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Sex differences in non-communicable disease multimorbidity among adults aged 45 years or older in India

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ABSTRACT

Objective Older male and female adults differ in key characteristics such as disease-specific life expectancy, health behaviours and clinical presentations and non-communicable disease multimorbidity (NCD-MM). Therefore, examining the sex differences in NCD-MM among older adults is vital, as this issue is understudied in low-income and middle-income country (LMIC) contexts such as India, and has been growing in the past few decades.

Design Large scale nationally representative cross-sectional study.

Settings and participants Longitudinal Ageing Study in India (LASI 2017–2018) had data on 27 343 men and 31 730 women aged 45+, drawn from a sample of 59 073 individuals across India.

Primary and secondary outcomes measures We operationalised NCD-MM based on prevalence of the presence of two or more long-term chronic NCD morbidities. Descriptive statistics and bivariate analysis along with multivariate statistics were used.

Results Women aged 75+ had a higher prevalence of multimorbidity as compared with men (52.1% vs 45.17%). NCD-MM was more common among widows (48.5%) than widowers (44.8%). The female-to-male ratios of ORs (RORs) for NCD-MM associated with overweight/obesity and prior history of chewing tobacco were 1.10 (95% CI: 1.01 to 1.20) and 1.42 (95% CI: 1.12 to 1.80), respectively. The female-to-male RORs show that the odds of NCD-MM were greater in formerly working women (1.24 (95% CI: 1.06 to 1.44)) relative to formerly working men. The effect of increasing NCD-MM on limitations in activities of daily living and instrumental ADL was greater in men than women but reversed for the hospitalisation.

Conclusions We found significant sex differences in NCD-MM prevalence among older Indian adults, with various associated risk factors. The patterns underlying these differences warrant greater study, given existing evidence on differential longevity, health burdens and health-seeking patterns all of which operate in a larger structural context of patriarchy. Health systems in turn must respond to NCD-MM mindful of these patterns and aim to redress some of the larger inequities they reflect.

STRENGTHS AND LIMITATIONS OF THIS STUDY

⇒ This study provides empirical evidence on sex differences on chronic non-communicable disease (NCD) multimorbidity using a large nationally representative sample of older adults aged 45+.
⇒ Findings suggest that multimorbidity in India may be gendered in terms of overall prevalence, socio-demographic and risk factors associated with multimorbidity, meaning that women and men experience multimorbidity differently.
⇒ Among men NCD multimorbidity was associated with limitations in activities of daily living (ADL) and instrumental ADL in greater proportions than in women, the pattern was reversed for hospitalisation.
⇒ Most of the NCDs included in the study are based on self-report, potentially underestimating the multimorbidity estimate.
⇒ The findings were based on a single round of a longitudinal survey; thus, no causality may be inferred.

BACKGROUND

With the advances in medicine, improvement in public health provisioning and longevity has increased the world over. Major demographic shifts have already occurred, and this trend is anticipated to continue.[1–5] From 2015 to 2050, the population of people aged 60 years and older globally is projected to almost double, reaching around 2.1 billion.[6] Over 41.5 million people worldwide die from non-communicable diseases (NCDs), which account for more than 73% of mortality.[7 8] In India, more than half of the elderly population has at least one chronic illness.[7 9] Ageing populations are growing significantly in low-income and middle-income countries (LMICs); in countries like India,[10] they face myriad health and development-related challenges. A growing concern for ageing populations is the existence of two or more coexisting long-term conditions, a phenomenon known as multimorbidity.[4 11–14] The precise definition and measurement of multimorbidity has varied substantially across several studies; myriad operational definitions of multimorbidity have led to heterogenous estimates of multimorbidity prevalence and burden.[3 15–18]

Evidence from high-income countries (HICs) has concluded that multimorbidity

affects elderly people (usually those over 65 years old) as well as younger populations.[19] As a result, chronic multimorbidity has become the norm in most HICs, affecting at least 50 million individuals in the European Union alone.[20] In LMICs, where already strained healthcare systems are stretched further by the dual burden of NCDs and infectious diseases, multimorbidity is becoming more of an issue.[21–24] Several studies suggest that the prevalence of multimorbidity is rapidly increasing in Southeast Asia, from 4.5% at the beginning of the 21st century to about 10% in recent years.[4 25–28] In India, research on multimorbidity is still at an early stage.[1 12 22 28 29] A 2017 study by Himanshu reported 23% prevalence of multimorbidity in India, with a number of states showing high prevalence (42% in Kerala followed by Punjab (36%), Maharashtra (24%) and West Bengal (23%)).[30]

In LMICs, the most common clustering of multimorbidity is of cardiorespiratory conditions such as angina, asthma and chronic obstructive pulmonary disease (COPD); metabolic conditions such as diabetes, obesity and hypertension; or mental-articular conditions such as arthritis and depression. In India, the most commonly clustering multimorbidity are arthritis with hypertension followed by cataract, with diabetes and hypertension.[30–32] Studies have shown that among older adults, the prevalence of dyads (presence of two chronic conditions) is greater compared with triads (presence of three chronic conditions) (31.8% vs 15.5%).[30 33]

Several factors have been found to be associated with multimorbidity such as physical activity, smoking, alcohol consumption, higher body mass index, obesity and nutrition.[34–38] Studies have indicated that presenting with a combination of unhealthy lifestyle factors raises the risk of multimorbidity.[37 39 40] Increasing age and physical inactivity lead to poor health quality and have a positive association with multimorbidity among older adults.[2 31 40–42] Similarly, the association between socioeconomic status (SES) and multimorbidity is not consistent. For instance, some studies concluded that being wealthy was a risk factor,[25 32 43–46] while others found the opposite association, that is, poorer populations had greater multimorbidity.[47–51] Higher levels of education have been linked to increased incidence of multimorbidity in a few studies.[21 40 52–54]

Gender and sex affect multimorbidity. While gender norms affect health behaviours and health seeking, biological differences related to sex may also affect clinical presentation.[55] Studying gender and sex differences in multimorbidity is vital. As individuals become aged, their health state and medication usage patterns are shaped differentially by caregiver or family assistance.[12 56 57] Several studies have concluded that gender is a determinant of multimorbidity; and typically, sex differences are measured, varying greatly across studies.[58–60] The effect of sex on multimorbidity has been less well defined.[17] A majority of previous studies found that prevalence of multimorbidity was higher among women compared with men.[12 25 58 60 61] These disparities between men and women were not only in the number of chronic ailments, but also in the cluster of diseases.[1 4 17 30 62 63] This disparity has been attributed to biological, sociocultural, economic, or environmental causes, which then signifies the importance of gender.[64 65]

Against this backdrop, and given the nature of our data, our study tried to understand sex differences in chronic NCD multimorbidity (MM) among adults aged 45+ in India using recently released data on Longitudinal Ageing Study in India (LASI 2017–2018). While the lack of longitudinal data precludes causal analysis, we undertook correlational analysis to explore factors affecting NCD-MM among male and female elderly persons in India. The specific objectives of the study were: (1) Are there sex differences in multimorbidity and multiple measures of multimorbidity? (2) How do various factors differentially affect multimorbidity in men as compared with women? and, (c) How does multimorbidity affect adverse health outcome such as activities in daily living limitations (ADL), instrumental ADL (IADL), self-rated poor health (SRPH) and hospitalisation/inpatient care visits in the last 12 months?

METHODS

Data

We used unit data from a large-scale population-based survey, namely, LASI, wave 1, conducted during 2017–2018, which is available in public domain. LASI is a nationally representative study on the health, economic and social well-being of older adults aged 45+ and their spouses in India. It has the distinction of being the largest-ever study, worldwide, with a representative sample of 72 250 individuals and 42 949 age-eligible households across all states and union territories of India except Sikkim. LASI used a multistage stratified area probability cluster sampling design in the selection of sample households.[66]

To collect the data, the English version of the LASI instrument was professionally translated into 16 regional languages. Administration of the survey was carried out using Computer-Assisted Personal Interviewing (CAPI). The CAPI program used in LASI has an inbuilt feature to select the appropriate language for the interviews from multiple regional languages. Respondents who were unable to read, were read out the consent form, and asked to provide a signature or inked fingerprint as signature.[67] Along with self-reported health and functional health, LASI measured blood pressure, grip strength, spirometry and visual impairment and collected dry blood samples. The details of the sampling procedure, the instrument and the findings of the survey are available in the national report.[66]

For the present study, two separate data sets, namely individual (n=72 250) and biomarker (n=65 900) were employed. These data sets were merged (N=65 900) and we restricted our sample to 59 073 respondent aged 45+ (men: 27 343 and women: 31 730) (after excluding 6136 participants below 45 years and considering missing

information of socio-demographic characteristics as 'no/never' or 'others') for whom the complete biomarker measurement was also available. All participants with complete item responses on biomarkers like blood pressure measurement, body mass index (BMI) and all other socio-demographic and behavioural variables are included in the analysis sample.

Patient and public involvement

As this was a secondary analysis of data, we did not have patient or public participation in the planning, execution, analysis or publication of our research.

Measures

Multimorbidity

The key variable of interest for the study was NCD-MM, defined as the presence of two or more long-term chronic NCD morbidities.[14 22 28 68] Chronic morbidities were assessed using the question 'has any health professional ever diagnosed with you the following chronic conditions or diseases'. Individual questions were asked regarding diagnosis of hypertension, chronic heart diseases, stroke, any chronic lung disease, diabetes, cancer or malignant tumour, any bone/joint disease, any neurological/psychiatric disease or high cholesterol, which we recoded as yes and no. We used the subdomain of each chronic NCD morbidity, for instance, chronic lung diseases covered COPD, chronic bronchitis, asthma and other chronic lung diseases. Information on 25 self-reported and 2 measured chronic NCDs were used to generate a Chronic Disease Score (CDS) (online supplemental table S1). The study included measured hypertension and Centre for Epidemiologic Studies Depression Scale measure of depression in creating the CDS. Trained enumerators measured the blood pressure of each participant three times using an automatic digital monitor (HEM7121, Omron Healthcare, Kyoto, Japan). We used the average of the last two measurements. We classified participants as having hypertension if (1) they had systolic blood pressure ≥140 mm mercury (Hg) or diastolic blood pressure ≥90 mm Hg and currently taking medication or being under diet and/or salt restriction to control their blood pressure. CDS was further segregated into two categories: no morbidity/single morbidities, and multimorbidity (respondent who suffered with two or more long-term chronic NCDs simultaneously) was computed and subsequently used as the outcome of interest/dependent variable. We have also used different definitions of multimorbidity such as complex multimorbidity (presence of 3+ NCD morbidities), physical–mental multimorbidity (presence of 2+ NCD morbidities: at least one physical and one mental morbidity), mental-only multimorbidity (presence of 2+ mental morbidities, no physical morbidity) and physical-only multimorbidity (presence of 2+physical morbidities, no mental morbidity).

Adverse health outcomes

Further, the study examined the effect of MM on some adverse health outcomes such as, limitations in ADL, IADL, SRPH and hospitalisation in the past 12 months (inpatients in the past 12 months). Limitation in ADL were based on self-reported difficulties in engaging in activities such as dressing (including putting on chappals, shoes, etc), walking across the room, bathing, eating difficulties, getting in and out of bed and using the toilet (including getting up and down). Similarly, limitation in IADL were based on difficulties such as preparing a hot meal, shopping for groceries, making telephone calls, taking medicine, doing work around the house or garden, managing money and getting around or finding an address in an unfamiliar place. The respondents were asked to report 'yes' or 'no'. In this study, we have considered a person to have functional limitation if he or she has either reported yes for any of the ADL or IADL. SRPH was measured using the specific question 'Overall, how is your health in general? Would you say it is very good, good, fair, poor, or very poor?' For the analysis, bad and very bad health responses were combined as 'poor health' and remaining categories combined into 'good health' to generate a dichotomous SRPH variable. Hospitalisation in the past 12 months was assessed through the following questions: 'Over the last 12 months, how many times you were admitted as patient to a hospital/long-term care facility for at least one night?' and recoded 'no' for zero or no hospitalisation, and 'yes' for ≥1 hospitalisation in the last 12 months.

Covariates

A number of independent variables were used in this study—participant background characteristics such as age (45–54, 55–64, 65–74 and 75+), education level (no education, primary, secondary, higher), marital status (currently married, widowed, divorced/separated/others), Monthly Per Capita Consumption Expenditure (MPCE) quintile, working status (not working, currently working, currently not working but worked in the past), living arrangement (loving alone/with others, living with family members), health behaviours including physical activity (inactive, active), smoking status (never, former and currently using), chewing tobacco (never, former and currently using) and alcohol consumption (no, yes), and clinical risk factors such as BMI. BMI was calculated as weight in kilograms divided by height in metres squared, and categories as BMI <18.59 as underweight, 18.5–24.99 as normal and BMI ≥25.0 considered as overweight or obese. For SES, we computed MPCE using the information related to household-level consumption of food (reference period of 7 days) and non-food (reference period of 1 year) items. Expenditures were standardised to the 30-day reference period and divided into five quintiles, that is, from poorest to richest. Religion was categorised as Hindu, Muslim and others. Caste and Tribal Status were categorised as Scheduled Tribe, Scheduled Caste, Other Backward Class and others. It is important to note that factors like social group and religion are taken into account in the study because they are fundamental components of Indian society and are

crucial in determining a respondent's SES.[1 59 60 69–72] 'Schedule Tribe' and 'Schedule Caste' are the tribal and caste groups recognised by the President of India according to article numbers 341 and 342 of the Constitution of India.[73] 'Backward Class' is the term used by the Government of India to classify groups that are educationally or socially disadvantaged.[74] Place of residence was categorised as rural and urban. The study also includes behavioural characteristics of individuals such as physical activity (inactive, active), smoking status (never, former and currently using), chewing tobacco (never, former and currently using) and alcohol consumption (no, yes). Physical activity status assessed through the questions 'How often do you take part in sports or vigorous activities, such as running or jogging, swimming, going to a health centre or gym, cycling, or digging with a spade or shovel, heavy lifting, chopping, farm work, fast bicycling, cycling with loads?' and 'How often do you take part in sports or activities that are moderately energetic such as, cleaning house, washing clothes by hand, fetching water or wood, drawing water from a well, gardening, bicycling at a regular pace, walking at a moderate pace, dancing, floor or stretching exercises?" categorised as frequent (every day), rare (more than once a week, once a week, one to three times in a month) and hardly or never. These two questions of physical activities were combined and recoded as 'no' for no physical activities and 'yes' for at least one physical activity. Tobacco and alcohol consumption were assessed through the questions 'have you ever smoked tobacco or used tobacco products?', 'And have you ever consumed alcoholic beverages such beer, wine, liquor, etc?'. It was coded as no and yes. Covariates in the multiple regression analysis were selected based on evidence of association with NCD-MM in the previous studies.[1 12 31 59 60 71 75–77]

Statistical analyses

We presented descriptive statistics for all variables—counts and percentages for categorical variables and mean±SD or median (IQR) for continuous variables. We used two sample t-test to test the significant difference in the mean prevalence of MM between men and women. We conducted bivariate and multivariable analyses to examine associations between multimorbidity and risk factors. We also examined associations between multimorbidity and adverse health outcomes after adjusting for background characteristics of participants. We used binary logistic regression for ascertaining the effect of various predictors on the outcome variable. We also applied a binary logistic regression model to understand the effect of MM on ADL, IADL, SRPH and inpatients in the past 12 months.

An interaction term was added to the logistic regression model to obtain the female-to-male ratio of OR estimate (RORs) and its 95% CIs. This interaction model included all main effects and their interaction with sex, otherwise the adjustments made in the interaction model will not vary by sex, as they do in the sex-specific models.[55] The OR for whatever sex is chosen as the reference group will be immediately generated by the interaction model, together with the RORs contrasting the other sex with the reference sex. For example, if men are used as the reference group, we will get the male OR and the female-to-male RORs (together with their 95% CIs).[63] The interaction model will directly produce the OR for whichever sex is taken as the reference group, as well as the RORs comparing the other sex with the reference sex. For instance, if men are taken as the reference group, we would get the male OR and the female-to-male RORs (as well as their 95% CIs). Men are used as the reference group in this study. A variance inflation factor (VIF) was used to assess multicollinearity between the selected predictors before executing the final model and the value of VIF is 2.2, which is less than 10. We have used χ^2 goodness-of-fit tests and classification analysis to check the fitness of regression model. All the statistical analyses were conducted by Stata/MP V.17 (StataCorp, Lakeway Drive, College Station, Texas, USA), using the individual sampling weight variables in the data set.

A sensitivity analysis was also performed to understand whether sex differences in multimorbidity hold the similar findings, or it differs. We included other morbidities like chronic pain, eyesight problem, hearing problem, etc, in the construction of CDS. Eyesight problems were assessed through the question 'With which eye problem or conditions were you diagnosed?' such as presbyopia, cataract, glaucoma, myopia (nearsightedness), hypermetropia (farsightedness) or other eye problems. Hearing problem was assessed through the question 'Have you ever been diagnosed with any hearing or ear-related problem or condition?'. Again, we have only considered the self-reported hypertension and depression along with other self-reported morbidities to construct the CDS.

RESULTS

Table 1 presents the socio-demographic, behavioural and lifestyle characteristics of 27 343 men and 31 730 women aged 45+ in India. We observed that more than two-thirds of both male and female respondents were below 65 years of age. About one-third of the male respondents (33.4%) and two-thirds of the female respondents (65.3%) had no formal education. Around 67% of the male respondents and 30% of the female respondents were currently working and approximately 90% living with their family members. A majority of men and women (more than 80%) were Hindu, and more than 27% belonged to the SC/ST group. While 4 in every 10 older adults belonged to the lowest 40% wealth quintile (lowest two wealth quintile), 7 in 10 older adults lived in a rural community, respectively. A greater proportion of women (72.9%) reported being physically active than men (65.9%). BMI-based overweight/obesity was more prevalent among women and men aged 45 years or older (31.9% vs 21.4%). Similarly, currently smoking (26% vs 2.8%), chewing tobacco (28% vs 14.9%) and consuming alcohol (30% vs 2.6%)

Table 1 Sample characteristics of adults aged 45+ in India by sex, LASI 2017–2018

Background characteristics	Male		Female	
	N	%	N	%
Age groups				
45–54	9290	33.97	11358	35.80
55–64	8160	29.84	9808	30.91
65–74	6795	24.85	7426	23.40
75+	3098	11.33	3137	9.89
Education level				
No education	9126	33.38	20725	65.32
Primary	7891	28.86	5923	18.67
Secondary	6234	22.80	3371	10.62
Higher	4092	14.96	1712	5.39
Marital status				
Currently married	23838	87.19	19854	62.57
Widowed	2770	10.13	10949	34.51
Di/Se/De/others*	734	2.69	927	2.92
Working status				
Not working	777	2.84	14532	45.80
Current working	18272	66.83	9673	30.48
Not working currently	8292	30.33	7525	23.72
Living arrangement				
Living alone or with others	1308	4.78	3334	10.51
Living with family members	26035	95.22	28395	89.49
MPCE quintile				
Poorest	5690	20.81	6761	21.31
Poorer	5833	21.33	6732	21.22
Middle	5557	20.32	6486	20.44
Richer	5366	19.63	6245	19.68
Richest	4896	17.91	5507	17.35
Religion				
Hindu	22655	82.86	26092	82.23
Muslim	3014	11.02	3505	11.05
Others	1674	6.12	2133	6.72
Social group				
Scheduled Caste	5287	19.33	6202	19.55
Scheduled Tribe	2318	8.48	2772	8.74
Other Backward Caste	12488	45.67	14415	45.43
Others	7251	26.52	8341	26.29
Place of residence				
Rural	19481	68.8	21831	69.92
Urban	7862	31.2	9899	30.08
Physical activity				
Inactive	9311	34.05	8592	27.08
Active	18032	65.95	23138	72.92
Body mass index				
Normal	15317	56.02	15141	47.72
Underweight	6182	22.61	6462	20.37
Overweight/obese	5844	21.37	10127	31.92
Smoking status				
Never	18183	66.50	30587	96.4
Former	1974	7.22	267	0.84
Current	7186	26.28	876	2.76
Chewing tobacco				
Never	18610	68.06	26536	83.63
Former	932	3.41	478	1.51
Current	7801	28.53	4716	14.86
Drinking status				
No	19162	70.08	30898	97.38
Yes	8181	29.92	832	2.62
Total	27343	100.0	31730	100.0

Missing values are treated as 'no', 'never' or 'others'.
*Di/Se/De/others: divorced/separated/deserted/others
LASI, Longitudinal Ageing Study in India; MPCE, Monthly Per Capita Consumption Expenditure.

was higher among men than women in the sample aged 45+ in India.

Figure 1 and online supplemental table S1 present the prevalence of different chronic conditions with 95% CI by sex among adults aged 45+ in India. It was found that the

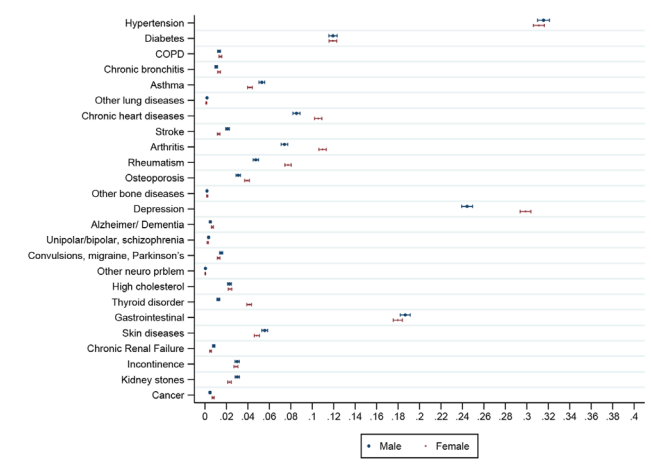

Figure 1 Prevalence of chronic NCD multimorbidities among male and female adults aged 45+, LASI 2017–2018. COPD, chronic obstructive pulmonary disease; LASI, Longitudinal Ageing Study in India; NCD, non-communicable disease.

most prevalent NCD morbidities among both sexes were hypertension (31.6% (95% CI: 31.0% to 32.1%) men vs 31.1% (95% CI: 30.6% to 31.6%) women; p=0.001), depression (24.4% (95% CI: 23.9% to 24.9%) men vs 29.9% (95% CI: 29.4% to 30.4%) women; p=0.000), gastrointestinal (18.7% (95% CI: 18.2% to 19.1%) men vs 18.0% (95% CI: 17.5% to 18.4%) women; p=0.000) and diabetes (11.93% (95% CI: 11.5% to 12.3%) men vs 11.92% (95% CI: 11.6% to 12.3%) women; p=0.000). Chronic heart diseases (CHD) ranked fifth in the highest prevalence of morbidities among men (8.5% (95% CI: 8.2% to 8.9%)), and ranked sixth among women (10.6% (95% CI: 10.2% to 10.9%)), however the CHD prevalence was greater in women.

Table 2 presents the prevalence of different measures of NCD-MM among adults aged 45+ in India. Overall, the prevalence of two or more NCD-MM conditions was significantly (p<0.001) higher among women (42.7% (95% CI: 42.1% to 43.2%)) than men (38.9% (95% CI: 38.4% to 39.5%)) and increased by age across sexes. About 20% (95% CI: 19.6% to 20.4%) of women and 16.2% (95% CI: 15.8% to 16.6%) of men had three or more NCD-MM. It was observed that around 21.6% (95% CI: 21.2% to 22.1%) of women and 17.9% (95% CI: 17.5% to 18.4%) of men had at least one physical and one mental morbidity. The prevalence of two or more mental morbidities without physical morbidity was extremely low (0.20% in women and 0.16% in men). On the other hand, about one in five men and women had two or more physical morbidities without any mental morbidities. The greatest magnitude of sex difference in NCD morbidities (11%) was observed in the age group of 75+ when at least one physical and one mental morbidity were measured.

Table 3 presents the percentage distribution of MM among older Indians—defined as two or more ailments—by their background characteristics. The prevalence of multimorbidity increased with age and education level for both men and women. It was found that the prevalence of multimorbidity was significantly (p<0.001) higher among women aged 75+ (52.1% (95% CI: 50.3% to 53.9%) vs 45.2% (95% CI: 50.3% to 53.9%)] with higher levels of education (44.3% (95% CI: 41.9% to 46.6%) vs 40.3% (95% CI: 38.7% to 41.8%)) compared with men. MM was more prevalent among widows (48.5% (95% CI: 47.5% to 49.5%)) as compared with widowers (44.8% (95% CI: 42.9% to 46.8%)) and increased by wealth (however, the prevalence was higher among women than men in each quintile). The prevalence of MM was significantly (p<0.001) higher among women than men in both rural (40.1% (95% CI: 39.4% to 40.7%) vs 37.3% (95% CI: 36.6% to 38.0%)) and urban areas (48.5% (95% CI: 47.6% to 49.4%) vs 43.0% (95% CI: 42.0% to 44.1%)).

While considering lifestyle and behavioural factors, it was observed that physically inactive adults had higher prevalence of NCD-MM, more so among women than men (men: 43.3% (95% CI: 42.3% to 44.3%) and women: 46.17% (95% CI: 45.1% to 47.2%)). The prevalence of NCD-MM was about 7% higher in women aged 45+ with overweight/obesity than in men (53.9% (95% CI: 53.0% to 54.9%) vs 46.61% (95% CI: 45.4% to 47.8%)) significantly (p<0.001). NCD-MM prevalence was significantly higher among those adults who formerly indulged in smoking and chewing tobacco than those who were currently involved and never involved in smoking and chewing tobacco and among consumers of alcohol.

Figure 2 and online supplemental table S2 show sex differences in the prevalence of NCD-MM among adults aged 45+ across Indian states. The NCD-MM prevalence was higher among women compared with men in most states except Andhra Pradesh, Chhattisgarh, Uttar Pradesh, Uttarakhand (although not significantly) and Manipur. The prevalence of NCD-MM was highest in Jammu and Kashmir (62% women vs 50% men), followed by Kerala (62% women vs 56% men), West Bengal (59% women vs 47.0% men), Karnataka (51% women vs 43% men) and Punjab (51% women vs 45% men).

Figures 3 and 4 shows the results of multivariable logistic regression computing the adjusted ORs of NCD-MM among men and women aged 45+ and female-to-male RORs according to their background characteristics in India. The odds of NCD-MM significantly increased with age in both sexes, with slightly greater odds seen in women. The adjusted female-to-male RORs for MM associated with age were 1.01 (95% CI: 0.93 to 1.11) in 55–54, 1.04 (95% CI: 0.94 to 1.16) in 65–74 and 1.04 (95% CI: 0.9 to 1.21) in 75+ (figure 4). In case of marital status, only widowed women had significantly higher odds of NCD-MM as compared with currently married women. In men, marital status did not affect the odds of NCD-MM. Compared with currently married adults aged 45+, widowed and divorced/separated/deserted had a considerably greater odds of NCD-MM among women relative to men.Widowed and divorced/separated/deserted women had 16% and 28% greater odds of NCD- MM as compared with men counterparts (see online supplemental table S3).

Similarly, female-to-male RORs shows that the odds of NCD-MM were greater in currently working women (1.29 (95% CI: 1.11 to 1.50)) and formerly working women (1.24 (95% CI: 1.06 to 1.44) as compared with men. It was observed that the adjusted odds of NCD-MM were significantly greater in women belonged to other/minority religious groups 1.22 (95% CI: 1.06 to 1.4) and other/majority caste and tribal status groups 1.14 (95% CI: 1.02 to 1.28) compared with men, respectively (see figure 4).

Those engaged in physical activity across both sexes had significantly lower odds of NCD-MM. The ROR was slightly higher among women compared with men; however, sex differences were not statistically significant. Overweight/obesity was associated with increased odds of MM in both sexes; with 10% greater odds of NCD-MM among women as compared with men (ROR: 1.10, 95% CI: 1.01 to 1.2). Former tobacco smoking among men was associated with greater NCD-MM odds; women who had formerly chewed tobacco had 42% greater odds of MM (95% CI: 1.12 to 1.80) relative to men, while those currently chewing had

Table 2 Prevalence of different measures of chronic NCD multimorbidity among adults aged 45+, LASI 2017–2018

	Male % (95% CI)					Female % (95% CI)				
Measure	**45–54**	**55–64**	**65–74**	**75+**	**Total**	**45–54**	**55–64**	**65–74**	**75+**	**Total**
Multimorbidity: presence of 2+ NCD morbidities	29.3 (28.4 to 30.2)	41.1 (40.0 to 42.1)	46.6 (45.4 to 47.8)	45.2 (43.3 to 47.0)	38.9 (38.4 to 39.5)	35.4 (34.6 to 36.3)	43.1 (42.1 to 44.1)	49.3 (48.1 to 50.5)	52.1 (50.3 to 53.9)	42.7 (42.1 to 43.2)
Complex multimorbidity: presence of 3+ NCD morbidities	10.7 (10.1 to 11.3)	15.7 (14.9 to 16.4)	21.8 (20.8 to 22.8)	21.8 (20.2 to 23.3)	16.2 (15.8 to 16.6)	13.6 (13.0 to 14.2)	20.4 (19.6 to 21.2)	26.4 (25.4 to 27.5)	26.5 (24.9 to 28.1)	20.0 (19.6 to 20.4)
Physical–mental multimorbidity: presence of 2+ NCD morbidities, at least one physical and one mental morbidity	14.1 (13.4 to 14.8)	19.0 (18.1 to 19.8)	20.9 (19.9 to 21.9)	20.1 (18.6 to 21.6)	17.9 (17.5 to 18.4)	18.5 (17.8 to 19.2)	21.0 (20.2 to 21.8)	23.3 (22.2 to 24.3)	31.2 (29.5 to 32.9)	21.6 (21.2 to 22.1)
Mental-only multimorbidity: presence of 2+ mental morbidities, no physical morbidity	0.18 (0.09 to 0.26)	0.24 (0.13 to 0.34)	0.09 (0.02 to 0.17)	0.08 (0.02 to 0.19)	0.16 (0.12 to 0.21)	0.25 (0.16 to 0.34)	0.14 (0.06 to 0.21)	0.15 (0.06 to 0.25)	0.29 (0.10 to 0.49)	0.20 (0.15 to 0.25)
Physical-only multimorbidity: presence of 2+ physical morbidities, no mental morbidity	15.1 (14.4 to 15.8)	21.9 (21.0 to 22.8)	25.6 (24.6 to 26.7)	25.0 (23.4 to 26.6)	20.9 (20.4 to 21.3)	16.6 (16.0 to 17.3)	22.0 (21.2 to 22.8)	25.9 (24.9 to 27.0)	20.6 (19.2 to 22.1)	20.9 (20.4 to 21.3)

LASI, Longitudinal Ageing Study in India; NCD, non-communicable disease.

Table 3 Percentage of adults aged 45 years and older suffering from chronic NCD morbidity by their background characteristics in India, LASI 2017–2018

Background characteristics	Male % (95% CI)	N	Female % (95% CI)	N
Age groups				
45–54	29.3 (28.4 to 30.2)	9290	35.4 (34.6 to 36.3)	11358
55–64	41.1 (40.0 to 42.1)	8160	43.1 (42.1 to 44.1)	9808
65–74	46.6 (45.4 to 47.8)	6795	49.3 (48.1 to 50.5)	7426
75+	45.2 (43.3 to 47.0)	3098	52.1 (50.3 to 53.9)	3137
Education level				
No education	36.5 (35.4 to 37.5)	9126	40.2 (39.6 to 40.9)	20725
Primary	41.5 (40.4 to 42.6)	7891	47.1 (45.9 to 48.3)	5923
Secondary	38.4 (37.3 to 39.6)	6234	49.1 (47.6 to 50.7)	3371
Higher	40.3 (38.7 to 41.8)	4092	44.3 (41.9 to 46.6)	1712
Marital status				
Currently married	38.5 (37.9 to 39.1)	23838	39.8 (39.2 to 40.5)	19854
Widowed	44.8 (42.9 to 46.8)	2770	48.5 (47.5 to 49.5)	10949
Di/SE/De/others	31.0 (27.9 to 34.1)	734	35.4 (32.5 to 38.3)	927
Working status				
Not working	45.5 (42.5 to 48.5)	777	45.2 (44.4 to 46.0)	14532
Current working	33.5 (32.8 to 34.2)	18272	33.5 (32.6 to 34.5)	9673
Not working currently	50.2 (49.1 to 51.3)	8292	49.6 (48.5 to 50.8)	7525
Living arrangement				
Living alone or with others	39.7 (37.1 to 42.3)	1308	47.7 (46.0 to 49.5)	3334
Living with family members	38.9 (38.3 to 39.5)	26035	42.1 (41.5 to 42.7)	28395
MPCE quintile				
Poorest	33.4 (32.1 to 34.7)	5690	37.2 (36.0 to 38.4)	6761
Poorer	37.6 (36.3 to 38.9)	5833	40.6 (39.4 to 41.8)	6732
Middle	38.1 (36.8 to 39.4)	5557	43.5 (42.3 to 44.7)	6486
Richer	42.0 (40.7 to 43.2)	5366	43.9 (42.7 to 45.1)	6245
Richest	44.6 (43.2 to 45.9)	4896	49.7 (48.5 to 50.9)	5507
Religion				
Hindu	38.3 (37.6 to 38.9)	22655	42.1 (41.4 to 42.7)	26092
Muslim	43.5 (41.7 to 45.2)	3014	47.6 (46.0 to 49.2)	3505
Others	39.9 (38.3 to 41.4)	1674	42.2 (40.7 to 43.6)	2133
Caste				
Scheduled Caste	37.5 (36.1 to 38.9)	5287	41.4 (40.1 to 42.8)	6202
Scheduled Tribe	30.5 (29.2 to 31.8)	2318	29.3 (28.1 to 30.5)	2772
Other Backward Caste	39.6 (38.6 to 40.5)	12488	42.9 (42.0 to 43.8)	14415
Others	41.6 (40.5 to 42.7)	7251	47.7 (46.7 to 48.8)	8341
Place of residence				
Rural	37.3 (36.6 to 38.0)	19481	40.1 (39.4 to 40.7)	21831
Urban	43.0 (42.0 to 44.1)	7862	48.5 (47.6 to 49.4)	9899
Physical activities				
Inactive	43.3 (42.3 to 44.3)	9311	46.2 (45.1 to 47.2)	8592
Active	36.7 (36.0 to 37.4)	18032	41.4 (40.8 to 42.0)	23138
Body mass index				
Normal	37.9 (37.1 to 38.6)	15317	39.0 (38.2 to 39.7)	15141
Underweight	34.3 (33.0 to 35.6)	6182	33.8 (32.6 to 35.1)	6462
Overweight/obese	46.6 (45.4 to 47.8)	5844	53.9 (53.0 to 54.9)	10127

Continued

Table 3 Continued

Background characteristics	Male % (95% CI)	N	Female % (95% CI)	N
Smoking status				
Never	38.1 (37.4 to 38.8)	18183	42.7 (42.2 to 43.3)	30587
Former	51.8 (49.8 to 53.8)	1974	47.2 (42.1 to 52.4)	267
Current	37.5 (36.4 to 38.6)	7186	40.0 (37.1 to 42.9)	876
Chewing tobacco				
Never	39.4 (38.7 to 40.1)	18610	42.4 (41.8 to 43.0)	26536
Former	42.5 (39.4 to 45.7)	932	53.6 (49.3 to 58.0)	478
Current	37.3 (36.2 to 38.5)	7801	43.0 (41.6 to 44.5)	4716
Drinking status				
No	38.4 (37.7 to 39.1)	19162	42.8 (42.3 to 43.4)	30898
Yes	40.2 (39.2 to 41.2)	8181	37.5 (34.9 to 40.2)	832
Total	38.9 (38.4 to 39.5)	27343	42.7 (42.1 to 43.2)	31730

Missing values are treated as 'no', 'never' or 'others'; Di/Se/De/others: divorced/separated/deserted/others.
LASI, Longitudinal Ageing Study in India; MPCE, Monthly Per Capita Consumption Expenditure; NCD, non-communicable disease.

9% greater odds (insignificant, 95% CI: 0.99 to 1.21) of MM as compared with never chewing. Similarly, ever-consumed alcohol was significantly associated with the risk of MM in both sexes, with 4% greater ROR (95% CI: 0.89 to 1.20) among women relative to men, a statistically insignificant difference.

Figure 5 and online supplemental table S4 show the results of adjusted ORs of for ADL, IADL, SRPH and hospitalisation/inpatient with NCD-MM among men and women aged 45+ and female-to-male RORs after controlling other covariates. We found that NCD-MM, after controlling other covariates, was associated with greater odds of limitations in ADL and IADL in both sexes; the relative increase was about 12% and 7% greater in men, respectively. Further, NCD-MM was associated with greater odds of hospitalisation/inpatient in both sexes, but the relative increase was about 14% greater in women.

Sensitivity analyses were performed using two new definitions of NCD-MM to confirm the consistency in the findings obtained from the adopted definition of NCD-MM in this study. In the first new definition of MM, we included some other morbidities such as eyesight problems, hearing problems, chronic pain, etc, and the second new definition only considered self-reported morbidities. The results are presented in online supplemental figures S1 and S2 in the supplementary file. The results from the sensitivity analysis demonstrated that both new definitions do not demonstrate divergent findings from those in this

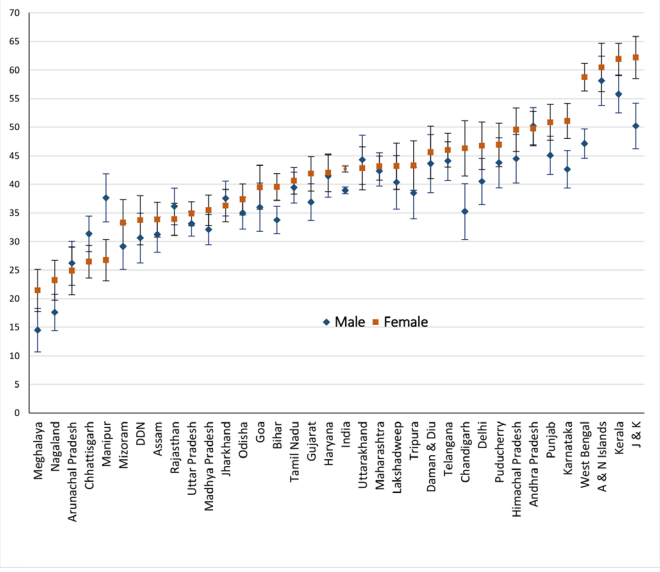

Figure 2 State-wise sex differences in prevalence of multimorbidity among adults aged 45+ in India, LASI, 2017–2018. DDN, Dadra and Nagar Haveli; J & K, Jammu and Kashmir, LASI, Longitudinal Ageing Study in India.

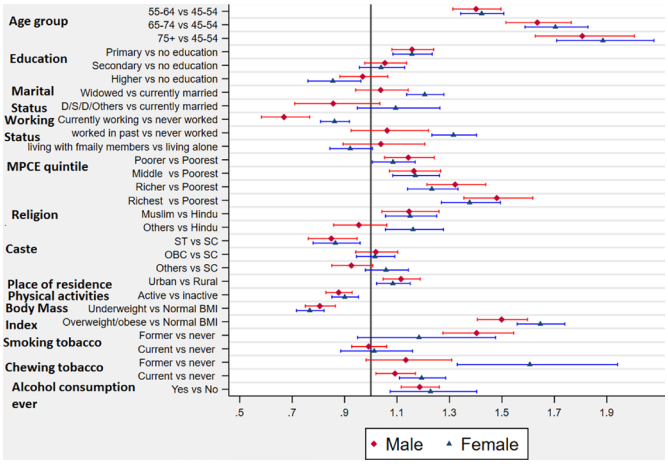

Figure 3 Adjusted OR for multimorbidity associated with risk factors by sex, LASI, 2017–2018. Note: All the estimates were controlled for states. BMI, body mass index; D/S/D/Others: divorced/separated/deserted/others; LASI, Longitudinal Ageing Study in India; MPCE, Monthly Per Capita Consumption Expenditure; OBC, Other Backward Caste; SC, Scheduled Cast; ST, Scheduled Tribe.

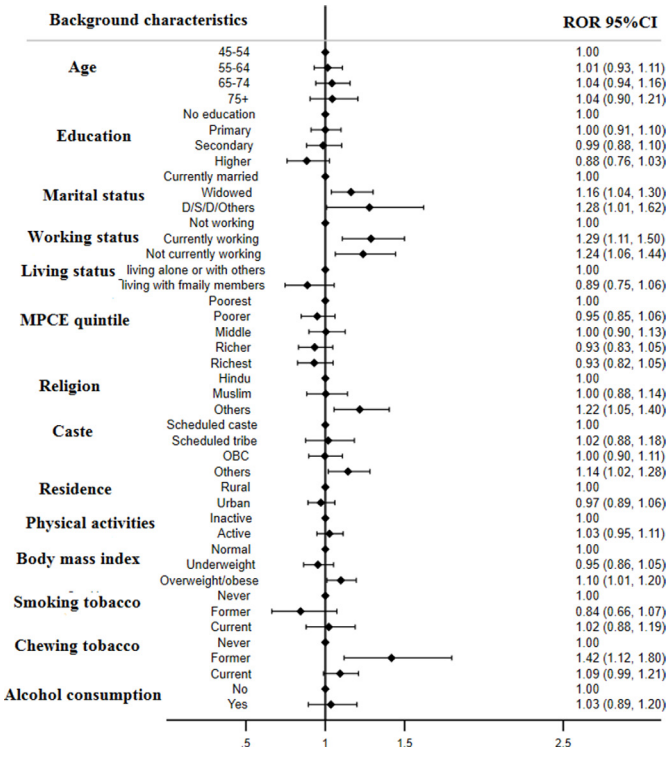

Figure 4 Adjusted women-to-men ratio of ORs (RORs) for multimorbidity associated with risk factors among adults aged 45 years or older. D/S/D/Others: divorced/separated/deserted/others; MPCE, Monthly Per Capita Consumption Expenditure; OBC, Other Backward Caste.

study. Online supplemental figures S1 and S2 showed that the odds of NCD-MM were significantly higher in women who were widowed, currently working, overweight/obese

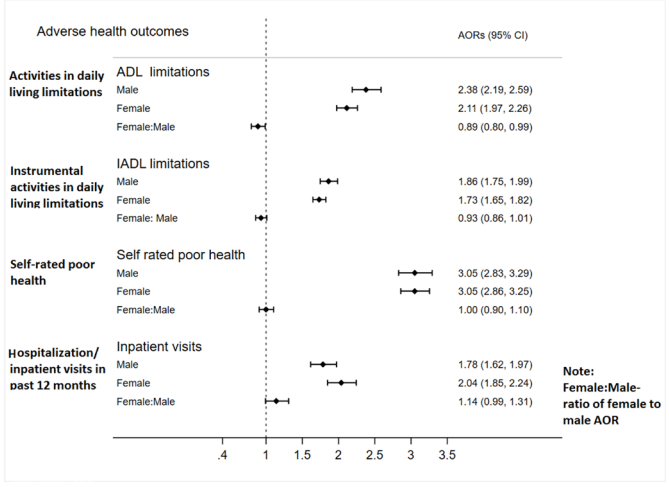

Figure 5 Adjusted women-to-men ratio of ORs for ADL, IADL, SRPH and inpatient with risk of multimorbidity among adults aged 45 years or older. Note: *All the estimates were controlled for age, education, marital status, working status, living status, MPCE quintile, religion, caste, place of residence, physical activities, body mass index, smoking tobacco, chewing tobacco and consumed alcohol, and states ** yes stand for women with MM. AOR, adjusted OR; SRPH, self-rated poor health; MM, multimorbidity; MPCE, Monthly Per Capita Consumption Expenditure.

and formerly chewing tobacco as compared with men, as was obtained from the adopted definitions of NCD-MM in this study.

DISCUSSION

Our study examined the sex disparities in chronic NCD-MM in 59 073 adults aged 45+ using a nationally representative large-scale sample survey in India. Our findings suggest that NCD-MM in India may be gendered in terms of overall prevalence, socio-demographics and risk factors associated with NCD-MM: in short, women and men experience NCD-MM differently.

Women had greater overall NCD-MM relative to men at all ages, although the magnitude of the difference was relatively small and may not have broader public health significance in some (but not all) cases. The most common NCD morbidities among both sexes were hypertension, depression, gastrointestinal and diabetes; however, the sex-differences were relatively very small. The biggest sex differences—a magnitude of 11%—was found in physical–mental multimorbidity in the age group 75+. The prevalence of depression, CHD and arthritis was higher among women than men aged 45+. Sex disparities in NCD-MM prevalence were significantly greater among women aged 75+ with higher levels of education, and among widows compared with men in similar categories. Prior chewing tobacco history, physical inactivity and overweight/obese were associated with significant and higher NCD-MM among women relative to men. Widowed and divorced/separated women had 16% and 28% greater odds of MM than men. Analysis of the ratio of adjusted ORs after adjusting for potential confounders revealed that the odds of having NCD-MM were significantly higher among women who were currently working or formerly worked, belonging to minority religious groups and majority caste groups compared with men.

Overweight/obesity was associated with 10% greater excess risk of MM in women compared with men aged 45+. Smoking was not associated with MM in women, whereas prior history of chewing tobacco conferred a 42% greater odds of MM in women than men. Similarly, ever-consumed alcohol had 4% greater odds of MM among women than men in India. Since overweight and obesity as well as tobacco chewing were more prevalent among women (as compared, for instance, to alcohol drinking), this was not unexpected.

Several studies have reported that women have more multimorbidity than men.[17 19 30 75] The probable explanations behind this could be vulnerability in later stages of life, gendered decision-making for healthcare, higher life expectancy and gender inequality in access to healthcare services through the life course.[58 60 78]

The level of sex difference in multimorbidity varies between studies.[79–82] According to one study, there was minimal difference in the risk of being multimorbid between men and women.[83] Multimorbidity was not only confined to elderly people, middle-aged cohort adults of

both sexes also suffered from this condition[58 84 85] which showed a significant association between higher SES and MM in both sexes, a finding suggested by earlier studies[86 87]; however, the likelihood of MM was lower in women as compared with men, contrary to our finding. Gender differences in SES, living and working environments, lifestyle factors and life events might affect the occurrence and outcome of MM among women.[88] Another study reported that MM was more prevalent in urban areas in both sexes. It was hypothesised that this may be due to rising urbanisation, which resulted in a noticeable shift in the population's dietary habits, with greater intake of foods high in saturated fats and sugar. In addition, urbanisation has for many resulted in increased work-related stress and little or no time for physical activity. The results can also be explained by greater healthcare facility accessibility and use in urban areas, which translates into greater diagnosed prevalence of disease in the country's urban and better-off regions. Indeed, the intersectionality of socio-demographic factors that affect NCD-MM warrants further exploration across each sex (for instance, what are the patterns of multimorbidity among formerly working religious minority women or currently working caste majority men).

Specific patterns of NCD-MM in states warrant further study. For example, the extremely high multimorbidity burden in Kashmir may follow a pattern that is different from that in Kerala, that is, further study should explore at the state level the types of morbidities. Our study also suggests that in many states, there was no significant difference in NCD-MM prevalence by sex. While there are many studies exploring NCDs morbidity and interventions in Kerala,[72 89] Karnataka and Punjab,[32 90 91] we found less discussion of NCDs in Jammu and Kashmir and West Bengal. State specific or regional analyses may also shed more light on patterns of multimorbidity, which in some cases should also include other determinants like nutritional status, substance use, presence of conflict, economic security, etc, which may have bearing on prevalence as well as coping with chronic disease. In cases where patterns are similar, aligned or linked intervention strategies may be attempted.

In agreement with previous studies, our study showed that late-life physical inactivity was significantly associated with higher likelihood of MM in both sexes.[92–94] The study found that obesity or being overweight was linked to an increased risk of a variety of long-term diseases that are important in primary and secondary care,[36 42] suggesting the need for a more integrated approach to risk factor prevention, diagnosis and treatment.[95] The findings showed that overweight or obese women aged 45+ presented a higher risk of chronic NCD multimorbidity, which concurs with Flores *et al*.[96] We identified male ex-smokers as having higher odds for MM, rather than current smokers and women. This finding might be interpreted as reverse causation, with smokers being more willing to quit when their health deteriorates or as weight increases after quitting smoking.[36] Findings revealed that women with prior history of chewing tobacco and ever consumed alcohol had a significant and greater risk of suffering with MM among older adults aged 45+, which is similar to the findings from other studies.[71 76]

While there is some evidence to suggest that healthcare usage—including chronic disease screening—has been better among women as compared with men in India,[72] efforts must take into account NCD-MM on the one hand and risk factors that seem to cause more pronounced burdens, variably by sex. Findings also suggest that certain risk factors, like obesity/overweight and reduction in chewing tobacco among women may yield benefits not just for single but for multiple morbidities. Given that India's as the Indian Comprehensive Primary Healthcare programme involves creating risk assessments which includes tracking of risk factors like overweight/obesity among women and use of tobacco among men could also be, some additional attention may be placed based on vulnerability to a wider range of morbidities based on these scores. In some cases, risk factors may be intervened on much earlier in life: these may include interventions in the intrapartum period (for which evidence is scant in LMICs)[97] as well as policy instruments like India's COTPA Act (Cigarettes and Other Tobacco Products Act) to reduce smoking (99) (awareness of which is currently low among women).[98] Greater exploration of gendered impacts of upstream fiscal interventions that can impact on multiple morbidities—like sugar, fat and tobacco taxes is also warranted.

Findings of the study revealed that the NCD-MM is significantly associated with higher level of functional limitations, SRPH and inpatient in the past 12 months in both sexes among adults aged 45+ in India. The effects of multimorbidity on various domains of health are likely to depend on disease severity, the unique combination of diseases and access to treatment and support.[22] These findings are consistent with the results from previous studies, which concluded that multiple chronic morbidities substantially affect other aspects of an individual's health, such as self-rated health, functional limitations, cognition and quality of life.[1 22 99 100] Our study found that men suffering with MM have a greater chance of functional limitations than women; however, a number of studies showed that multimorbidity was associated with increases in functional limitations, and the associations were stronger among women than among men.[99 101 102] Findings also revealed that women with MM had a higher likelihood of being hospitalised in the last 12 months. It may be due to the fact that women have a higher MM rate than men. Since multimorbidity has a higher impact on women, efforts should be made to improve clinical care equality and ensure that everyone has access to healthcare.[103]

LIMITATIONS

There are a few limitations to this study that should be highlighted. First, with the exception of depression and

hypertension, all other conditions were self-reported from a previous medical diagnosis, potentially underestimating the multimorbidity estimate. Although there have been studies that have confirmed the information provided by the respondent when evaluating the medical diagnosis, such as reporting hypertension,[104] it is well recognised that self-reported information may contain some bias. We looked only at chronic multimorbidity, there are known other multimorbidity that cause a substantial burden. Further, owing to the design of the survey, we were not able to disaggregate by occupational group or include other key disaggregation that would reflect the nature of and exposures associated with work/labour, which likely would have strong bearing on NCD-MM.

CONCLUSION

The study found that women have more multimorbidity across all age groups compared with men. Sex disparities in NCD-MM prevalence were significantly greater among women aged 75+ with higher levels of education, and widows. Overweight/obesity, having a prior history of chewing tobacco, and having ever consumed alcohol were associated with a greater odds of NCD-MM in women compared with men aged 45+. The effect of increasing multimorbidity on ADL and IADL limitations was greater in men than women but reversed for hospitalisation. Given these clear sex differences in the prevalence and factors associated with NCD-MM among men as compared with women, it is vital that both research and policy going forward seek to address differential pathways to NCD-MM and entry points for intervention to avert disability and mortality attributable to NCD-MM.

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Contributors SKS: data analysis, writing and manuscript preparation. DN: conceptualisation, fund acquisition, monitoring, supervision, manuscript preparation and review. AG: conceptualisation, data analysis, manuscript editing and review. All the authors accepts full responsibility for the work and/or the conduct of the study, had access to the data, and controlled the decision to publish

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Competing interests None declared.

Patient and public involvement Patients and/or the public were not involved in the design, or conduct, or reporting, or dissemination plans of this research.

Patient consent for publication Not applicable.

Ethics approval The necessary guidelines and ethics for undertaking the LASI survey was approved by the Indian Council of Medical Research (ICMR). The agencies that conducted the field survey for the data collection had collected prior informed consent (signed and oral) for both the interviews and biomarker tests from the eligible respondents in accordance with the Human Subjects Protection. All methods in this study were carried out in accordance with relevant guidelines and regulations by the ICMR. There was no number/ID of the approval(s) mentioned in the LASI report (https://www.iipsindia.ac.in/sites/default/files/LASI_India_Report_2020_compressed.pdf). Participants gave informed consent to participate in the study before taking part.

Provenance and peer review Not commissioned; externally peer reviewed.

Data availability statement Data are available upon reasonable request. Data are available upon reasonable request. The data has been archived in the public repository of the Longitudinal Ageing Study in India, 2017–2018. Access to the data requires registration and is granted only for legitimate research purposes. A guide on applying for the data set access is available at https://www.iipsindia.ac.in/content/LASI-data. The data can be accessed by filling out the request form available at https://iipsindia.ac.in/sites/default/files/LASI_DataRequestForm_0.pdf and sending it to the Data Center (datacenter@ iipsindia.ac.in) held at the International Institute for Population Sciences, Mumbai, India.

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