low physical activity | 1.24 (1.08–1.43)[b] | 0.83 (0.69–1.00) | 1.72 (1.40–2.11)[c] |
| Body mass index, kg/m$^2$ (reference 18.5–24.9) | | | |
| <18.5 | 1.21 (1.00–1.47) | 1.44 (1.11–1.87)[b] | 0.95 (0.67–1.34) |
| 25.0–29.9 | 0.93 (0.81–1.06) | 1.07 (0.90–1.27) | 0.78 (0.64–0.95)[a] |
| ≥30.0 | 1.30 (1.02–1.65)[a] | 1.54 (1.12–2.11)[b] | 1.06 (0.76–1.49) |
| Depression | 0.93 (0.69–1.24) | 0.87 (0.61–1.25) | 0.90 (0.57–1.44) |

The model was mutually adjusted for all variables in the table, sociodemographic variables (age, sex, education, wealth), and country.
p<[a].05, [b].01, [c].001.

Our study results are in line with those of previous studies reporting high risk of MCI in individuals with multiple chronic conditions.[13,14,48] One study found that faster accumulation of chronic conditions was associated with greater decline in cognitive function.[48] Multimorbidity may reflect an age-related multisystem failure, which can also be accompanied by neurodegeneration or cognitive decline.[48] Some combinations of chronic conditions may act synergistically to accelerate cognitive decline, as in the case of heart disease and cerebrovascular disease, whereas polypharmacy and drug interactions may also increase the risk of cognitive decline in individuals with multimorbidity.[13] One study found that several health problems not individually recognized as risk factors for dementia were associated with greater risk of dementia when combined into a frailty index.[49] This finding, together with increasing evidence that multimorbidity is related to poor cognitive performance, reinforces the notion that promoting overall health of the population might mitigate the burden of late-life dementia.[50] Finally, a moderate level of between-country heterogeneity in the association between multimorbidity and MCI was found. Although the reason for this heterogeneity is not clear, it may be related to factors such as access to health care and quality of care (e.g., availability of drugs). This is an area for future research.

If confirmed with longitudinal and interventional studies, the key to prevention of MCI and subsequent dementia may be to strengthen a multidisciplinary approach simultaneously targeting lifestyle factors and physical health outcomes (e.g., chronic diseases, multimorbidity). Health promotion can specifically target risk factors contributing to chronic physical conditions and ultimately multimorbidity, which might include diet, exercise, and smoking cessation, all of which are also considered to be important for dementia prevention even in the absence of chronic physical conditions.[16]

To address chronic diseases in LMICs, the WHO Innovative Care for Chronic Conditions framework provides a health systems roadmap, but it does not incorporate the complexity associated with multimorbidity.[51] In LMICs, there is a particular need to enhance integration of care and capacity building and to improve quality of services to address multimorbidity.[52]

The study results should be interpreted in the light of several limitations. First, although we included a wide variety of important chronic conditions, we lacked data on diseases such as hypercholesterolemia and human immunodeficiency virus infection. Second, symptom-based algorithms were used to define some chronic conditions to minimize underdiagnosis, but there may still be some level of misclassification, and underdiagnosis is likely to have occurred for diseases based solely on self-report (diabetes mellitus, stroke). For example, chronic lung diseases and asthma are not easy to differentiate for the overlapping symptoms, especially in older populations.[53] Third, because the study was not designed to generate clinical diagnoses of dementia, some individuals with mild dementia may have been included in our analytical sample, although the prevalence of MCI in our study was within previously reported figures.[54] Furthermore, in line with previous publications,[9,22] we used a definition for preservation of independence in functional abilities based on only 2 ADL domains so as not to overexclude MCI cases with disability not related to their cognitive ability. There is no consensus in terms of the acceptable level of functional impairment that individuals with MCI could have,[55] but it is reassuring that the results were similar even when applying a different definition of disability (impairment in all 6 ADL domains[25]). Furthermore, we lacked data on dietary factors, medication, and past alcohol drinking patterns, which may also explain the link between chronic conditions and MCI. Next, the response rate for the SAGE survey was comparable with or higher than that of other national surveys on aging in most of the countries included in our study. Nevertheless, there was some between-country variability, and the response rate for Mexico was low. Finally, because this was a cross-sectional study, causality cannot be inferred, and the possibility of reverse causality cannot be dismissed.

In conclusion, several chronic conditions and multimorbidity were found to be associated with MCI. Our study results highlight the need to investigate the underlying mechanisms linking chronic conditions and MCI and whether prevention or treatment of chronic conditions or multimorbidity can reduce the onset of cognitive decline and subsequent dementia, especially in LMICs.

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## SUPPORTING INFORMATION

Additional Supporting Information may be found in the online version of this article.

**Table S1.** Details of variables and additional analyses

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