Multimorbidity and out-of-pocket expenditure for medicines in China and India

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ABSTRACT
Introduction Using nationally representative survey data from China and India, this study examined (1) the distribution and patterns of multimorbidity in relation to socioeconomic status and (2) association between multimorbidity and out-of-pocket expenditure (OOPE) for medicines by socioeconomic groups.

Methods Secondary data analysis of adult population aged 45 years and older from WHO Study on Global Ageing and Adult Health (SAGE) India 2015 (n=7397) and China Health and Retirement Longitudinal Study (CHARLS) 2015 (n=11570). Log-linear, two-parts, zero-inflated and quantile regression models were performed to assess the association between multimorbidity and OOPE for medicines in both countries. Quantile regression was adopted to assess the observed relationship across OOPE distributions.

Results Based on 14 (11 self-reported) and 9 (8 self-reported) long-term conditions in the CHARLS and SAGE datasets, respectively, the prevalence of multimorbidity in the adult population aged 45 and older was found to be 63.4% in China and 42.2% in India. Of those with any long-term health condition, 38.6% in China and 20.9% in India had complex multimorbidity. Multimorbidity was significantly associated with higher OOPE for medicines in both countries (p<0.05); an additional physical long-term condition was associated with an 18.8% increase in OOPE for medicine in China (p<0.05) and a 20.9% increase in India (p<0.05). Liver disease was associated with highest increase in OOPE for medicines in China (61.6%) and stroke in India (131.6%). Diabetes had the second largest increase (China: 58.4%, India: 91.6%) in OOPE for medicines in both countries.

Conclusion Multimorbidity was associated with substantially higher OOPE for medicines in China and India compared with those without multimorbidity. Our findings provide supporting evidence of the need to improve financial protection for populations with an increased burden of chronic diseases in low-income and middle-income countries.

INTRODUCTION
Multimorbidity, defined as the coexistence of two or more long-term conditions (LTCs) within an individual, is a growing yet unaddressed major public health challenge in low-income and middle-income countries (LMICs) undergoing rapid demographic and epidemiological transition.1 Evidence from...
high-income countries indicates that multimorbidity is becoming the norm rather than exception among the older adult population. A recent study in China found that over 60% of the population aged 45 years and above is multimorbid. Emerging evidence from high-income countries indicates that multimorbidity is a major contributor to health inequalities. However, studies from LMICs have revealed mixed findings in terms of the socioeconomic patterning of multimorbidity. The mixed findings might be due to the differences in the distribution of risk factors for LTCs across socioeconomic groups as well as underdiagnosis in those of lower socioeconomic status (SES).

Reducing the financial burden of prescription medicines in patients with multimorbidity is a key priority for countries that aim to achieve universal health coverage (UHC). Patients with multimorbidity have complex health needs that require more frequent visits to healthcare providers. Patients with multimorbidity are also at a higher risk of financial impoverishment caused by higher out-of-pocket expenditure (OOPE) on doctor visits and medication, and loss of income due to job losses or decline in productivity. Our earlier study (2015) revealed that OOPE for medicines constitute a significant proportion of total healthcare expenditures for those with multimorbidity, in six major LMICs. For example, in India, it constituted approximately 60% of outpatient service spending, and 50% of inpatient service spending. The high level of OOPE is concerning as cost is the major barrier to access to healthcare, especially for the poor that are more sensitive to costs for health services.

Recent statistics indicate that, roughly 95% of the population is covered by at least one of the three social basic health insurance schemes. These insurance schemes are the Urban Employee Basic Medical Insurance Scheme (UEBMI), the Urban Resident Basic Medical Insurance Scheme (URBMI) and the New Rural Cooperative Medical Scheme (NRCMS). China has been focusing on implementing URBMI and NRCMS into the new Urban–Rural Resident Medical Insurance scheme since 2015. Patients are required to pay user fees for their health services under the form of deductibles, copayments, reimbursement caps and patient cost sharing. Studies have found that the level of cost sharing varies substantially based on the type of health services, insurance, province and patient characteristics. These studies have shown that the percentage of cost sharing for outpatient care was significantly higher than for inpatient care. The most recent Healthy China 2030 policy has set an ambitious target of reducing patient cost-sharing (the percentage of out-of-pocket spending in total health expenditure) from 60% in 2001 to 25% by 2050.

According to the latest data, just around 37% of the Indian population has health insurance (including public and private). Low levels of public health insurance coverage are mostly attributable to insufficient public health spending, particularly in low-income states. Studies have shown that wealthy Indians are more likely to have private health insurance than their counterparts. There is a focused public health insurance programme in India for the disadvantaged population. Recent statistics estimate that OOPE accounts for around 62.5% of total health expenditures, results in both impoverished and catastrophic health expenditures. Data from national analysis suggested that medicines accounted for more than half of total OOPE for individuals with multimorbidity.

Despite the critical importance of OOPE for medicines for LMICs to achieve UHC, to date, most research evaluating the impact of multimorbidity on OOPE for medicine has been conducted in high-income countries, with few comparative studies in LMICs (see Research in context). To address this critical evidence gap, using nationally representative data in China and India, we have examined the patterning of multimorbidity and their effect on OOPE for medicines in both countries. Specifically we have investigated (1) the distribution and patterns of multimorbidity in relation to SES and (2) association between multimorbidity and OOPE on medicines by socioeconomic groups.

METHODS
Data sources
Secondary data analysis was conducted on nationally representative data from wave 2 of the WHO Study on Global Ageing and Adult Health (SAGE) India and wave 3 of the China Health and Retirement Longitudinal Study (CHARLS) both conducted in 2015. Wave 2 of SAGE India contained 9116 respondents. In brief, CHARLS is an ongoing nationally representative longitudinal survey where baseline measures were conducted in the year 2011 and subsequent rounds of data were collected every 2 years. CHARLS used a multistage stratified probability-proportionate-to-size sampling and face to face computer assisted personal interviews were conducted in individuals aged 45 years or older. SAGE is an longitudinal study that began in 2007 by the WHO. SAGE wave 2 is a follow-up to sage wave 1 conducted in 2007. SAGE used a multistage stratified cluster sampling design where face-to-face interviews were conducted on a larger sample of individuals aged 50 and older and on a smaller comparative sample of those aged 18–49 in six selected sates of Assam, Karnataka, Maharashtra, Rajasthan, Uttar Pradesh and West Bengal. More detailed description of study design, tools and protocols have been reported elsewhere.

This study included respondents aged 45 years and older from the interviewed samples, with valid blood pressure readings from the survey nurse visit (n=7567) and excluded respondents with missing data on other outcome or independent variables, resulting in 7397 respondents. The wave 3 of CHARLS contained 20197 respondents. This study included respondents aged 45 years and older from the interviewed samples, with
valid blood pressure reading from the interviewer’s visit 
(n=13354) and excluded respondents with missing data 
on other outcome or independent variables, resulting in 
11 570 respondents. The sample flow chart of respon-
dents for both countries is summarised in online supple-
mental appendix figures S1 and S2.

Variables

LTC multimorbidity

Our main variable of interest was the number of coex-
istent LTCs reported by each respondent. We counted 
the number of LTCs for each respondent and defined 
those with multimorbidity as the presence of two or more 
of these conditions.1

Furthermore, we used the International Classification 
of Diseases-10th revision to group LTCs into organ systems 
and counted the number of organ systems affected for 
each respondent. Those with complex multimorbidity 
were defined as ‘three or more chronic conditions 
affecting at least three different body systems within one 
person’ which has been used in previous research.33 34

In SAGE, nine LTCs were included: angina, arthritis, 
asthma, cataracts, diabetes, stroke, chronic lung disease, 
hypertension and depression.35 36 The presence of LTCs 
was ascertained by either self-reporting or direct measure-
ment.35 36 For angina, arthritis, asthma, chronic lung 
disease, diabetes, cataracts, stroke and hypertension, 
respondents were defined as having an LTC, through 
self-reporting, if they have answered yes to the question, 
‘Have you ever been diagnosed with….?’ 6 12 35 36 Furth-
ermore, extra sets of symptomatic questions were provided 
to assess angina, arthritis, asthma and chronic lung 
disease.36 Symptom-based assessment of angina was based 
from the WHO’s Rose Angina Questionnaire.37 Symptom-
Based assessment of arthritis, asthma and chronic lung 
disease was based from an algorithm created by the WHO 
SAGE study team in the Diagnostic Item Probability 
Study.37 For hypertension, trained health investigators 
carried out measurement of systolic and diastolic levels 
of each respondent.38 Three blood pressure readings 
were taken at 1 min intervals and the average was calcu-
lated.38 In this analysis, we also categorised an indi-
vidual as having hypertension if the average systolic levels 
were ≥140 mmHg and average diastolic levels were ≥90 
mm Hg.38 The presence of a mental health disorder is 
defined as having depression in WHO SAGE.35 Diagnosis 
of depression was based on either self-reported diagnosis 
or from clinical-based assessment.36 Self-reported diag-
nosis of depression occurs if respondents have answered 
yes to the question ‘Have you ever been diagnosed with 
depression?’ 12 36 Clinical-based assessment of depression 
was based from the algorithm-based World Mental health 
Survey version of the Composite International Diagnostic 
Interview (CIDI).39

For CHARLS, there were 14 LTCs. Twelve of which 
were physical (hypertension, diabetes, dyslipidaemia, 
heart disease, stroke, cancer, chronic lung disease, digestive 
disease, liver disease, kidney disease, memory disease 
and arthritis).3 Two were mental LTCs: depression and 
psychological and emotional illness. Presence of a physical 
chronic condition was defined from a set of self-reported 
questions or confirmation through measurements such as 
blood pressure.40 Respondents were hypertensive if 
systolic levels were ≥140 mm Hg or diastolic levels were 
≥90 mm Hg or taking antihypertensive medication at the 
time of the survey.41 Presence of mental LTCs was defined 
as having depressive symptoms or psychological and 
emotional illness. Psychological and emotional illness 
was assessed from self-reported questions and depression 
symptoms were assessed through a questionnaire based 
on a self-reported Centre for Epidemiologic Studies 
Depression 10 items score.42 Respondents who scored 
more than 10 were found to have depression.42

Outcome variable

Our primary outcome of interest was OOPE for medi-
cines. OOPE for medicines was assessed by examining 
outpatient OOPE for medicines on their last outpatient 
visit. In SAGE, individuals were asked about their OOPE 
for medicines by answering the question ‘thinking about 
your last visit, how much did you or your household pay 
for…’ for the following categories: Healthcare provider’s 
fees, medicines, tests, transport and other fees in their 
local currency.6 For respondents who responded in the 
previous question ‘who paid for this most recent visit?’ that their last hospitalisation was free and did not 
provide a value for OOPE for medicine, we assumed that 
OOPE for medicine will equate to zero.6 In CHARLS, 
respondents wrote down OOPE spending on medicine 
by answering the question ‘how much will you eventu-
ally pay out of pocket for the medications from this 
visit, including prescriptions you received?’ 63 Those who 
did not pay anything will have an OOPE for medicines 
as zero.43 As values for OOPE were highly skewed, we 
removed observations with the highest 0.5% of OOPE 
to lessen the skewing effects and influence of outlier 
on the analysis.6 In both China and India, we used their 
local currency, Yuan (¥) and Rupee (₹), respectively, for 
OOPE for medicines.

Covariates

The following covariates were included in the analyses: 
age (45–54, 55–64, 65–74, 75+ years), sex (male/female), 
residence (urban/rural), marital status (currently married/not married), education (primary or less, 
secondary or high school, tertiary or higher), economic status defined as wealth quintiles with 1 being the 
lowest and 5 being the highest, caste (scheduled, none, other), health insurance status (yes/no), religion (Hinduism, 
Islam, other) and geographical regions defined as state 
names (Assam, Karnataka, Maharashtra, Rajasthan, Utter 
Pradesh, West Bengal). For CHARLS, the following covar-
iates were included in the analyses: sex (male/female), 
age (45–54, 55–64, 65–74, 75+ years), marital status 
(currently married/not married), residence (urban/ 
rural), education (primary or less, secondary, tertiary
or higher), social health insurance status (none/Urban Employee Basic Medical Insurance (UEBMI)/Urban Resident Medical Insurance (URBMI)/New Rural Cooperative Medical Scheme (NRCMS)/other), region (east/central/west) and economic status defined as wealth quintiles with 1 being the lowest and 5 being the highest.

Statistical analysis
We first summarised the prevalence for the following variables in both countries: (1) multimorbidity; (2) physical–mental multimorbidity and (3) complex multimorbidity at national level by SES subgroups. We examined multimorbidity patterns in each country, by showing the size of the bubble and its associated percentage of individuals with each dyad of disease.

We estimated the relationships between multimorbidity and OOPE for medicine using log-linear models where a constant, equals to one, was added to the outcome variable prior to the log transformation to reduce skewness. To interpret the coefficients estimated from the model, we converted the coefficients to a percentage change in outcome.

We examined the potential differential effect of multimorbidity on OOPE for medicine across socioeconomic groups by including interaction terms between socioeconomic groups and number of LTCs in our regression models. Similarly, we examined the differential effect across health insurance status by including interaction terms between health insurance and number of LTCs in our regression models.

To examine the association between multimorbidity and OOPE for medicines across cost distribution, we performed quantile regression analyses. Quantile regression fits a line to minimise the sum of absolute residuals. The objective is to estimate the median (as well as the 25th, 75th and 90th percentile) of the outcome variable conditional on independent variables. The method is robust to outliers because it allows for studying the full distribution of the outcome variable and is suitable for modelling outcomes such as OOPE, which are often skewed or not normally distributed.

In both countries, some patients reported zero OOPE for medicine (6.43% in China and 14.8% in India). Thus, we conducted sensitivity analyses that examined the relationships between multimorbidity and outcomes using two additional models that explicitly take into account, the zero outcome. These were (1) two-part model and (2) zero-inflated negative binomial model. The two-part model consists of a logistic regression model that estimates OOPE for medicine being non-zero and a generalised linear model. The zero-inflated negative binomial model was fitted to observe the zero and count outcome variables.

All OOPE on medicines was estimates in inflation-adjusted 2020 US$. This was done by using Purchasing Power Parity Indices to convert costs from one country to another (in this case, the USA), and subsequently the overall US Consumer Price Index was used to convert historical costs to 2020 US$. We also displayed money in China (yuan) and India (rupee) separately to enhance comprehension for local policy-makers.

We tested for multicollinearity for covariates adjusted for in our analysis with the variance inflation factor. The multicollinearity diagnostics (variance inflation factor) were all less than five, indicating that the assumption of reasonable independence among predictor variables was met. We presented adjusted ORs (AOR) for results in logistic regression model, and regression coefficient for results in log-linear models. All data analyses were weighted to account for the complex, multistage design of the SAGE and CHARLS survey. We performed the statistical analyses using Stata V.16.1 (StataCorp).

RESULTS
Sample characteristics
In China, the median age of respondents was 60 years old (IQR=52–67). The average number of LTCs per respondent was 2.42 (table 1) and 50.6% were female. 8.8% had no health insurance whereas 91.2% had health insurance. Of those with health insurance, 18.8% had UEBMI, 8.0% with URBMI, 61.6% had NRCMS with 2.7% having other types (online supplemental table S1). In India, the median age of respondents was 60 years (IQR=54–68). The average number of LTCs per respondent was 1.51. (table 2), 53.7% were female and only 10.1% had health insurance (online supplemental table S1).

Prevalence of multimorbidity
Tables 1 and 2 present the mean number of LTCs and the prevalence of multimorbidity, coexisting physical–mental multimorbidity and complex multimorbidity in China and India, respectively. Online supplemental tables S2 and S3 present the number of LTCs by the sample characteristics from China and India, respectively.

In China, the overall prevalence of any type of multimorbidity was 63.4% which ranged from 47.2% (45–54 years) to 76.4% (75 years and above). The prevalence of coexisting physical–mental health multimorbidity was 23.2%. Among patients with any long-term health condition, 38.6% of those with complex multimorbidity (table 1). The most common LTC was dyslipidaemia (37.4%), followed by arthritis (35%) and hypertension (31.4%) (online supplemental figure S3) while that of depression was 23.5%. For patterns of multimorbidity, the most common dyad was asthma and chronic lung disease (75.6%) (figure 1A). The most common physical–mental multimorbidity dyad was depression and arthritis (63.2%) (figure 1). Hypertension, arthritis and depression have a higher prevalence among respondents with the highest economic status whereas diabetes,
| Variables               | Mean no of morbidities (SD) | Prevalence of any type of multimorbidity % (95% CI) | Prevalence of coexisting physical–mental multimorbidity % (95% CI) | The prevalence of complex multimorbidity among those with chronic disease % (95% CI) |
|-------------------------|-----------------------------|-------------------------------------------------|-----------------------------------------------------------------|--------------------------------------------------------------------------------|
| All individuals         | 2.42 (1.84)                 | 63.4 (61.9 to 64.8)                             | 23.2 (21.8 to 24.6)                                             | 38.6 (36.9 to 40.3)                                                          |
| Sex                     |                             |                                                 |                                                                |                                                                                |
| Male                    | 2.32 (1.73)                 | 62.4 (60.6 to 64.2)                             | 18.3 (16.9 to 19.8)                                             | 35.1 (33.2 to 37.1)                                                          |
| Female                  | 2.51 (1.93)                 | 64.3 (62.1 to 66.4)                             | 27.9 (26.1 to 29.8)                                             | 42.0 (39.9 to 44.1)                                                          |
| Age (years)             |                             |                                                 |                                                                |                                                                                |
| 45–54                   | 1.76 (1.53)                 | 47.2 (44.4 to 50.0)                             | 17.3 (15.5 to 19.4)                                             | 23.7 (20.9 to 26.7)                                                          |
| 55–64                   | 2.52 (1.78)                 | 67.8 (65.5 to 70.1)                             | 24.7 (22.3 to 27.4)                                             | 39.9 (37.2 to 42.6)                                                          |
| 65–74                   | 2.99 (2.06)                 | 74.8 (72.3 to 77.1)                             | 29.0 (26.3 to 31.9)                                             | 50.5 (47.5 to 53.5)                                                          |
| 75+                     | 2.97 (1.78)                 | 76.4 (72.1 to 80.2)                             | 23.6 (20.2 to 27.3)                                             | 50.9 (45.8 to 56.0)                                                          |
| Education level         |                             |                                                 |                                                                |                                                                                |
| Primary or less         | 2.48 (1.97)                 | 64.0 (62.2 to 65.8)                             | 26.6 (24.8 to 28.5)                                             | 42.9 (41.0 to 44.8)                                                          |
| Secondary               | 2.36 (1.74)                 | 63.2 (59.2 to 67.0)                             | 20.7 (17.1 to 24.8)                                             | 34.4 (31.8 to 37.0)                                                          |
| Tertiary or higher      | 2.22 (1.34)                 | 61.0 (57.4 to 64.4)                             | 11.3 (8.7 to 14.5)                                             | 26.1 (22.2 to 30.4)                                                          |
| Residence               |                             |                                                 |                                                                |                                                                                |
| Urban                   | 2.30 (1.57)                 | 60.9 (58.5 to 63.3)                             | 16.4 (14.8 to 18.2)                                             | 33.6 (31.1 to 36.2)                                                          |
| Rural                   | 2.52 (2.06)                 | 65.8 (64.1 to 67.4)                             | 29.6 (27.9 to 31.3)                                             | 43.2 (41.4 to 45.0)                                                          |
| Marital status          |                             |                                                 |                                                                |                                                                                |
| Currently married       | 2.34 (1.81)                 | 62.0 (60.3 to 63.6)                             | 21.7 (20.3 to 23.1)                                             | 36.8 (35.0 to 38.6)                                                          |
| Not married             | 2.79 (1.92)                 | 70.7 (67.9 to 73.3)                             | 30.6 (27.8 to 33.7)                                             | 47.1 (43.7 to 50.4)                                                          |
| Region                  |                             |                                                 |                                                                |                                                                                |
| East                    | 2.22 (1.59)                 | 60.9 (58.3 to 63.5)                             | 18.6 (16.7 to 20.5)                                             | 32.9 (30.6 to 35.4)                                                          |
| Central                 | 2.54 (2.00)                 | 65.1 (63.1 to 67.1)                             | 24.3 (22.0 to 26.7)                                             | 41.2 (38.6 to 43.9)                                                          |
| West                    | 2.58 (1.98)                 | 65.2 (62.2 to 68.1)                             | 29.8 (27.0 to 32.7)                                             | 44.5 (41.5 to 47.6)                                                          |
| Health Insurance        |                             |                                                 |                                                                |                                                                                |
| None                    | 2.24 (1.62)                 | 59.3 (54.4 to 64.0)                             | 20.3 (17.0 to 24.1)                                             | 31.3 (26.8 to 36.3)                                                          |
| UEBMI                   | 2.37 (1.46)                 | 61.1 (56.3 to 65.7)                             | 13.4 (10.8 to 16.4)                                             | 32.5 (27.9 to 37.5)                                                          |
| URBMI                   | 2.42 (1.78)                 | 60.8 (53.8 to 67.4)                             | 18.4 (14.3 to 23.3)                                             | 40.3 (35.9 to 44.8)                                                          |
| NRCMS                   | 2.45 (1.98)                 | 64.8 (63.2 to 66.4)                             | 27.6 (26.1 to 29.2)                                             | 41.4 (38.9 to 43.9)                                                          |
| Other                   | 2.47 (1.43)                 | 68.4 (61.2 to 74.7)                             | 12.4 (8.4 to 18.1)                                             | 34.1 (25.7 to 43.5)                                                          |
| Economic status         |                             |                                                 |                                                                |                                                                                |
| First quintile (lowest) | 2.55 (1.90)                 | 70.4 (67.3 to 73.4)                             | 29.4 (26.5 to 32.5)                                             | 43.2 (39.3 to 47.1)                                                          |
| Second quintile         | 2.44 (1.94)                 | 64.5 (61.6 to 67.2)                             | 26.0 (23.6 to 28.6)                                             | 40.0 (37.3 to 42.7)                                                          |
| Third quintile          | 2.29 (1.80)                 | 58.3 (52.5 to 63.8)                             | 21.2 (18.2 to 24.4)                                             | 36.4 (32.4 to 40.7)                                                          |
| Fourth quintile         | 2.47 (1.79)                 | 62.9 (59.9 to 65.8)                             | 21.9 (19.5 to 24.5)                                             | 40.8 (37.3 to 44.3)                                                          |
| Fifth quintile (highest)| 2.37 (1.75)                 | 62.7 (57.5 to 67.6)                             | 19.5 (16.5 to 22.9)                                             | 34.0 (30.2 to 38.1)                                                          |
| No of LTCS              |                             |                                                 |                                                                |                                                                                |
| 0                       | –                           | –                                               | –                                                               | –                                                                               |
| 1                       | –                           | –                                               | –                                                               | –                                                                               |
| 2                       | –                           | –                                               | –                                                               | –                                                                               |
| 3                       | –                           | –                                               | –                                                               | –                                                                               |
| 4+                      | –                           | –                                               | –                                                               | –                                                                               |

All estimates are adjusted for sample weight. Multimorbidity defined as having at least two chronic conditions. Physical–mental multimorbidity defined as having both physical and mental chronic conditions. Complex multimorbidity defined as having at least three chronic conditions affecting at least three different body systems.

LTC, long-term conditions; NRCMS, New Rural Cooperative Medical Scheme; UEBMI, Urban Employee Basic Medical Insurance; URBMI, Urban Resident Basic Medical Insurance.
| Variable          | Mean no of morbidities (SD) | Prevalence of any types of multimorbidity (%; 95% CI) | Prevalence of coexisting physical–mental multimorbidity (%; 95% CI) | The prevalence of complex multimorbidity among those with chronic disease (%; 95% CI) |
|-------------------|----------------------------|-----------------------------------------------------|---------------------------------------------------------------------|----------------------------------------------------------------------------------|
| All individuals   | 1.51 (1.38)                | 42.2 (40.1 to 44.5)                                  | 8.2 (7.2 to 9.3)                                                     | 20.9 (19.4 to 22.5)                                                              |
| Sex               |                            |                                                     |                                                                     |                                                                                  |
| Male              | 1.48 (1.43)                | 41.3 (38.7 to 43.9)                                  | 8.3 (7.1 to 9.8)                                                     | 21.4 (19.3 to 23.6)                                                              |
| Female            | 1.53 (1.34)                | 43.1 (40.6 to 45.6)                                  | 8.1 (6.8 to 9.5)                                                     | 20.6 (18.9 to 22.4)                                                              |
| Age (years)       |                            |                                                     |                                                                     |                                                                                  |
| 45–54             | 1.13 (1.18)                | 31.4 (28.7 to 34.4)                                  | 7.2 (5.8 to 8.9)                                                     | 12.5 (10.5 to 14.7)                                                              |
| 55–64             | 1.45 (1.36)                | 39.9 (37.4 to 42.4)                                  | 7.4 (6.2 to 8.9)                                                     | 19.3 (17.3 to 21.5)                                                              |
| 65–74             | 1.80 (1.45)                | 51.3 (46.8 to 55.7)                                  | 9.3 (7.6 to 11.4)                                                   | 26.0 (22.5 to 29.9)                                                              |
| 75+               | 2.00 (1.48)                | 57.3 (52.1 to 62.2)                                  | 10.7 (8.3 to 13.7)                                                  | 30.6 (26.4 to 35.1)                                                              |
| Education level   |                            |                                                     |                                                                     |                                                                                  |
| Primary or less   | 1.53 (1.40)                | 43.1 (40.8 to 45.3)                                  | 8.5 (7.3 to 9.9)                                                    | 21.1 (19.3 to 23.0)                                                              |
| Secondary         | 1.45 (1.36)                | 39.3 (35.5 to 43.3)                                  | 7.5 (5.8 to 9.6)                                                    | 21.8 (18.3 to 25.7)                                                              |
| Tertiary or higher| 1.46 (1.25)                | 41.3 (33.5 to 49.6)                                  | 6.1 (4.0 to 9.1)                                                    | 17.0 (12.6 to 22.5)                                                              |
| Residence         |                            |                                                     |                                                                     |                                                                                  |
| Urban             | 1.50 (1.45)                | 41.9 (39.8 to 44.0)                                  | 8.8 (7.6 to 10.0)                                                   | 20.4 (18.8 to 22.1)                                                              |
| Rural             | 1.54 (1.20)                | 43.2 (37.5 to 49.1)                                  | 6.7 (4.9 to 9.1)                                                    | 22.2 (18.7 to 26.3)                                                              |
| Marital status    |                            |                                                     |                                                                     |                                                                                  |
| Currently married | 1.43 (1.36)                | 39.9 (37.7 to 42.2)                                  | 7.1 (6.1 to 8.3)                                                    | 19.6 (17.8 to 21.5)                                                              |
| Not married       | 1.77 (1.41)                | 49.7 (46.1 to 53.3)                                  | 11.6 (9.8 to 13.7)                                                 | 24.5 (21.9 to 27.2)                                                              |
| Caste             |                            |                                                     |                                                                     |                                                                                  |
| Schedule          | 1.48 (1.36)                | 41.5 (39.4 to 43.7)                                  | 7.7 (6.6 to 9.0)                                                    | 20.8 (18.9 to 22.8)                                                              |
| None              | 1.60 (1.57)                | 45.4 (40.0 to 50.9)                                  | 10.8 (8.1 to 14.3)                                                 | 22.7 (18.7 to 27.2)                                                              |
| Other             | 1.54 (1.28)                | 42.7 (37.9 to 47.6)                                  | 8.1 (6.2 to 10.5)                                                  | 20.0 (16.7 to 23.7)                                                              |
| Religion          |                            |                                                     |                                                                     |                                                                                  |
| Hinduism          | 1.48 (1.35)                | 41.5 (39.2 to 43.8)                                  | 8.1 (7.1 to 9.4)                                                    | 20.4 (18.8 to 22.2)                                                              |
| Islam             | 1.63 (1.49)                | 45.5 (40.8 to 50.3)                                  | 8.3 (5.9 to 11.4)                                                  | 23.3 (19.7 to 27.3)                                                              |
| Other             | 1.82 (1.70)                | 50.8 (43.9 to 57.6)                                  | 8.5 (5.1 to 14.0)                                                  | 24.9 (19.0 to 32.0)                                                              |
| Health insurance  |                            |                                                     |                                                                     |                                                                                  |
| Yes               | 1.56 (1.44)                | 43.9 (39.5 to 48.3)                                  | 6.2 (4.7 to 8.3)                                                   | 21.8 (18.3 to 25.8)                                                              |
| No                | 1.50 (1.37)                | 42.1 (38.8 to 44.4)                                  | 8.4 (7.3 to 9.6)                                                   | 20.8 (19.2 to 22.5)                                                              |
| Economic status   |                            |                                                     |                                                                     |                                                                                  |
| First quintile    | 1.45 (1.31)                | 41.1 (36.8 to 45.6)                                  | 9.7 (7.5 to 12.4)                                                  | 18.8 (15.4 to 22.7)                                                              |
| Second quintile   | 1.51 (1.39)                | 42.7 (39.2 to 46.3)                                  | 9.7 (7.7 to 12.1)                                                  | 20.0 (17.0 to 23.4)                                                              |
| Third quintile    | 1.42 (1.36)                | 38.9 (35.1 to 42.8)                                  | 7.5 (5.9 to 9.4)                                                   | 19.8 (17.0 to 23.0)                                                              |
| Fourth quintile   | 1.53 (1.36)                | 42.1 (38.4 to 45.8)                                  | 7.5 (5.5 to 10.0)                                                  | 22.0 (19.1 to 25.3)                                                              |
| Fifth quintile    | 1.61 (1.47)                | 45.7 (42.2 to 49.3)                                  | 6.9 (5.3 to 8.9)                                                   | 23.3 (20.4 to 26.6)                                                              |
| States            |                            |                                                     |                                                                     |                                                                                  |
| Assam             | 1.54 (2.00)                | 42.3 (37.5 to 48.7)                                  | 5.5 (3.7 to 8.3)                                                   | 22.4 (18.5 to 27.0)                                                              |
| Karnataka         | 1.61 (1.39)                | 45.4 (42.0 to 48.9)                                  | 9.9 (7.5 to 13.0)                                                  | 24.5 (21.7 to 27.5)                                                              |
| Maharashtra       | 1.57 (1.30)                | 44.2 (39.7 to 48.8)                                  | 6.1 (4.6 to 8.0)                                                   | 23.9 (20.5 to 27.7)                                                              |
| Rajasthan         | 1.60 (1.80)                | 45.8 (42.4 to 49.2)                                  | 9.7 (7.8 to 12.1)                                                  | 21.4 (17.9 to 25.4)                                                              |
| Uttar Pradesh     | 1.32 (1.07)                | 35.3 (30.9 to 39.8)                                  | 8.3 (6.1 to 11.3)                                                  | 17.1 (14.2 to 20.6)                                                              |
| West Bengal       | 1.63 (1.42)                | 47.6 (44.5 to 50.8)                                  | 8.9 (7.2 to 11.0)                                                  | 20.7 (18.3 to 23.3)                                                              |
| No of LTCs        |                            |                                                     |                                                                     |                                                                                  |
| 0                 | –                          | –                                                   | –                                                                  | –                                                                                |
| 1                 | –                          | –                                                   | –                                                                  | –                                                                                |

Continued
dyslipidaemia and cancer have a higher prevalence in the lowest economic status (figure 2B).

In India, the overall prevalence of any type of multimorbidity was 42.2%, that ranged from 31.4% (45–54 years) to 57.3% (75 years and above). The prevalence of physical–mental health comorbidity was 8.2% with percentage of these individuals ranging from 7.2% (45–54 years) to 10.7% (75 years and older). Among patients with any long-term health condition, 20.9% of those with complex multimorbidity (table 2). The most common LTC was hypertension (40.83%) and the prevalence of depression was 9.27% (online supplemental figure S4). The most common dyad was diabetes and hypertension (71.9%). The most common physical–mental multimorbidity dyad was depression and hypertension (48.1%) (figure 1B). Our results show hypertension and diabetes were more common in the respondents with the highest economic status whereas depression, asthma and chronic lung disease was more common in the lowest economic status (figure 2B).

**Patterns of multimorbidity**

Online supplemental table S4 presents the multimorbidity patterns in China. An increase in age was associated with a higher odds of multimorbidity. When compared with individuals aged between 45 and 54 years, those that are 55–64 years, had an AOR of 2.47 (95% CI 2.13 to 2.86, p<0.001); 65–74 years had an AOR of 3.49 (95% CI 2.95 to 4.13, p<0.0001) and those 75 years and above had an AOR of 3.82 (95% CI 2.94 to 4.97, p<0.0001). Males were associated with a lower odd of multimorbidity when compared with females (AOR 0.86; 95% CI 0.76 to 0.97; p=0.016). Marital status and SES showed no significant effect on the odds of multimorbidity.

Online supplemental table S5 shows the multimorbidity patterns in India. An increase in age was associated with a higher odds of multimorbidity. When compared with individuals aged 45–54 years, those aged 55–64 years had an AOR of 1.51 (95% CI 1.30 to 1.75, p<0.001); 65–74 years had an AOR of 2.06 (95% CI 1.68 to 2.52, p<0.0001) and those aged 75 years and above had an AOR of 2.58 (95% CI 2.07 to 3.21, p<0.0001). Males were associated with a lower odd of multimorbidity when compared with females (AOR 0.85; 95% CI 0.75 to 0.96; p=0.011). Online supplemental table S5 suggests significant heterogeneity in the prevalence of multimorbidity across states in India. For instance, when compared with living in Utter Pradesh, Karnataka had an AOR of 1.33 (95% CI 1.01 to 1.75; p=0.039), Maharashtra had an AOR of 1.35 (95% CI 1.00 to 1.81; p=0.047). Rajasthan had an AOR of 2.17 (95% CI 1.69 to 2.78, p<0.0001) and West Bengal had an AOR of 1.88 (95% CI 1.48 to 2.38; p<0.0001). On the other hand, those living in Assam showed no significant effect on the odds of multimorbidity. Rurality, residence, religion, marital status, caste, socioeconomic and health insurance status showed no significant effect on the odds of multimorbidity.

**Associations between multimorbidity and OOPE for medicines**

In China, online supplemental table S6 shows that a one-unit increase in the number of physical LTCs was associated with an 18.5% increase in OOPE for medicines (p<0.05). There was no association between the presence of mental health conditions and OOPE for medicines. In India, online supplemental table S7 shows that as the number of physical LTCs increased by one unit, OOPE for medicines increased by 20.9% (p<0.05). In both China and India, the coefficients for the interaction term between the number of physical LTCs and presence of a mental health condition was not statistically significant. This suggested that the amount of OOPE for medicines of physical and mental LTCs is similar the expected given the independent costs of each types of the LTCs.

Online supplemental table S8 shows that in China, liver disease was associated with highest increase in OOPE for medicine by 61.6% (p<0.05) compared with individuals with no disease. Online supplemental table S9 shows that in India, stroke was associated with the highest increase in OOPE for medicine of 131.6% (p<0.05). In both China and India, diabetes showed the second highest increase in OOPE for medicine with 58.4% (p<0.05) and 91.6% (p<0.05), respectively.

**Association of multimorbidity and OOPE by economic groups and health insurance**

Online supplemental tables S10 and S11 examines whether the associations between multimorbidity and

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**Table 2** Continued

| Variable | Mean no of morbidities (SD) | Prevalence of any types of multimorbidity (% 95% CI) | Prevalence of coexisting physical-mental multimorbidity (% 95% CI) | The prevalence of complex multimorbidity among those with chronic disease (% 95% CI) |
|----------|-----------------------------|------------------------------------------------------|------------------------------------------------------------------|----------------------------------------------------------------------------------|
| 2        | –                           | 12.2 (10.0 to 14.7)                                   | –                                                                |                                                                                  |
| 3        | –                           | 19.3 (16.3 to 22.8)                                   | 53.6 (49.1 to 58.1)                                               |                                                                                  |
| 4+       | –                           | 35.1 (31.0 to 39.5)                                   | 94.5 (92.2 to 96.1)                                               |                                                                                  |

All estimates are adjusted for sample weight. Multimorbidity defined as having at least two chronic conditions. Physical–mental multimorbidity defined as having both physical and mental chronic conditions. Complex multimorbidity defined as having at least three chronic conditions affecting at least three different body systems. LTC, long-term conditions.
% individuals with this condition

| Condition                  | % Individuals |
|----------------------------|---------------|
| Psychological and emotional illness | 3.5%          |
| Stroke                     | 0.6%          |
| Asthma                     | 0.0%          |
| Liver disease              | 0.0%          |
| Kidney disease             | 0.0%          |
| Chronic Lung disease       | 0.0%          |
| Cancer                     | 0.0%          |
| Heart disease              | 0.0%          |
| Diabetes                   | 0.0%          |
| Depression                 | 0.0%          |
| Stomach disease            | 0.0%          |
| Hypertension               | 0.0%          |
| Arthritis                  | 0.0%          |
| Dyslipidaemia              | 0.0%          |

% individuals also with this condition

Figure 1  The prevalence of coexisting long-term conditions for each long-term condition for people with multimorbidity in China, 2015 (A); The prevalence of coexisting long-term conditions for each long-term condition for people with multimorbidity in India, 2015 (B). (A) Data source: China Health and Retirement Longitudinal Survey. (B) Data source WHO Study on Global Ageing and Adult Health survey, wave 2.

OOPE for medicines vary by economic groups. As the coefficients for most of the interactions between LTCs and economic groups were not statistically significant, our results indicated that these associations were similar across economic groups (p>0.05).
multimorbidity across health insurance status in China, except for the association between physical LTCs and NRCMS (coefficient for the interaction terms between NRCMS and physical LTCs = -0.36; 95% CI –0.59 to –0.12) and the association between physical LTCs and UEBMI (coefficient for the interaction terms between UEBMI and physical LTCs = -0.34; 95% CI -0.61 to -0.07). Online supplemental table S13 shows that differential effect of multimorbidity on OOPE was similar across health insurance status in India and again there were no significant associations in all interaction terms between health insurance status and LTCs.

**Associations between multimorbidity and OOPE for medicines across the cost distribution**

Tables 3 and 4 present the effect of the number of physical LTCs on OOPE for medicines across the cost distribution in China and India, respectively. An increase in the number of long-term physical conditions was significantly associated with greater OOPE for medicines across every quantile in India whereas it was significantly associated up to the 75th percentile in China. As expected, the effect of physical LTCs was found to be greater in the top percentiles than those in the lower percentiles in the cost distribution in both China (25th percentile: 3.6; 50th percentile: 6.0).

**Figure 2** Prevalence of long-term conditions by socioeconomic status (SES) in China, 2015 (A); Prevalence of long-term conditions by SES in India, 2015 (B). (A) Data source: China Health and Retirement Longitudinal Survey. (B) Data source WHO Study on Global Ageing and Adult Health survey, wave 2.
| Variables | 25th percentile | 50th percentile | 75th percentile | 90th percentile |
|-----------|----------------|----------------|----------------|----------------|
| No of physical LTCs | 13.2 | 3.6 | 1.0 | 2.3 |
| Mental health condition | 6.1 | 3.6 | 2.5 | 0.5 |
| Economic status (ref. first quintile (lowest)) | 6.1 | 3.6 | 2.5 | 0.5 |
| Gender (ref. female) | 3.6 | 1.0 | 0.5 | 0.2 |
| Age group (ref. 45–54) | 3.6 | 1.0 | 0.5 | 0.2 |
| Residence (ref. urban) | 3.6 | 1.0 | 0.5 | 0.2 |
| Education Status (ref. primary or less) | 3.6 | 1.0 | 0.5 | 0.2 |
| Not married | 3.6 | 1.0 | 0.5 | 0.2 |
| Fifth quintile (highest) | 3.6 | 1.0 | 0.5 | 0.2 |
| Fourth quintile | 3.6 | 1.0 | 0.5 | 0.2 |
| Third quintile | 3.6 | 1.0 | 0.5 | 0.2 |
| Second quintile | 3.6 | 1.0 | 0.5 | 0.2 |
| Economic status (ref. first quintile (lowest)) | 3.6 | 1.0 | 0.5 | 0.2 |
| Gender (ref. female) | 3.6 | 1.0 | 0.5 | 0.2 |
| Age group (ref. 45–54) | 3.6 | 1.0 | 0.5 | 0.2 |
| Residence (ref. urban) | 3.6 | 1.0 | 0.5 | 0.2 |
| Education Status (ref. primary or less) | 3.6 | 1.0 | 0.5 | 0.2 |
| Not married | 3.6 | 1.0 | 0.5 | 0.2 |
| Fifth quintile (highest) | 3.6 | 1.0 | 0.5 | 0.2 |
| Fourth quintile | 3.6 | 1.0 | 0.5 | 0.2 |
| Third quintile | 3.6 | 1.0 | 0.5 | 0.2 |
| Second quintile | 3.6 | 1.0 | 0.5 | 0.2 |
| Economic status (ref. first quintile (lowest)) | 3.6 | 1.0 | 0.5 | 0.2 |
| Gender (ref. female) | 3.6 | 1.0 | 0.5 | 0.2 |
| Age group (ref. 45–54) | 3.6 | 1.0 | 0.5 | 0.2 |
| Residence (ref. urban) | 3.6 | 1.0 | 0.5 | 0.2 |
| Education Status (ref. primary or less) | 3.6 | 1.0 | 0.5 | 0.2 |
| Not married | 3.6 | 1.0 | 0.5 | 0.2 |
| Fifth quintile (highest) | 3.6 | 1.0 | 0.5 | 0.2 |
| Fourth quintile | 3.6 | 1.0 | 0.5 | 0.2 |
| Third quintile | 3.6 | 1.0 | 0.5 | 0.2 |
| Second quintile | 3.6 | 1.0 | 0.5 | 0.2 |
| Economic status (ref. first quintile (lowest)) | 3.6 | 1.0 | 0.5 | 0.2 |
| Gender (ref. female) | 3.6 | 1.0 | 0.5 | 0.2 |
| Age group (ref. 45–54) | 3.6 | 1.0 | 0.5 | 0.2 |
| Residence (ref. urban) | 3.6 | 1.0 | 0.5 | 0.2 |
| Education Status (ref. primary or less) | 3.6 | 1.0 | 0.5 | 0.2 |
| Not married | 3.6 | 1.0 | 0.5 | 0.2 |
| Fifth quintile (highest) | 3.6 | 1.0 | 0.5 | 0.2 |
| Fourth quintile | 3.6 | 1.0 | 0.5 | 0.2 |
| Third quintile | 3.6 | 1.0 | 0.5 | 0.2 |
| Second quintile | 3.6 | 1.0 | 0.5 | 0.2 |
| Economic status (ref. first quintile (lowest)) | 3.6 | 1.0 | 0.5 | 0.2 |
| Gender (ref. female) | 3.6 | 1.0 | 0.5 | 0.2 |
| Age group (ref. 45–54) | 3.6 | 1.0 | 0.5 | 0.2 |
| Residence (ref. urban) | 3.6 | 1.0 | 0.5 | 0.2 |
| Education Status (ref. primary or less) | 3.6 | 1.0 | 0.5 | 0.2 |
| Not married | 3.6 | 1.0 | 0.5 | 0.2 |
| Fifth quintile (highest) | 3.6 | 1.0 | 0.5 | 0.2 |
| Fourth quintile | 3.6 | 1.0 | 0.5 | 0.2 |
| Third quintile | 3.6 | 1.0 | 0.5 | 0.2 |
| Second quintile | 3.6 | 1.0 | 0.5 | 0.2 |
| Economic status (ref. first quintile (lowest)) | 3.6 | 1.0 | 0.5 | 0.2 |
| Gender (ref. female) | 3.6 | 1.0 | 0.5 | 0.2 |
| Age group (ref. 45–54) | 3.6 | 1.0 | 0.5 | 0.2 |
| Residence (ref. urban) | 3.6 | 1.0 | 0.5 | 0.2 |
| Education Status (ref. primary or less) | 3.6 | 1.0 | 0.5 | 0.2 |
| Not married | 3.6 | 1.0 | 0.5 | 0.2 |
| Fifth quintile (highest) | 3.6 | 1.0 | 0.5 | 0.2 |
| Fourth quintile | 3.6 | 1.0 | 0.5 | 0.2 |
| Third quintile | 3.6 | 1.0 | 0.5 | 0.2 |
| Second quintile | 3.6 | 1.0 | 0.5 | 0.2 |
| Economic status (ref. first quintile (lowest)) | 3.6 | 1.0 | 0.5 | 0.2 |
| Gender (ref. female) | 3.6 | 1.0 | 0.5 | 0.2 |
| Age group (ref. 45–54) | 3.6 | 1.0 | 0.5 | 0.2 |
| Residence (ref. urban) | 3.6 | 1.0 | 0.5 | 0.2 |
| Education Status (ref. primary or less) | 3.6 | 1.0 | 0.5 | 0.2 |
| Not married | 3.6 | 1.0 | 0.5 | 0.2 |
| Variables                          | Mean (95% CI)      | 25th percentile (95% CI) | 50th percentile (95% CI) | 75th percentile (95% CI) | 90th percentile (95% CI) |
|-----------------------------------|--------------------|--------------------------|--------------------------|--------------------------|--------------------------|
|                                   | China US$         | China US$                | China US$                | China US$                | China US$                |
| Tertiary or higher                | 54.1 (−48.2 to 156.4) | 14.6 (−13.0 to 42.3) | −0.1 (−5.5 to 4.5) | 0.0 (−2.3 to 2.3) | 3.3 (−22.3 to 28.9) |
|                                   | −0.1 (−5.5 to 4.5) | 0.0 (−2.3 to 2.3) | 3.3 (−22.3 to 28.9) | 0.9 (−6.0 to 7.8) | −29.1 (−107.8 to 49.7) |
|                                   | −9.1 (−107.8 to 49.7) | −21.1 (−22.0 to 445.3) | 57.2 (−5.9 to 120.3) |                      |                          |

Health insurance status (ref. no)

| Variables                          | Mean (95% CI)      | 25th percentile (95% CI) | 50th percentile (95% CI) | 75th percentile (95% CI) | 90th percentile (95% CI) |
|-----------------------------------|--------------------|--------------------------|--------------------------|--------------------------|--------------------------|
|                                   | China US$         | China US$                | China US$                | China US$                | China US$                |
| UEBMI                             | −24.2 (−120.1 to 71.7) | −6.5 (−32.5 to 19.4) | −8.2 (−20.6 to 4.1) | −2.2 (−5.6 to 1.1) | −3.5 (−40.9 to 33.9) |
|                                   | −6.5 (−32.5 to 19.4) | −8.2 (−20.6 to 4.1) | −2.2 (−5.6 to 1.1) | −3.5 (−40.9 to 33.9) | −62.1 (−177.0 to 52.8) |
|                                   | −62.1 (−177.0 to 52.8) | −146.7 (−487.6 to 194.2) | −39.6 (−131.7 to 52.5) |                      |                          |
| URBMI                             | 21.2 (−88.4 to 130.9) | 5.7 (−23.9 to 35.4) | 3.4 (−10.0 to 16.8) | 0.9 (−2.7 to 4.5) | 26.6 (−14.1 to 67.3) |
|                                   | 5.7 (−23.9 to 35.4) | 3.4 (−10.0 to 16.8) | 0.9 (−2.7 to 4.5) | 26.6 (−14.1 to 67.3) | 7.2 (−3.8 to 18.2) |
|                                   | 7.2 (−3.8 to 18.2) | 4.5 (−120.5 to 129.5) | 1.2 (−32.5 to 35.0) | −230.0 (−600.8 to 140.8) | −62.1 (−162.3 to 38.0) |
| NRCMS                             | 39.1 (−32.9 to 111.1) | 10.6 (−8.9 to 30.0) | 1.7 (−8.2 to 11.6) | 0.5 (−2.2 to 3.1) | 16.0 (−14.1 to 46.1) |
|                                   | 10.6 (−8.9 to 30.0) | 1.7 (−8.2 to 11.6) | 0.5 (−2.2 to 3.1) | 16.0 (−14.1 to 46.1) | 4.3 (−3.8 to 12.4) |
|                                   | 4.3 (−3.8 to 12.4) | −39.2 (−131.6 to 53.1) | −10.6 (−35.6 to 14.3) | −268.3 (−542.3 to 5.7) | −72.5 (−146.5 to 1.5) |
| Other                             | −5.6 (−139.0 to 127.8) | −1.5 (−37.6 to 34.5) | −6.2 (−24.6 to 12.2) | −1.7 (−6.6 to 3.3) | 42.8 (−13.1 to 98.7) |
|                                   | −5.6 (−139.0 to 127.8) | −1.5 (−37.6 to 34.5) | −6.2 (−24.6 to 12.2) | −1.7 (−6.6 to 3.3) | 42.8 (−13.1 to 98.7) |
|                                   | 42.8 (−13.1 to 98.7) | 11.6 (−3.5 to 26.7) | −13.9 (−185.6 to 157.7) | −3.8 (−50.1 to 42.6) | −92.5 (−601.8 to 416.8) |
|                                   | 11.6 (−3.5 to 26.7) | −13.9 (−185.6 to 157.7) | −3.8 (−50.1 to 42.6) | −92.5 (−601.8 to 416.8) | −25.0 (−162.6 to 112.6) |
| Region (ref. east)                | 37.9 (−32.1 to 108.0) | 10.2 (−8.7 to 29.2) | −2.6 (−8.2 to 3.0) | −0.7 (−2.2 to 0.8) | −3.5 (−20.5 to 13.5) |
|                                   | 10.2 (−8.7 to 29.2) | −2.6 (−8.2 to 3.0) | −0.7 (−2.2 to 0.8) | −3.5 (−20.5 to 13.5) | −0.9 (−5.5 to 3.6) |
|                                   | −0.9 (−5.5 to 3.6) | 37.7 (−14.5 to 89.9) | 10.2 (−3.9 to 24.3) | 192.5 (37.6 to 347.4) | 52.0 (10.2 to 93.9) |
| West                              | −45.9 (−110.0 to 18.1) | −12.4 (−29.7 to 4.9) | 1.7 (−4.4 to 7.8) | 0.5 (−1.2 to 2.1) | −12.4 (−30.9 to 6.0) |
|                                   | −45.9 (−110.0 to 18.1) | −12.4 (−29.7 to 4.9) | 1.7 (−4.4 to 7.8) | 0.5 (−1.2 to 2.1) | −12.4 (−30.9 to 6.0) |
|                                   | 1.7 (−4.4 to 7.8) | 0.5 (−1.2 to 2.1) | −12.4 (−30.9 to 6.0) | −3.4 (−5.3 to 1.6) | −50.6 (−107.2 to 6.1) |
|                                   | 0.5 (−1.2 to 2.1) | −12.4 (−30.9 to 6.0) | −3.4 (−5.3 to 1.6) | −50.6 (−107.2 to 6.1) | −13.7 (−29.0 to 1.7) |
|                                   | −13.7 (−29.0 to 1.7) | −50.6 (−107.2 to 6.1) | −13.7 (−29.0 to 1.7) | −50.6 (−107.2 to 6.1) | −90.0 (−258.2 to 78.2) |
|                                   | −90.0 (−258.2 to 78.2) | −24.3 (−69.8 to 21.1) | −90.0 (−258.2 to 78.2) | −24.3 (−69.8 to 21.1) |                      |

Mean values were derived from a generalised linear model.

All estimates adjusted for sample weight. Bolded values indicate p<0.05.

LTCs, long term conditions; NRCMS, New Rural Cooperative Medical Scheme; OOPE, out-of-pocket expenditure; UEBMI, Urban Employee Basic Medical Insurance; URBMI, Urban Resident Basic Medical Insurance.
| Variables                                      | Mean | US$ | 25th percentile | 50th percentile | 75th percentile | 90th percentile |
|-----------------------------------------------|------|-----|-----------------|-----------------|-----------------|----------------|
| No of physical LTCs                           |      |     |                 |                 |                 |                |
| India                                         | 99.0 | 453 | 256             | 1.2             | 48.1            | 5.1            |
| 5% to 156.2                                   | 2.5  | 8.1 | 16.1 to 35.1    | (34.8 to 61.4)  | 1.9 to 3.4      | (32.7 to 7.1)  |
| Mental health condition                      | 290.9| 628 | −93             | 0.1             | 2.21            | 0.04           |
| 45.3 to 106.9                                 | 50   | 9.3 | −71 to 53.3     | (−85.4 to 88.9) | (−5.9 to 5.9)  | (−6.9 to 9.4)  |
| Residential status                           |      |     |                 |                 |                 |                |
| No of physical LTCs × mental health condition| −27.3| 100 | −3.7            | −1.6 to 1.5     | 0.77            | −1.9 to 2.3    |
| Economic status (ref. first quintile (lowest))|      |     |                 |                 |                 |                |
| Second quintile                               | 201.2| 626 | 0.5             | 0.7             | 106.9           | 8.8            |
| 3.1 to 94.7                                   | 0.5  | 3.5 | 19.8 to 34.1    | (19.8 to 422.2) | (0.5 to 31.4)  | (2.4 to 15.1)  |
| Third quintile                                | 197.5| 647 | 1.2             | 101.5           | 101.5           | 152.7          |
| 6.7 to 101.5                                  | 1.2  | 6.7 | 17.8 to 89.2    | (239.8)         | (14.9 to 14.8) | (14.8 to 42.4) |
| Fourth quintile                               | 151.9| 157 | 2.5             | 100.8           | 100.8           | 97.9           |
| 6.8 to 23.8                                   | 2.5  | 6.8 | 17.8 to 89.2    | (235.7)         | (2.5 to 13.9)  | (9.0 to 35.9)  |
| Fifth quintile (highest)                      | 265.8| 444 | 2.7             | 62.9            | 62.9            | 151.9          |
| 118.7 to 412.9                                | 2.7  | 2.7 | 9.16 to 116.6   | (165.9 to 287.3) | (1.0 to 7.3)  | (12.8 to 39.8) |
| Gender (ref. female)                          |      |     |                 |                 |                 |                |
| Male                                          | −16.5| −30 | −5.18           | −0.4            | −24.0           | −9.0           |
| −143.3 to 110.2                               | −8.6 | 6.8 | −31.1 to 20.7   | (−2.0 to 1.2)   | (−60.5 to 12.5) | (−9.5 to 1.7)  |
| Age group (ref. 45–54)                        |      |     |                 |                 |                 |                |
| 55–64                                         | −23.8| −38 | −5.70           | −0.4            | 1.82            | 0.9            |
| −141.1 to 93.5                                | −8.7 | 5.3 | −35.2 to 23.8   | (−2.2 to 1.4)   | (−39.7 to 43.3) | (−5.5 to 7.2)  |
| 65–74                                         | −19.1| −23 | −1.91           | −0.2            | 0.72            | 0.9            |
| −113.8 to 152.1                               | −6.6 | 9.3 | −36.2 to 32.3   | (−2.2 to 2.0)   | (−47.5 to 48.9) | (−2.8 to 12.0) |
| 75+                                           | 161.6| 176 | −9.55           | −0.1            | 13.7            | 12.7           |
| −59.0 to 382.2                                | −3.5 | 27.7| −53.9 to 34.8   | (−2.8 to 2.7)   | (−48.7 to 76.2) | (−2.7 to 16.4) |
| Residence (ref. urban)                        |      |     |                 |                 |                 |                |
| Rural                                         | −67.5| −32 | −3.8            | 0.5             | 5.57            | −0.5           |
| −218.9 to 103.8                               | −13.5| 5.9 | −14.8 to 46.8   | (−1.3 to 2.4)   | (−37.8 to 49.0) | (−22.3 to 21.3) |
| Marital status (ref. currently married)       |      |     |                 |                 |                 |                |
| Not married                                   | 137.9| 346 | 8.1             | 1.2             | 28.3            | 7.6            |
| (12.1 to 263.7)                               | 0.7  | 15.5 | (13.9 to 44.7)  | (−0.6 to 3.0)   | (−12.9 to 69.5) | (1.3 to 14.0)  |
| Education status (ref. primary or less)       |      |     |                 |                 |                 |                |
| Secondary                                     | 52.0 | 136 | 3.5             | 1.2             | 29.7            | 5.5            |
| −126.0 to 230.0                               | −7.1 | 14.1| −9.66 to 57.7   | (−0.9 to 3.2)   | (−17.7 to 77.1) | (−1.8 to 12.7) |
| Tertiary or higher                            | 141.5| 87.5 | 8.4             | 0.1             | −10.6           | 7.9            |
| −197.0 to 480.0                               | −11.7| 28.4| −42.8 to 68.7   | (−3.3 to 3.5)   | (−89.1 to 67.9) | (−10.0 to 14.1) |
| Caste (ref. scheduled)                        |      |     |                 |                 |                 |                |
Table 4  Continued

| Variables                                      | Mean          | 25th percentile | 50th percentile | 75th percentile | 90th percentile |
|------------------------------------------------|---------------|-----------------|-----------------|-----------------|-----------------|
|                                                 | Mean          | Absolute difference | Mean          | Absolute difference | Mean          | Absolute difference |
|                                                 | India US$     | India US$       | India US$       | India US$       | India US$       | India US$       |
| None                                           | -5.7 (-146.2 to 134.8) | -0.4 (-8.8 to 8.0) | 14.8 (-20.9 to 50.5) | 0.9 (-1.2 to 3.1) | 20.3 (-29.9 to 70.6) | 1.1 (-1.8 to 4.0) | 47.3 (-79.4 to 174.0) | 1.3 (-6.4 to 9.0) | 27.8 (-398.7 to 453.2) | 2.0 (-23.3 to 27.3) |
| Other                                          | 151.2 (-27.4 to 329.8) | 9.0 (-1.7 to 19.6) | 0.80 (-33.4 to 35.0) | 0.05 (-2.0 to 2.1) | 21.0 (-27.2 to 69.2) | 1.1 (-1.7 to 3.9) | 41.2 (-80.4 to 162.7) | 0.8 (-6.6 to 8.2) | 128.6 (-279.5 to 536.7) | 12.5 (-11.7 to 36.8) |
| Religion (ref. hinduism)                       |               |                 |                 |                 |                 |                 |                 |                 |                 |                 |
| Islam                                          | 162.6 (11.7 to 313.6) | 9.6 (0.5 to 18.7) | 9.6 (-24.0 to 43.3) | 0.3 (-1.8 to 2.3) | 27.8 (-19.6 to 75.2) | 1.4 (-1.4 to 4.2) | 91.5 (-28.0 to 211.0) | 6.2 (-1.1 to 13.4) | 487.8 (86.5 to 889.1) | 31.7 (7.8 to 55.6) |
| Other                                          | 12.8 (-319.3 to 344.8) | 0.3 (-19.7 to 20.3) | -71.1 (-136.3 to -5.9) | -3.8 (-7.8 to 0.1) | -136.9 (-228.6 to -45.1) | -8.1 (-13.5 to -2.8) | -118.5 (-349.8 to 112.9) | -7.4 (-21.5 to 6.6) | -56.4 (-833.2 to 720.5) | -4.4 (-50.6 to 41.8) |
| Health insurance status (ref. No)              |               |                 |                 |                 |                 |                 |                 |                 |                 |                 |
| Yes                                            | 94.7 (-66.4 to 255.8) | 5.4 (-4.2 to 15.0) | 1.70 (-31.6 to 35.0) | -0.03 (-2.1 to 2.0) | 11.0 (-35.8 to 57.9) | 0.4 (-2.3 to 3.1) | 3.85 (-114.3 to 122.0) | -0.5 (-7.6 to 6.7) | 42.1 (-354.8 to 438.9) | 2.9 (-20.7 to 26.5) |
| State (ref. Utter Pradesh)                     |               |                 |                 |                 |                 |                 |                 |                 |                 |                 |
| Assam                                          | 605.9 (201.6 to 1010.2) | 37.5 (13.5 to 61.5) | 318.0 (230.4 to 405.6) | 20.1 (14.7 to 25.4) | 550.1 (426.7 to 673.4) | 33.2 (26.0 to 40.4) | 720.4 (409.4 to 1031.4) | 48.0 (29.1 to 66.8) | 2137.3 (1093.1 to 3181.4) | 131.6 (69.6 to 193.6) |
| Karnataka                                      | 375.6 (53.1 to 698.1) | 23.6 (4.3 to 42.8) | -8.34 (-59.4 to 42.7) | -0.02 (-3.1 to 3.1) | 18.0 (-53.9 to 89.8) | 1.8 (-2.4 to 6.0) | -40.0 (-221.2 to 141.2) | 1.9 (-9.1 to 12.9) | 609.1 (0.72 to 1217.5) | 41.0 (4.9 to 77.1) |
| Maharashtra                                    | -136.0 (-355.1 to 83.2) | -7.3 (-20.3 to 5.7) | 18.0 (-32.9 to 68.6) | 1.2 (-1.9 to 4.3) | 28.9 (-42.7 to 100.5) | 1.9 (-2.3 to 6.1) | 10.8 (-169.7 to 191.3) | 1.3 (-9.6 to 12.2) | -19.5 (-625.5 to 586.8) | 1.2 (-34.8 to 37.2) |
| Rajasthan                                      | 53.9 (-98.8 to 206.6) | 2.8 (-6.4 to 12.0) | -39.2 (-82.2 to 3.87) | -2.4 (-5.1 to 0.2) | 51.9 (-8.70 to 112.5) | 2.6 (-0.9 to 6.2) | -58.8 (-211.6 to 93.9) | -1.6 (-10.9 to 7.7) | -12.2 (-525.1 to 500.7) | -0.8 (-31.4 to 29.7) |
| West Bengal                                    | -146.3 (-278.0 to -14.5) | -8.2 (-16.0 to -0.4) | 16.1 (-27.1 to 59.4) | 0.9 (-1.8 to 3.5) | 38.3 (-22.6 to 99.2) | 2.3 (-1.2 to 5.9) | -102.3 (-255.7 to 51.1) | -3.3 (-12.6 to 6.0) | -240.4 (-755.6 to 274.8) | -14.9 (-45.5 to 15.7) |

Note: Mean values were derived from a generalised linear model. Bolded values indicate p<0.05. All estimates adjusted for sample weight. LTCs, long-term conditions; OOPE, out-of-pocket expenditure.
Our findings provide new evidence to inform the development of targeted policies and interventions to tackle the growing financial burden of multimorbidity in LMICs. With rapidly ageing population, China and India are both facing a rapidly growing burden of multimorbidity. Efforts to reduce multimorbidity risk factors are integral to prevention strategies to reduce disease burden, avoidable mortality, OOPE and financial risk. Such efforts include greater investment in cost-effective public health interventions for risk factor reduction including reduced pollution, effective implementation of Framework Convention on Tobacco Control and the Global Strategy for Diet, Physical Activity and Health.\textsuperscript{55,56} These interventions are effective in reducing common risk factors shared by cardiovascular diseases (CVDs), cancer, diabetes and chronic respiratory disease. These interventions should be targeted to those at greatest risk by conducting risk profiling at the population level and designing focused prevention and treatment strategies with appropriate strengthening of health services.\textsuperscript{57,58} These targeted interventions should then be integrated into health policies at the national level in the context of centralised China or at the subnational level for India where the primary responsibilities for health is at the state level.\textsuperscript{59}

**WHO Package of essential noncommunicable, high-impact cost-effective interventions could be delivered at the primary care level.\textsuperscript{60}** However, healthcare delivery in both China and India are highly hospital-based and fragmented, with little coordination among healthcare providers across different tiers of the system.\textsuperscript{61} In China and India, stronger primary healthcare, underpinned by multidisciplinary teams is critical for addressing health and economic burden of multimorbidity.\textsuperscript{3,62} Health systems may need to adapt from single-disease responsive models to new financing and service delivery models to prevent and manage multimorbidity more effectively. Studies are needed to develop suitable care delivery models for multimorbidity and should include infectious diseases that are common on both countries, such as TB. Rigorous evaluation of these new healthcare delivery models is warranted to ensure effectiveness, efficiency and quality of care.

China has undertaken major reforms to increase population access to essential medicines over the last decades with notable increase in social health insurance coverage for prescription drugs.\textsuperscript{63} Recent studies suggest that the current reimbursement rate is around 45% for medicines in an outpatient setting, however, the monthly reimbursements are capped at a relatively low rate.\textsuperscript{64,65} Optimising a health insurance system plays an extremely important role in improved financial risk protection. At the end of 2015, China had officially announced the merger of the UEBMI and the NRCMS,\textsuperscript{17} representing a commendable milestone towards UHC.\textsuperscript{66} However, the current health insurance system still leaves much financial risk for households to bear, and a relatively high incidence (5.14%) of health impoverishment. In the implementation of this...
integration, the most critical element was the further extension of funding pools and narrowing of disparities in covered services and medications between the Unified Resident Health Insurance and UEBMI. This new phase in China’s reform needs special attention devoted to disadvantaged groups, particularly the poor and households with members suffering multiple chronic diseases. Extending insurance coverage to include long-term care for chronically ill patients, essential medications, outpatient and rehabilitation services are a priority. The reform of the Public Medical Assistance System could also be deeply integrated with National Poverty Alleviation Projects, giving priority to a comprehensive benefits package with services and cost-sharing mechanisms for citizens with multimorbidity.

An earlier study in India has indicated that almost 50% of the population does not have regular access to essential medicines and the proportion of out-of-pocket-payments as a percentage of total health expenditures was at the high rate of 62.6% in 2015. An important first step in improving access and affordability to essential medicines is to define an essential medicines list on the basis of effectiveness, quality and cost, followed by inclusion of this list in public health insurance benefits, supported by price regulation and efficient procurement and delivery of a single payer public health financing programme.

As part of its commitment to Sustainable Development Goals, India recently launched major public health insurance expansion through the Rashtriya Swasthya Bima Yojana and Pradham Mantri Jan Arogya Yojana. The programme aimed to help lower financial barriers of low-income households to access to essential medicines and UHC. However, affordability of quality healthcare and essential medicine could pose a challenge for low-income and middle-income households. Individuals in India still incur high levels of OOPE for medicines. For instance, between 1998 and 2005, low-income groups in India spent around 27%–34% of their annual income on care for LTCs, where the largest proportion of the expenditure (65% of the OOPE) was for medicines. Thus, expanding health insurance coverage to all individuals in India and ensuring the affordability of essential medicines is key to reducing OOPE.

The study has several limitations. First, the cross-sectional study limits the causal interpretation of our findings. Further studies are warranted to investigate the long-term or dynamic effect of multimorbidity using panel or cohort study design. Second, similar to other studies based on survey datasets, our study is subject to well-known self-reported bias for chronic disease status. It is also worth mentioning that the measures in CHARLS and SAGE are not completely comparable because (1) the number of LTCs measured are not equal, (2) there are differences in the type of LTCs measured and (3) the clinical measurements for depression, CIDI and CESD are not exactly comparable. This could lead to underestimation of the prevalence of LTCs and prohibits us from comparing the outcome variable between China and India. Our study had a potential limitation in that our outcome variable was OOPE for the last visit. However, CHARLS and SAGE do not include data on patients’ total OOPE in the previous year. A calculation to determine OOPE for medicines over the year was considered, but it was based on the assumption that OOPE would be the same for each visit. This is unlikely in this case because patients seek outpatient care for a variety of reasons. Some visits may necessitate patients purchasing medications, while others may not. As a result, patients may incur varying amounts of OOPE. Another limitation of the study is the inability to conduct analyses on individuals who used inpatient services. This is due to the small proportion of people using inpatient services in both India (6.84%) and China (6.5%) in the survey sample. Appropriately powered future studies are needed to ascertain how multimorbidity, different multimorbidity dyads and complex multimorbidity affect hospital inpatient admissions and OOPE for hospital care and medicines.

In conclusion, multimorbidity is associated with substantial increase in OOPE for prescription medicines in China and India. Our study calls for acceleration of UHC and policy interventions to extend coverage of health insurance and to reduce financial burden associated with prescription medicines in LMICs.

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