Understanding Morbidity Gap in India: Role of Lifestyle and Socioeconomic Factors using LASI (2017-18) data

1 Introduction

Multimorbidity has emerged as a crucial public health challenge globally, particularly among ageing populations. Multimorbidity, also known as multiple long-term conditions (MLTC), is defined as the simultaneous existence of two or more chronic diseases. Examining multimorbidity in a population goes beyond the numbers as the socioeconomic, demographic, and lifestyle factors do differentiate the gradient of diseases and their consequent burden (Arokiasamy et al., 2015; Talukdar et al., 2017). Further, a shift in the pattern of degenerative or chronic diseases in adult ages has persuaded the gradient of multimorbidity prevalence. First of all, it leads to a high prevalence of a single disease or currently one condition at adult ages, and secondly, thereafter, it is more likely to increase the multimorbidity prevalence. The prevalence of a single disease in a population, maybe a dominant disease, is critical for understanding the course of multimorbidity while intersecting with socioeconomic and demographic differentials (Khan et al., 2022).

Multimorbidity underscores the multifaced interplay of ailments, signalling a higher degree of complexity that shapes the disease prevalence in a population. In high-income countries (HICs), with a large proportion of the ageing population, multimorbidity is recognised as the crucial determinant for the senility conditions and consequent huge disease burden. On the other hand, low- and middle-income countries (LMICs), with comparatively lower percentages of ageing population, are experiencing a shift in the prevalence of many chronic diseases owing to the rising gradients of diseases and early onset of chronic diseases (Roman Lay et al., 2020). The large burden of multimorbidity in adult age groups has been a concern, considering the expansion of morbidity has been experienced in LMICs, whereas by and large compression of morbidity has been evident in HICs.

A systematic review revealed that adults in HICs had around 37.9% prevalence of multimorbidity, which was 5% higher compared to that at the global level. Compared to HICs, LMICs showed a lower prevalence of multimorbidity at 29.7% in adults (Nguyen et al., 2019). In one of the LMICs India, multimorbidity is recognised at a higher frequency of 50% in 45 years and above, using the Longitudinal Aging Study in India (LASI) (Sinha et al., 2021) (Kanungo et al., 2021). Given such a high frequency of multimorbidity in India, the differentials and determinants of multimorbidity in India have been quite at variance from that of HICs. India has been enduring a dual burden of diseases for decades, a unique experience also among LMICs. A variation in the burden of multimorbidity between HICs and LMICs countries in the levels and severity of multimorbidity have been related to their phases of epidemiological transition that explain the structural changes in the burden of diseases (Asogwa et al., 2022).

While numerous studies have examined the pattern, differentials, and determinants of multimorbidity, the study focuses on the mechanisms of change in the morbidity status or the morbidity gap, i.e. the difference in mean morbidity prevalence between two entities, via. examining the role of demographics, socioeconomic conditions, and lifestyle behaviours in the Indian population. The specific objectives of the study are (1) to examine the prevalence and pattern of no morbidity (zero diseases), single disease (currently have one disease/condition only) and multimorbidity (two and more diseases/conditions), (2) to examine the effect of socioeconomic, demographic, and lifestyle factors on multimorbidity, (3) to examine the contribution of socioeconomic, demographic, and lifestyle factors to the morbidity gap between men and women. The study aims to understand the mechanism of change in morbidity status from no morbidity to single morbidity and to multimorbidity in the Indian population ages 45 years and above using LASI Wave-1 (2017-18) data.

2 Data and Methods

2.1 Study Design and Sample

We retrieved the individual-level data from the Longitudinal Ageing Study in India (LASI) Wave 1 (2017-18). The LASI survey adopted a multistage stratified cluster sampling design for collecting the unit-level data, including three stages in rural areas and four stages in urban areas. The LASI survey provides information on the socioeconomic, demographic and lifestyle factors of 73,396 older adults aged 45 years and above, including their spouses, living in the states and union territories (UTs) of India. The individual response rate in LASI, Wave 1 (2017-18), was 87.3%. After excluding the missing values, we have considered 60,643 individuals with valid biomarker measurement data in the study.

2.2 Independent variable

We focused on ten chronic conditions based on self-reported diagnoses of individuals in the LASI survey (Table S1). We defined respondents as having an illness if they answered affirmatively the following two questions; for example, "HT002 – HT010. Has any health professional ever diagnosed you with the following chronic conditions or diseases?, Has any health professional ever told you that you have…HT002 … HT010 (Yes/No)?

We counted the number of health conditions for each respondent. We defined those with multimorbidity with the presence of two or more of the above-listed ten chronic conditions without a specific reference condition. These responses were combined into a trichotomous variable of morbidity status with categories as no morbidity (=0), single morbidity(=1), and more than one morbidity (=2 or 2+) to study the multimorbidity prevalence. The reference period of the LASI wave is of ~one year between April 2017 to February 2018.

2.3 Outcome Variable

The probability of chronic disease status of individuals categorised as no (zero) chronic Illness, single chronic illness, and multiple chronic illnesses (two or more conditions), a trichotomous variable, on the basis of multinomial logistic regression analysis was the outcome of the study. Each of these was a binary variable, with values 0 (zero) for females and 1 (one) for males.

The sex differential in chronic disease statuses was analysed by the application of Fairlie decomposition analysis to understand the contribution of covariates.

2.4 Control (dependent) variables

A range of explanatory variables were considered for this study. The socioeconomic variables included in models were religion (Hindu, Muslim, Christian, Others), caste (scheduled castes, scheduled tribes, other backward class (OBCs), others), education (illiterate, up to primary, secondary; higher), wealth index (poorest, poorer, middle, richer, richest), marital status (currently married, never married, and others).

The demographic variables included in the models were the individual age (45-49 years, 50-54 years, 55-59 years, 60-64 years, 65-69 years, 70-74 years, 75+ years), residence (rural, urban).

The lifestyle behaviour variables included in the models were the working status (never worked, ever worked), alcohol consumption (lifetime abstainer; infrequent non-heavy drinker, frequent drinker, heavy episodic drinker), tobacco consumption (lifetime abstainer, smokes tobacco, smokeless tobacco, both), physical activity (frequent, rare, never), living arrangements (living alone, living with a spouse, children or others), the activity of daily living (ADL) (severe ADL disability, moderate ADL disability, no ADL disability), instrumental activity of daily living (IADL) (severe ADL disability, moderate ADL disability, no ADL disability), body mass index (BMI) (underweight, normal weight, overweight, obese).

Region has been an important factor of variation in multimorbidity prevalence in India. The states and UTs of India were clubed into six categories based on the report of the LASI Wave-1 (2017-18) (Table S2).

2.5 Statistical analysis

We applied bivariate analysis to investigate the association between chronic morbidity status and socioeconomic and demographic variables. The Chi-square test was applied to examine the significance of the associations between morbidity status and socioeconomic, demographic and lifestyle variables.

Multinomial logistic regressions were applied to the trichotomous variable of morbidity status to examine the risk factors for multimorbidity in the Indian population 45 years and above. The Multinomial logistic regression model is expressed as

$$P(Y=j)=\frac{\exp(\alpha_j+\beta_{j1}X_1+\beta_{j2}X_2+\dots\dots\dots+\beta_{jk}X_{k)}}{1+\sum_{m=1}^{2}\ \exp(\alpha_m+\beta_{m1}X_1+\beta_{m2}X_2+\dots\dots\dots+\beta_{mk}X_{k)}} \qquad (1)$$

where, $P(Y=j)$ is the probability of the outcome being in category j, α_j is the intercept for category j, β_{j1}, β_{j2}, …….. β_{jk} are the coefficients for the independent variables X_1, X_2,……… X_k for category j, *m* ranges over all non-reference categories (1 and 2 in this case).

Three different sets of models were carried out to examine the effects of sex and other socioeconomic and demographic factors on the outcome variable. Model 1 demonstrated the effect of sex on the morbidity status. Model 2 included age, place of residence, caste, religion, marital status, education, wealth status, along with sex. Model 3 included working status, alcohol consumption, tobacco consumption, living arrangements, physical activity, Body Mass Index (BMI), Activities of Daily Living (ADL), Instrumental Activities of Daily Living (IADL), and regions, along with the variables in the Model 2. The results of these models were reported as adjusted relative risk ratios (RRR) with 95% CI. The analysis helped to understand the changes in explained variance and effects of sex, then age and socioeconomic factors and then lifestyle factors on morbidity status, which explains their role in the change in morbidity status from no morbidity to single morbidity and to multimorbidity.

2.6 Decomposition analysis

We applied the Fairlie decomposition (2006) to examine the contribution of socioeconomic, demographic, and lifestyle factors to the morbidity gap for single morbidity and multimorbidity prevalence between men and women. We define morbidity gap as the intergroup differences in the mean of morbidity status between men and women. Fairlie decomposition was applied to the morbidity gaps between men and women for a change in their morbidity status from no morbidity to (1) one morbidity (single morbidity), (2) one or more morbidities, and (3) to two or more morbidities (multimorbidity), respectively. We have considered the change in morbidity status from no morbidity to one or more morbidity, allowing us to check the sensitivity of the LASI data to the applied decomposition technique, in addition to single morbidity and multimorbidity prevalence. These three respective morbidity gaps were examined for analytical outcomes. For details on Fairlie decomposition, please see Appendix A1.

All analyses of this study were carried out using STATA 17.0 (Stata Corp, LP, college station, Texas) with consideration given to appropriate sampling weights.

3 Results

3.1 Sample distribution, descriptive statistics and the association between multimorbidity and demographic, socioeconomic, and lifestyle factors

Table 1 shows the sample characteristics of no chronic disease, single chrnic disease and multiple chronic diseases by demographic, socioeconomic, and lifestyle characteristics. Women showed a higher prevalence of single morbidity and multimorbidity compared to their male counterparts. They showed a prevalence of 29.05% and 20.04% in single morbidity and multimorbidity, respectively, compared to that of 25.88% and 17.24% in men. Multimorbidity showed a sharp gradient from a prevalence of 9% in 45-49 years to 25.8% in 70-74 years whereas no morbidity prevalence showed a decline from 66.8% to 43.2% and the single morbidity prevalence has remained in a narrow range of ~23.7-31.8%, with some variations over age.

People living in urban areas endured a higher multimorbidity prevalence of 27.44% compared to 15.02% in rural areas, approximately two-fold multimorbidity prevalence in urban areas than in rural areas. The multimorbidity prevalence was 25.08% and 29.29% in urban men and urban women and 14.06% and 15.87% in rural men and rural women, respectively, (Supplementary Table A1). Women do have higher prevalence compared to men; regardless, urbanicity seems a strong contextual factor for multimorbidity prevalence. Multimorbity prevalence in rural men align closely with that of rural women. By socioeconomic variables, single morbidity was greater in persons with higher education (31.66%) compared to that with primary education (28.16%), no education (27.25%), and secondary education (25.86%). In comparison with single morbidity, multimorbidity was higher in persons with secondary education (25.73%) than in those with higher education (23.19%), primary education (20.72%), and no education (15.42%). Likewise, those people who belong to the higher wealth index showed higher single morbidity and multimorbidity prevalence compared to the poorest. The richest quintile showed single morbidity and multimorbidity prevalence of 28.1 and 27.95%, respectively.

Multimorbidity prevalence was higher in the upper caste than in the SCs/STs/OBCs. This higher prevalence of multimorbidity prevalence in the upper caste could be on account of their higher education and longevity in comparison to the OBCs/SCs/STs. The prevalence of single morbidity was similar across social groups. By marital status, divorced and separated showed a multimorbidity prevalence of 22.7% in comparison to 8.01% in never married and 17.06% in currently married. Never-married persons showed a small percentage of multimorbidity as their marital status changed with age, as in 45 years and above, the proportion of married was 75%, much larger than 1.2% in never-married. Contrast to that, the single morbidity prevalence was similar across the marital status. By regions, southern and western regions showed a higher prevalence of single morbidity as well as multimorbidity prevalence compared to other regions. Specifically, the prevalence of single and multimorbidity prevalence, respectively, was as high as 30.89% in northern regions and 25.75% in southern regions.

By working status, persons who never worked showed single morbidity and multimorbidity prevalence at 28.89% and 24.33%, whereas persons who ever worked showed those prevalence at 27.14% and 16.79%, respectively. The multimorbidity prevalence was one-and-a-half times higher in never-worked than in ever-worked persons. Multimorbidity showed a larger gap by working status compared to single disease prevalence. Likewise, those people who never did physical exercise showed a higher prevalence of single morbidity (28.94%) as well as multimorbidity (23.01%) compared to those who did some physical activity. The higher prevalence of single morbidity could be attributed to the early onset of degenerative diseases in the Indian population. These prevalence suggest that frequent or some physical activity or working status that involves physical activity maintains a low prevalence of multimorbidity.

Multimorbidity prevalence was higher in persons with high BMI; it was 39.17% and 26.84% in persons with obesity and overweight compared to 16.29% and 9.77% in normal weight and underweight, respectively. The highest prevalence of multimorbidity was 41.88% in persons with severe ADL disability. Persons with moderate ADL disability showed a prevalence of 30.08% and a similar prevalence was shown in persons with severe IADL disability. Compared to persons with severe and moderate ADL as well as IADL, persons without ADL or IADL showed a smaller multimorbidity prevalence of ~15%.

Contrarily, results shows that men and women who consume alcohol or tabacco show higher single morbidity prevalence compared to multimorbidity prevalence. The differentials were stronger who do not consume alcohol and tobacco than in those who consume. Men consume alcohol and tobacco 34% and 56%, respectively, compared to 4% and 20% in women. Multimorbidity prevalence in frequent drinkers and heavy episodic drinkers was 10.7% and 15.01% among men whereas it was 3.3% and 4.7%, respectively, among women, however, sample for women was small. Compared to drinkers, men and women who are smokers show higher single morbidity and multimorbidity prevalence; but, by gender, the prevalence was higher in women than in men, oppsitie to that among drinkers. Lifetime abstainers of tobacco consumption showed a multimorbidity prevalence of 20.9% for multimorbidity prevalence whereas smokers (both) showed a prevalence of 14.5%. Single morbidity prevalence among tobacco consumption was 28.4% in lifetime abstainers versus 26.51 in smokers (both).

3.2 Dominance of diseases in single morbidity versus multimorbidity: a regional variation

Figures 1 and 2 show the prevalence of single (one) morbidity, and Figures 3 and 4 show the prevalence of multimorbidity (two or more morbidities) by gender in persons aged 45 years and above in the states and union territories of India. The prevalence of single morbidity in women and men living in India was 29.05% and 25.88%, respectively. Single morbidity in women was the highest in the states of Haryana (39.21%), followed by Sikkim (38.27%), and the lowest in Nagaland (13.39%), followed by Arunachal Pradesh (18.76%) (Figure 1). On the other hand, the prevalence of single morbidity in men was the highest in Sikkim (34.86%) followed by Goa (32.72%) and was the lowest in Nagaland (13.51%) followed by Meghalaya (15.28%) (Figure 2).

Multimorbidity in women was the highest in Kerala (43.23%), followed by Jammu & Kashmir (35.35%), and was the lowest in Nagaland (7.22%), followed by Chhatisgarh (7.32%) (Figure 3). In comparison to women, men showed multimorbidity prevalence at 17.24%. The prevalence of multimorbidity in men was the highest in Kerala (38.34%), followed by Daman and Diu (29.39%), and was the lowest in Meghalaya (3.26%), followed by Nagaland (6.49%) (Figure 4).

Table 2 shows the proportion of men and women enduring single chronic disease in India and its states. Amongst ten chronic diseases, hypertension showed its highest prevalence at 27.16% followed by bone disease (16.4%), diabetes (11.98%), chronic lung disease (6.64%), neurological (2.33%), cholesterol (2.32%), stroke (1.83%), and cancer (0.63%). Therefore, the analysis revealed that hypertension was the most frequent disease in the Indian population. Interestingly, bone disease followed by hypertension showed higher frequency compared to diabetes, most studied in the Indian context. Also, hypertension was as common as 33.7% in combination with other nine diseases (Table 3).

Hypertension was the highest in Sikkim (44.34%) and Goa (44.33%) and was the lowest in Nagaland (15.92%). Bone disease was the highest in West Bengal (28.26%) and was the lowest in Nagaland (2.26%). Diabetes being on third rank at the national level was the highest in Kerela (30.28%) and was the lowest in Meghalaya (3.57%) (Table 3). The regional variation in single morbidity and multimorbidity prevalence reveals that the demographically developed states, compared to developing states of India, have a higher prevalence of single morbidity and multimorbidity.

3.3 Understanding the mechanism of multiple chronic diseases in India

3.3.1 Analysing effect of covariates on multimorbidity: A multinomial regression approach

Table 4 shows the effect of contextual factors on the trichotomous chronic illnes status based on the application of multinomial logistic regression analysis. We performed model 1 for sex, model 2 for socioeconomic and demographic factors including sex, and model 3 for lifestyle factors and regions including sex, socioeconomic, demographic (full model) on the trichotomous chronic disease status. Model 1 reveals that women had higher relative risk ratio (RRR) in reference to their men counterparts. The relative risk ratio (RRR) of single morbidity was 0.25 times higher in women [RRR: 1.25, CI: 1.17,1.35] than that in men, and that of multimorbidity was 0.30 times higher in women than in men. After socio-economic and demographic variables were considered in model 2, the RRR of single morbidity was 0.32 times higher in women than in men, and that of multimorbidity was 0.30 times higher in women than in men, lower than that in model 1. However, considering lifestyle factors and region, in model 3, the RRR of single morbidity is 0.18 times more in women than in men and that of multimorbidity was insignificant; nonetheless, socioeconomic, demographic, and lifestyle factors were significant. It confirms that other factors in comparison to gender strongly explain the variation of the morbidity status in the studied population.

The final model 3 revealed that age with a rising gradient showed the highest RRR value at 4.36 [3.58,5.31] for multimorbidity and 2.16 [1.83,2.54] for single morbidity in 70-74 years. The age gradient was higher for multimorbidity compared to that of single morbidity. Urban residents with reference to rural residents showed a higher RRR value of 1.64 [1.44,1.87] for multimorbidity and 1.23 [1.12,1.35] for single morbidity prevalence. Those with higher education showed an RRR value of 1.35 [1.01,1.79] for single morbidity, and those with secondary education showed an RRR value of 1.66 [1.32,2.07] for multimorbidity prevalence. Single morbidity showed a stronger gradient with levels of education catching up with that of multimorbidity. Similar to education, the wealth index also showed strong differentials. The richest showed RRR values of 1.28 [1.11,1.47] and 2.54 [2.09,3.08] for single morbidity and multimorbidity, respectively, which was higher than that of the poorest and middle wealth quintiles.

Amongst social groups, STs with reference to OBCs showed a lower RRR value of 0.69 [0.61,0.79] for single morbidity and 0.58 [0.47,0.70] for multimorbidity. The low RRR value among STs, who are economically weak and stand at the bottom of the social hierarchy in Indian society, could be because of low education and low financial capacity, and thus less access to healthcare facilities. By marital status, never married compared to currently married persons showed 0.59 times lower prevalence of multimorbidity. Amongst religious groups, Muslims, compared to Hindus, showed higher RRR values of 1.19 [1.05,1.35] for single morbidity and 1.37 [1.19,1.57] for multimorbidity prevalence. By work status, those who ever worked compared to never worked showed a lower RRR value at 0.86 [0.76,0.98] for multimorbidity prevalence. Amongst demographic and socioeconomic factors, the gradient of age attests to the strongest risk for multimorbidity. The regional variation in multimorbidity was noticeable. While multimorbidity prevalence was smaller in many regions, except southern regions, single morbidity prevalence was higher in many regions, except central regions, in comparison to eastern regions.

Amongst the lifestyle factors, the RRR value for multimorbidity prevalence was at 3.36 [2.75, 4.11], i.e. 2.36 times higher for obese than for normal weight persons. Obesity showed a high value of RRR for multimorbidity prevalence preceded by that of age in our model. Overweight persons compared to normal weighted persons show 0.98 times higher multimorbidity prevalence; however, underweight persons showed 0.48 times lower multimorbidity prevalence. A similar differential of BMI categories was evident for single morbidity prevalence with the higher RRR value of 1.98 times in obese persons than in normal weight persons. These RRR values of the model confirm that obesity showed a strong effect for multimorbidity in comparison to single morbidity prevalence. Activities of daily living (ADL) and instrumental activities of daily living (IADL) disabilities were positively associated with single morbidity and multimorbidity prevalence. After controlling other variables, severe ADL disability showed the RRR value of 3.81 [2.58,5.64] and 1.79 [1.13,2.84] for multimorbidity and single morbidity prevalence, respectively. The effects of severe ADL disability align closely to those of obesity. IADL showed a smaller RRR value of 1.54 [1.16,2.04] in comparison to that of severe ADL disability.

Contrary to IADL/ADL activities and high BMI, physical activity showed a positive effect on lowering single morbidity and multimorbidity prevalence. Multimorbidity prevalence was 0.36 times lower in physically active persons and 0.26 times lower in moderately active persons than in physically inactive persons. As an exception, alcohol consumption was associated with a lower prevalence of single morbidity and multimorbidity prevalence. Heavy episodic drinkers and frequent drinkers, respectively, showed 0.34 and 0.27 lower multimorbidity prevalence compared to lifetime abstainers. A similar differentiation was also noticed for single morbidity prevalence. Smokeless tobacco consumption in reference to lifetime abstainer showed 0.16 times lower multimorbidity prevalence.

3.3.2 Contribution of covariates to morbidity gap: A decomposition analysis approach

Table 5 elucidates the application of Fairlie decomposition to the morbidity gap, i.e. the mean difference in the disease prevalence between men and women. The results of the decomposition analyses revealed that the contextual factors showed endowment effects of 75%, 87%, and 103% to the morbidity gaps between men and women for a change in their morbidity status from no morbidity to (1) one morbidity, (2) one and more morbidities, and (3) to two and more morbidities (multimorbidity), respectively.

The morbidity gap between men and women widened with the differences in their age gradient. Amongst age groups, the largest contributions of 75 years and above were -18.9%, -17.7% and -16.4%, respectively, to the respective three morbidity gaps, and were approximately similar. It implies that age explained the gender disparity in multimorbidity prevalence to a large extent. Educational status played a crucial role in the widening of the three respective morbidity gaps. Reducing the differences in secondary education and primary education between men and women would lead to a widening of -24.4% and -13.05%, respectively, to the morbidity gap, whereas higher education showed a small contribution of -9.73% to the morbidity gap for multimorbidity prevalence. The findings show that differences in primary, secondary, and tertiary education largely explained the wide gender disparity in the morbidity status. It implies that a similar distribution of levels of education between men and women would lead to higher multimorbidity prevalence in women.

Working status has shown the largest contribution to the narrowing of the three respective morbidity gaps, though results of the regression model showed its role in lowering multimorbidity, however, smaller than that of age, obesity, severe ADL disability, and wealth. The contribution of ever worked was 77.13% to the morbidity gap for multimorbidity prevalence; also, ever worked explained a large contribution of 57.6% to the morbidity gap for single morbidity prevalence. The working status by gender matters the most while explaining the higher prevalence of multimorbidity in women than in men or shows the strongest possibility for reducing multimorbidity prevalence in women. Also, wide differences in the distributions of separated and divorced persons by gender also explained large contributions of 43.78%, 39.38%, and 35.5% to the three respective morbidity gaps.

The wealth index showed varying contributions to the morbidity gaps from the poorest to the richest quintiles. With reference to the poorest quintile, the poorer and middle quintiles showed contributions of -1.15% and -0.12%, whereas the richer and richest quintiles had contributions of 2.25% and 4.36% to the morbidity gap for multimorbidity prevalence. It is noteworthy that a similar distribution of lower quintiles in men and women contributed to the widening of the gender disparity in disease. On the other hand, removing differences between the higher wealth quintiles between men and women would lead to the narrowing of the morbidity gaps. It confirms that the wealth distribution of the rich versus the poor has behaved differently for the shifts in disease patterns by gender. While the similarities among the rich proved to be managing the multimorbidity prevalence especially among women, the poor remained vulnerable to multimorbidity prevalence because of their financial limitations and accessibility and availability of health care & services, especially for men. Other socioeconomic factors such as urbanicity, religion, social groups, wealth index, and regions showed their contribution of less than 10% to the morbidity gaps. By social groups, STs showed a contribution of, on average, 9% to the respective three morbidity gaps.

Compared to socioeconomic factors, lifestyle factors do explain the morbidity gaps between men and women. Obesity (high BMI) showed respectively contributions of 8.08%, 10.19%, and 11.95% to the three respective morbidity gaps between men and women. Women have higher BMI compared to men, and so mirroring the distribution of obesity in women to that of men confirmed a narrowing of the gender disparity in multimorbidity prevalence. Also, reducing differences in overweight by gender would contribute 7.47% to the narrowing of the morbidity gap for multimorbidity prevalence. Obesity proved to be one of the denting factors for high multimorbidity prevalence in women. Contrarily, underweight contributed on average -3.7% to the widening of the morbidity gaps as men are more underweight compared to women. It highlights that underweight status would make men more vulnerable to disease.

Physical activity and IADL showed sizeable positive contributions to the morbidity gaps. The result confirms that a similar level of physical activity in women to that in men would lead to the narrowing of the gender disparity in the multimorbidity prevalence by 13.47%. Specifically, frequent physical activity showed large contributions of 8.42%, 10.04%, and 11.27%, respectively, to the three respective morbidity gaps. Similar contributions to morbidity gaps by obesity and physical activities go together with the challenges of narrowing the morbidity gaps, especially gender disparity in multimorbidity prevalence. Moderate IADL disability contributed ~18% to the morbidity gaps, though multinomial logistic regression results showed a moderate effect on multimorbidity prevalence. It is one of the largest contributions among the contextual factors considered in the study, suggesting a narrowing of the gender disparity in the disease pattern. In comparison to IADL disabilities, ADL disabilities showed small contributions to the widening of the morbidity gaps.

Smokeless tobacco showed an average contribution of ~10% to the three morbidity gaps. Whereas, smokers showed a contribution of 4.01% and 8.22% to the morbidity gaps for one and more morbidities and two and more morbidities (multimorbidity), respectively, whereas a contribution of -1.09% to the morbidity gap for single morbidity. Women majorly consume smokeless tobacco (15%) compared to men consuming often smokes tobacco (28%) and smokeless tobacco (22%). While smokeless tobacco and smoked tobacco showed contributions towards narrowing the gender disparity in multimorbidity, consuming both smokeless and smoked tobacco showed contributions of -8.05%, -5.08%, and -2.58% to widening the respective three morbidity gaps. Occupation hazards may be the confounding factors to such results.

Discussion

The study illustrated the contextual factors explaining the prevalence of single as well as multimorbidity (multiple long-term conditions) in older adults in India and their contributions to the morbidity gaps explaining sex differences in single/multimorbidity prevalence.

As expected, age turns out to be the largest risk factor for chronic conditions, with the age gradient being more prominent (Table 4: Model 3 versus Model 2, and Model 6 versus Model 5) and sex was not a significant factor (Model 6) when controlled for behavioural risk factors like alcohol/tobacco use, physical activity, IADL, ADL, and BMI in the multinomial logistic regression model. This indirectly shows that it is the behavioural factors that are contributing to the observed early onset of chronic conditions in the middle ages in the population. Amongst the other contextual factors, obesity, a proxy for lifestyle modification, and severe ADL disability showed greater gradients for multimorbidity prevalence than for single morbidity prevalence (Table 4: Model 3 versus Model 6). The gradient of single/multimorbidity prevalence by wealth quintiles has been forbidding; there were narrow differences in the relative risk ratios for single/multimorbidity prevalence between the rich and the poor, in comparison to the gradients of age, obesity, and IADL/ADL disability, despite that wealth differential determine higher multimorbidity prevalence for the rich than in the poor. Nonetheless, if the behavioural characteristics are controlled, the relative disadvantage in the relative risk of single/multiple chronic diseases experienced by richer sections, rural residents, and literates when compared to their respective counterparts narrows down.

The unexpected, less adverse risk of alcohol/tobacco consumption on single/multiple chronic diseases could be subdued on account of unscreened and undiagnosed cases of hypertension and diabetes. In particular for hypertension, the proportion of undiagnosed hypertension among nonsmokers was as high as 22%; these undiagnosed cases have worked as confounding factors plummeting the risk ratio lower than expected. For diabetes, biomarker data in the LASI survey is yet awaited. Alcohol/tobacco have been the strong risk factors for hypertension and diabetes; however, people from lower economic strata visit doctors and hospitals and allow for medical diagnoses mostly when the symptoms are very apparent. The reporting of alcohol/tobacco consumption in the LASI survey is 30.4%, close to that reported in GATS (2016-17). Notwithstanding, those with chronic diseases are currently abstaining from alcohol/tobacco due to medical advice or adverse effects in the past can be underreported. Almost 10% of respondents who ever smoked have quit smoking in the past, with a mean age of 48 years. Possibly, occupational and environmental hazards are also the confounding factors of alcohol/tobacco consumption that partly explain the less severe risk of alcohol/tobacco on single/multimorbidity prevalence, although together they would affect the body organs in the long-term. Similarly, physical activity might have been initiated only after the onset of chronic illness and due to fragility-induced inability to perform physical activities in old age which might explain its comparable relative risk ratios with other contextual factors.

The results of the decomposition analyses (Table 5) revealed the distributional differences of covariates such as education, wealth, marital status, and working status accounted for the shift or progression in the morbidity status from no morbidity to single (Table 5: Model 7) and to multimorbidity prevalence (Table 5: Model 9) and explained the role of contextual factors more prominently as compared to their relative risk ratios. Amongst contextual factors, working status, education, marital status, and age showed large endowment effects and small coefficient effects that varied across the morbidity gaps for single and multimorbidity prevalence, while some of them have shown narrowing versus widening effects on multimorbidity.

A high multimorbidity prevalence in women is largely explained on account of their non-working status (77.13%) and separated and divorced marital status (35.05%) to the narrowing of morbidity gaps for multimorbidity prevalence. 35% of women are divorced and separated in comparison to 10% of men, which highlights higher adult mortality in men than in women and 5-7 years of more longevity in women than in men.

Women's work participation has been less compared to men; women who ever-worked was 52% compared to 95% in men. 35.2% of Indian women in their older adult ages were working across various industries (Table 6) and occupations (Table 7). By occupation, women compared to men working in hard and laborious jobs are lesser; mostly, they were employed in elementary occupations and skilled agricultural and fishery works, and least were working in plant and machine operators and assemblers. By industry, women are employed in Agriculture, forestry and fishing (41%), Accommodation and food storage activities (48.4%), Education (41.2%), Human health and social work activities (47.3%), Art, entertainment, and recreation (40.4%), Activities of households as employers (49.2%) etc.

The Time Use Surveys (2019) revealed the activities in the ambit of the system of national accounts (SNA) are performed approximately three-fold by men than by women, of course, which are labour intensive and burn large amounts of calories (CSO, 2020, pp. 110-112, Table 5.15, 5.16, 5.17). Time spent in SNA activities was two-fold in illiterate men than in illiterate women and three-fold in graduate and above men than in women counterparts. By marital status, SNA activities were two-fold in never-married/currently married men than in their women counterparts, which were almost similar in divorced/separated/widowed statuses. The gender ratio (men by women) of SNA activities in casual workers, salaried workers, and household enterprises as own-account workers is almost three, six, and nine-fold, respectively. It explains that working activities in equivalence to physical activity matter the most for lowering multimorbidity prevalence, as explained by the application of Fairlie decomposition to the LASI survey data.

Distributional differences in education by gender have been wider in India. The secondary education showed widening contributions of -3.41% and -24.44%, respectively, to the morbidity gaps for single and multimorbidity prevalence, had differences in secondary education were reduced between men and women. On the other hand, reducing differences in higher education between men and women would show narrowing contributions of -16.26% and -9.78%, respectively, to the morbidity gaps for single and multimorbidity prevalence. With the ongoing improvements in educational level and increasing women's work participation, lifestyle behaviours related risks are bound to increase among Indian women. Hence, in the absence of interventions, the existing sex difference in the prevalence of single/multiple chronic diseases is likely to get aggravated in the near future. A similar distribution of education between men and women with the adoption of lifestyle behaviours could contribute to the widening of the morbidity gaps by increasing the multimorbidity prevalence in women. Also, with the shift towards higher educational and occupational status, a rise in sedentary activities further augments to multimorbidity prevalence. While the risk increases with the severity of ADL, the distributional differences of moderate IADL disability contributed ~17.5% to multimorbidity prevalence.

Therefore, large differences in their distribution of work status and marital status were responsible for the narrowing of the morbidity gaps, whereas men and women show large differences in the distribution of their older age and level of education, which explained the widening of morbidity gaps. As a major concern, these factors explained a shift or progression in the morbidity status and sex differences in single/multimorbidity prevalence.

Socioeconomic factors showed both narrowing as well as widening contributions to the morbidity gap and attested strong sex differences in single as well as multimorbidity prevalence. In comparison, lifestyle factors mainly contributed to the narrowing of the morbidity gaps between men and women on account of their distributional differences.

Amongst lifestyle factors, obesity showed a larger contribution of 12% for multimorbidity prevalence than 10% for single morbidity prevalence. Physical activity showed a larger contribution of 13.5% to lowering multimorbidity than a contribution of 10.4% to lowering single morbidity prevalence. Alcohol consumption, smokeless tobacco consumption, and severe IADL disability together explain ~35% of the gender difference for single as well as multimorbidity prevalence. Lowering obesity and doing physical activity exhibited a stronger role in curbing a shift from no morbidity to single/multimorbidity status and is an alternative approach, especially for women who are not working. Not only do these lifestyle factors explain the gender differences, but they also explain the possibility of lowering multimorbidity as demographic and socioeconomic factors are, in general, inexpugnable.

The study documents that demographic and socioeconomic factors such as age, education, marital status, and working status have shown stronger contributions to gender differences in single/multimorbidity prevalence, whereas lifestyle factors mainly explain their role in curbing the shift from no morbidity to single/multimorbidity status. The results show that managing distributional differences in lifestyle factors could be effective in lowering the multimorbidity prevalence. However, in the backdrop, the large contribution of the distributional differences in socioeconomic factors to the morbidity gap for single/multimorbidity prevalence strongly highlights the disparity in the Indian population. Among socioeconomic covariates, working status showed the widest distributional difference by gender. The differential of covariates could be of importance; nevertheless, many contextual factors explained a risk for multimorbidity in a narrow range, which was slightly higher than for single prevalence. As collateral to this, the Fairlie decomposition reveals that large distributional differences by gender in working status, marital status, education, obesity, and physical activity were distinct compared to those of other covariates including many lifestyle covariates.

Indian population shows a large prevalence of hypertension, as high as ~27%, with early onset as the most frequent single disease, and also the most frequent with bone diseases and diabetes (33.8%). The high prevalence of these diseases could be possibly attributed to early onset, obesity, low physical activity, low nutrient diets, and tobacco/alcohol consumption in their adult ages. Hypertension, bone diseases, and diabetes are more contemporary with lifestyle factors rather than background factors. The dominance of degenerative diseases such as hypertension, bone diseases, and diabetes is much more prevalent among women than in men since adult ages. Higher longevity and lower mortality rates in women than in men, so ageing increases their likelihood of developing multiple chronic conditions. Also, the old population often face financial crises and disparities in access to health care, commuting, etc., which leads to fewer opportunities for medical treatments unless supported by family members or national or state-sponsored health programs. Hence, in the absence of consistent preventive interventions, the existing sex difference in the prevalence of single/multimorbidity is likely to widen. It is noteworthy that there is no disadvantage to women for multimorbidity prevalence if they do regular physical activity and maintain food diet and their BMI, i.e. when lifestyle factors are concerned, it is quite feasible. The programs for controlling smoking behaviour are concurrent; however, the occupational and environmental hazards as one of the confounding factors are of greater concern for compounding multimorbidity prevalence.

Conclusion

The paper examined the morbidity gap between men and women by examining the role of contextual factors for single and multimorbidity prevalence in India. The study demonstrates lifestyle factors are crucial for curbing the shift from a healthy state to single/multimorbidity prevalence. However, the distributional difference in working status, education, and marital status are the reinforcing contributors to the disparity in multimorbidity prevalence by gender. Hypertension is the most frequent single disease and also most frequent with bone diseases and diabetes. It testifies to the dominance of degenerative diseases, and hence, the results expect 65% of the morbidity gap to be managed by adopting a better lifestyle. In order to further lower the multimorbidity prevalence in the Indian population, the disparity in work status and marital status by gender provides a scope in the ambit of reducing disparity in education and employment. However, particularly with a rise in the level of education in women, it is likely to see an increase in the adoption of (sedentary) lifestyle behaviours that could contribute to the widening of the morbidity gaps by increasing the multimorbidity prevalence in women.

References

Appendix

Table A1: Sample characteristics of zero (no) morbidity, single (one) morbidity, and multimorbidity (two or more morbidities) by demographic, socioeconomic, and lifestyle variables in India, LASI 2017-18

Variables	Zero		Single		Multimorbidity		P Value
	Sample Size (N)	Prevalence (%)	Sample Size (N)	Prevalence (%)	Sample Size (N)	Prevalence (%)	
Demographic Variables							
Sex							
Male	15,986	56.88	7,259	25.88	4,890	17.24	0.000
Female	16,388	50.89	9,483	29.05	6,637	20.05	
Age							
45-49	8,156	66.8	2,886	23.74	1,233	9.46	0.000
50-54	5,934	59.73	2,718	26.93	1,474	13.34	
55-59	5,015	53.1	2,595	27.89	1,697	19.01	
60-64	4,770	51.79	2,619	27.01	2,048	21.20	
65-69	3,664	46.54	2,461	28.77	2,064	24.70	
70-74	2,248	44.02	1,592	30.15	1,430	25.83	
75+	2,587	43.22	1,871	31.88	1,581	24.90	
Place of Residence							
Rural	23,343	58.38	10,474	26.59	5,993	15.02	0.000
Urban	9,031	42.64	6,268	29.93	5,534	27.44	
Socioeconomic variables							
Caste							
SCs	5,612	56.55	2,838	28	1,643	15.45	0.000

STs	7,351	71.5	2,343	20.16	1,179	8.34	
OBCs	11,808	52.51	6,583	27.73	4,605	19.76	
Others	7,603	47.63	4,978	29.5	4,100	22.87	
Religion							
Hindu	23,950	54.62	12,282	27.36	8,069	18.02	0.000
Muslim	3,169	47.66	2,088	29.93	1,848	22.41	
Christian	3,788	56.68	1,388	22.68	943	20.64	
Others	1,467	46.85	984	30.03	667	23.13	
Marital status							
Never Married	452	67.85	190	24.13	89	8.01	0.000
Currently Married	25,222	55.47	12,215	26.94	8,225	17.59	
Others	6,699	47.5	4337	29.74	3,212	22.77	
Education							
Illiterate	16,379	57.34	7,724	27.25	4,487	15.42	0.000
Primary	10,803	51.13	5,809	28.16	4,302	20.72	
Secondary	3,753	48.42	2,220	25.86	1,925	25.73	
Higher	1,439	45.15	989	31.66	813	23.19	
Wealth quintile							
Poorest	7,555	61.65	2,905	25.87	1,568	12.49	0.000
Poorer	6,989	56.37	3,308	27.83	1,934	15.8	
Middle	6,550	54.59	3,445	27.69	2,249	17.73	
Richer	5,989	49.74	3,578	28.68	2,647	21.58	
Richest	5,291	43.97	3,506	28.09	3,129	27.95	
Other Variables							
Working status							
Never Worked	7,797	46.77	5,015	28.89	4,064	24.33	0.000
Ever Worked	24557	56.07	11715	27.14	7460	16.79	
Alcohol consumption							
Lifetime Abstainers	25,810	52.39	14,068	28.19	9,813	19.42	0.000
Infrequent Non-Heavy Drinkers	4,742	58.47	2,040	25.61	1,356	15.91	
Frequent Drinkers	863	70.75	257	19.43	133	9.82	
Heavy Episodic Drinkers	807	66.88	296	19.11	172	14.01	
Tobacco consumption							
Lifetime Abstainers	19,351	50.66	10,940	28.43	8,065	20.91	0.000
Smokes Tobacco	5,132	56.82	2,451	27.09	1,472	16.09	
Smokeless Tobacco	6,622	59.79	2,822	25.56	1,673	14.65	
Both	1,231	58.94	504	26.51	295	14.54	
BMI							

Underweight	7,299	65.88	2,686	24.35	1,017	9.77	0.000
Normal weight	18,016	57.03	8,346	26.68	4,981	16.29	
Overweight	5,393	41.44	4,089	31.72	3,651	26.84	
Obesity	1,391	29.04	1,393	31.79	1,655	39.17	
Living arrangements							
Living Alone	1,082	46.44	632	32.36	427	21.21	0.026
Living With A Spouse Children or Others	31,292	53.92	16,110	27.41	11,100	18.67	
Physical activity							
Frequent	9,132	61.84	3,545	25.81	1,827	12.35	0.000
Rare	5,797	61.1	2,481	25.53	1,259	13.38	
Never	17,445	48.05	10,716	28.94	8,441	23.01	
ADL							
No ADL Disability	29,371	56.66	14,097	26.94	8,657	16.4	0.000
Moderate ADL Disability	2,763	38.68	2,417	31.24	2,551	30.08	
Severe ADL Disability	240	29.12	228	29	319	41.88	
IADL							
No IADL Disability	23,598	58.73	10,781	26.27	6,415	14.99	0.000
Moderate IADL Disability	8,231	45.44	5,542	30.01	4,623	24.55	
Severe IADL Disability	545	39.18	419	28.07	489	32.74	
Regions							
North	5,280	49.23	3,396	30.89	2,316	19.88	0.000
Central	5,483	66.67	1,852	22.62	855	10.71	
East	6,079	55.31	2,816	26.58	1,852	18.12	
North East	5,665	61.55	2,155	27.8	858	10.65	
West	3,885	49.19	2,269	29.81	1,702	21	
South	5,982	44.46	4,254	29.8	3,944	25.75	
Total	32,374	53.64	16,742	27.6	11,527	18.76	

Table A2: State-wise pattern of single and multimorbidity prevalence among aged 45 years and above population by sex in India, LASI, 2017-18

State	Single Morbidity (%)			Multimorbidity (%)		
	Female	Male	Both	Female	Male	Both
Jammu and Kashmir	31.61	29.01	30.42	35.35	22.18	29.36
Himachal Pradesh	32.22	25.13	29.06	19.66	19.05	19.39
Punjab	31.25	30.62	30.96	35.2	24.33	30.2

Chandigarh	35.81	22.96	29.65	31.73	27.99	29.94
Uttarakhand	31.81	30.18	31.1	15.28	15.29	15.28
Haryana	39.21	32.68	36.43	16.73	13.67	15.42
Delhi	30.77	28.43	29.59	22.2	21.51	21.85
Rajasthan	28.92	29.47	29.16	15.86	15.16	15.55
Uttar Pradesh	24.04	22.93	23.5	11.34	10.67	11.01
Bihar	27.67	24.26	26.07	15.9	13.21	14.64
Sikkim	38.27	34.86	36.44	17.36	17.66	17.52
Arunachal Pradesh	18.76	20.5	19.68	8.45	13.26	11
Nagaland	13.39	13.51	13.45	7.22	6.49	6.87
Manipur	27.27	25.68	26.53	12.57	14.38	13.4
Mizoram	25.17	23.63	24.41	11.11	12.38	11.73
Tripura	31.8	28.9	30.47	15.35	12.38	13.99
Meghalaya	30.4	15.28	24.05	8.08	3.26	6.06
Assam	33.26	24.99	29.31	9.39	11.28	10.29
West Bengal	31.31	27.78	29.61	29.92	22.54	26.38
Jharkhand	23.86	22.35	23.16	9.04	10.78	9.85
Odisha	25.36	20.94	23.25	12.53	12.97	12.74
Chhatisgarh	21.12	16.71	19.01	7.32	8.26	7.77
Madhya Pradesh	23.33	20.98	22.15	12.69	9.42	11.05
Gujarat	28.69	25.29	27.19	23.28	16.74	20.4
Daman and Diu	32.46	27.92	30.56	23.64	29.39	26.05
Dadra and Nagar Haveli	24.54	20.66	22.63	16.35	14.18	15.28
Maharashtra	33.64	27.77	31.06	21.44	20.92	21.21
Andhra Pradesh	34.07	30.67	32.51	26.07	26.39	26.21
Karnataka	26.58	24.84	25.85	26.59	23.81	25.43

Goa	32.19	32.72	32.42	29.94	27.06	28.69
Lakshadweep	27.86	27.03	27.52	30.39	27.58	29.23
Kerala	29.27	28.81	29.09	43.23	38.34	41.23
Tamil Nadu	32.46	30.51	31.62	23.77	21.4	22.75
Puducherry	31.92	25.38	29.14	30.59	25.54	28.45
Andaman and Nicobar	25.33	30.78	28.06	34.04	23.33	28.66
Telangana	34.39	31.54	33.15	23.32	22.9	23.14
India	**29.05**	**25.88**	**27.6**	**20.05**	**17.24**	**18.76**

Figure 1: Prevalence of single chronic morbidity in women, India, LASI, 2017-18

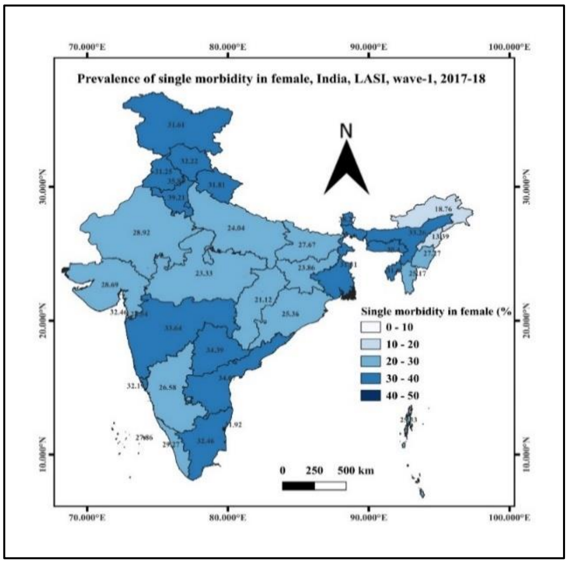

Figure 3: Prevalence of multimorbidity in women, India, LASI, 2017-18

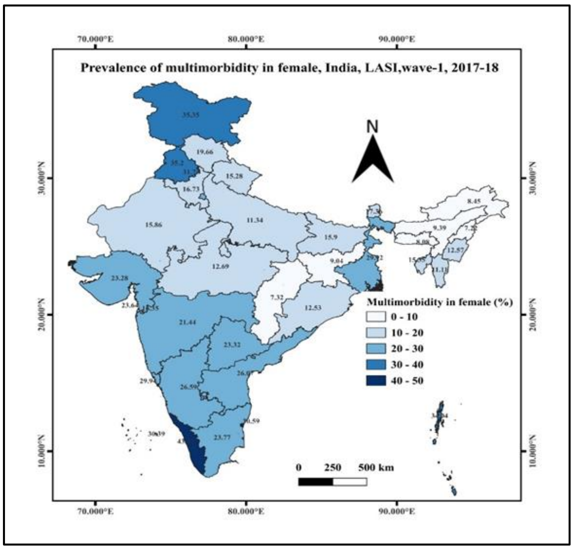

Figure 2: Prevalence of single chronic morbidity in men, India, LASI, 2017-18

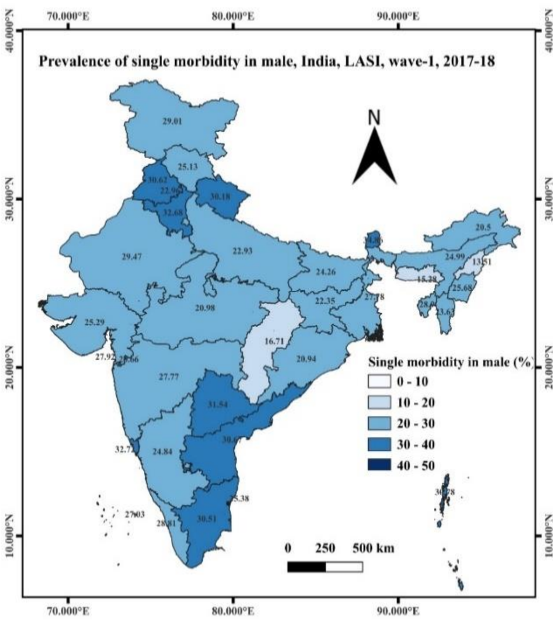

Figure 4: Prevalence of multimorbidity in men, India, LASI, 2017-18

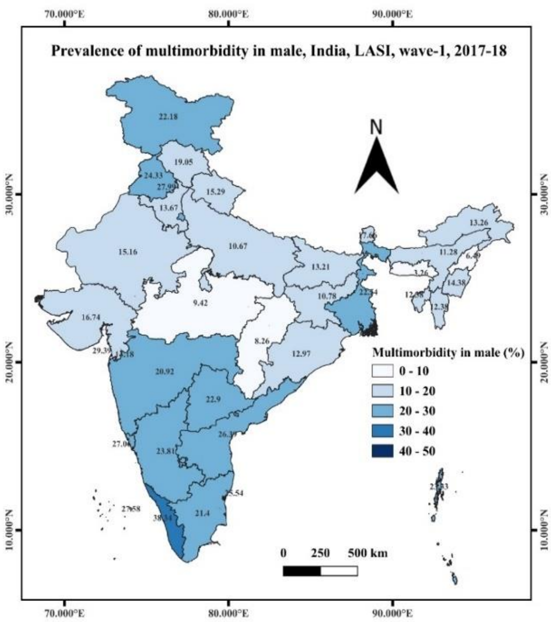

Figure 5: Prevalence of disease-specific morbidity in India, LASI, wave-1, 2017-18

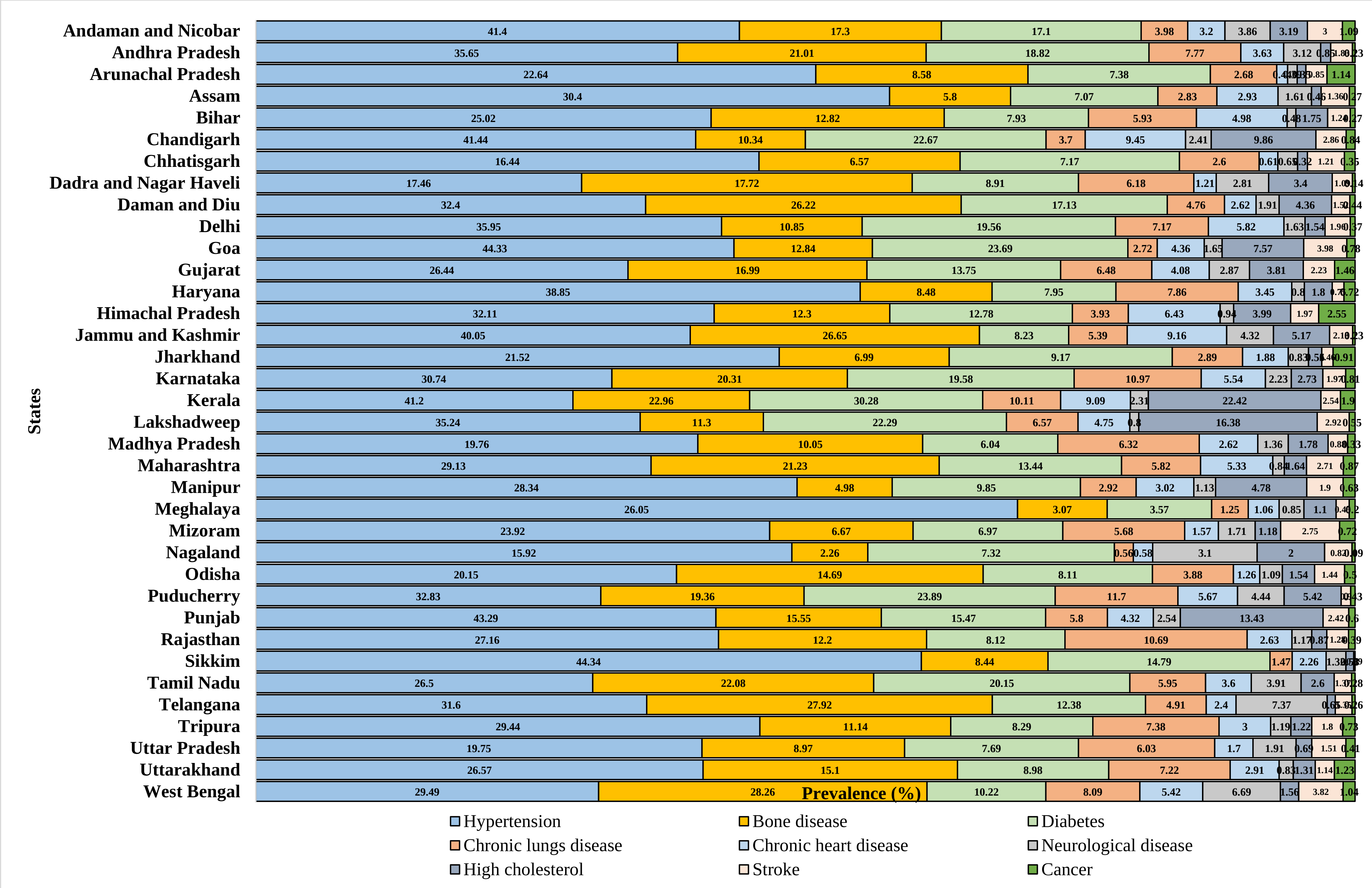

Table 6: Distribution of workers by gender and industry, LASI Wave-1, 2017-18

	Kind of Business or Industry	Male	Female	Total
1	Agriculture, forestry and fishing	65.78	34.22	100
2	Mining and quarrying	72.79	27.21	100
3	Manufacturing	71.52	28.48	100
4	Electricity, gas, steam or air conditioning supply	97.44	2.56	100
5	Water supply: sewerage, waste management and remediation activities	73.71	26.29	100
6	Construction	77.64	22.36	100
7	Wholesale and retail trade	77.8	22.2	100
8	Transportation and storage	98.22	1.78	100
9	Accommodation and food storage activities	56.86	43.14	100
10	Information and communication	82.4	17.6	100
11	Financial and insurance activities	76.49	23.51	100
12	Real estate activities	79.53	20.47	100
13	Professional, scientific, and technical activities	80.66	19.34	100
14	Administrative and support service activities	82.66	17.34	100
15	Public administration and defense; compulsory social security	97.47	2.53	100
16	Education	58.31	41.69	100
17	Human health and social work activities	50.98	49.02	100
18	Art, entertainment, and recreation	69.86	30.14	100
19	Other service activities	61.48	38.52	100
20	Activities of households as employers: undifferentiated goods/services-producing activities of households for own use	58.86	41.14	100
21	Activities of extraterritorial organizations and bodies	52.19	47.81	100
22	Others	42.78	57.22	100
	Total	**67.87**	**32.13**	**100**

Table 7: Distribution of workers by gender and occupation, LASI Wave-1, 2017-18

	Occupation	Male	Female	Total
1	Legislators, senior officials and Managers	92.79	7.21	100
2	Professionals	84.93	15.07	100
3	Technicians and associate professionals	88.87	11.13	100
4	Clerks	89.96	10.04	100
5	Service workers and shop and market sales workers	77.17	22.83	100
6	Skilled agricultural and fishery workers	67.25	32.75	100
7	Craft and related trade workers	72.52	27.48	100
8	Plant and machine operators and assemblers	96.22	3.78	100
9	Elementary occupations	61.64	38.36	100
10	Workers not classified anywhere	63.49	36.51	100
11	Others	62.97	37.03	100
	Total	**67.87**	**32.13**	**100**

Supplementary File: Socioeconomic and Demographic Correlates of Multimorbidity in India: An Insight from LASI, Wave I, 2017-18, Survey data

Table S1: Description of explanatory variables

Si. No.	Explanatory variables	Description
1	Age	45-49 years, 50-54 years, 55-59 years, 60-64 years, 65-69 years, 70-74 years and 75+ years
2	Sex	Male and Female
3	Residence	Rural and Urban
4	Caste Category	Scheduled Caste (SCs), Scheduled Tribe (STs), Other Backward Class (OBCs) and others
5	Religion	Hindu, Muslim, Christian, and Others
6	marital status	Currently married, Never married, and Others
7	Level of Education	Education was derived from the self-reported highest level of education and was regrouped as “Illiterate (no formal education)”, “up to primary”, “secondary”, and “higher”.
8	MPCE Quintiles	Poorest, Poorer, Middle, Richer, and Richest
9	Working status	Occupation was predicated on past work engagement for at least three consecutive months in the lifetime and current working status, categorised into two groups: “never worked” and “ever worked”.
10	Alcohol consumption	Lifetime abstainer, Infrequent non-heavy drinker, Frequent drinker, Heavy episodic drinker
11	Tobacco consumption	Lifetime abstainer, Smokes tobacco, Smokeless tobacco, and Both (smokes tobacco and smokeless tobacco)
12	Body Mass Index (BMI)	Body mass index (BMI) was calculated by using the formula (weight (kg)/height2 (m2)) and was categorized as underweight, normal weight, overweight and Obese.
13	Living arrangements	Living alone and living with a spouse children or others.
14	Physical activity	Frequent, Rare, and Never

15	Activities of daily living (ADL)	In LASI, the participants were asked if they had any limitations in the ADL with a duration longer than 3 months. The functional problems that occurred in the last less than 3 months were excluded from the study. The participants reported about six basic ADLs. The ADL scale was considered from six indicators. The six basic ADLs included dressing, bathing, walking across the room, eating difficulties, getting in or out of bed, and using the toilet. Further, ADL has been categorised into three categories "severe ADL disability," "moderate ADL disability," and "No ADL disability." Severe ADL disability is considered as those elderly who were not able to do any of six activities, moderate ADL disability includes those elderly who could not function in less than six activities, and no ADL disability includes elderly who were able to perform in all six activities.
16	Instrumental activities of daily living (IADL)	Likewise, the participants were asked if they had any limitations in the IADL with a duration longer than three months. The functional problems that occurred in the last less than 3 months were excluded from the study. The IADL covered seven instrumental activities. The seven instrumental ADLs included preparing a hot meal (cooking and serving), shopping for groceries, making telephone calls, taking medications, doing work around the house or garden, managing money, such as paying bills and keeping track of expenses and getting around or finding an address in an unfamiliar place. Similarly, the IADL disability has been categorised into three categories as "severe IADL disability," "moderate IADL disability," and "no IADL disability." Severe IADL disability includes those elderly who cannot do any of seven activities; moderate IADL disability includes those elderly who can function less than seven activities. No IADL disability had to those elderly who were able to perform in all seven activities.
17	State	North, Central, East, Northeast, West, and South

Table S2: The list of ten chronic diseases in LASI Wave-I (2017-18)

Sl. no.	Ten chronic diseases
1	Hypertension or high blood pressure
2	diabetes or high blood sugar
3	cancer or a malignant tumour
4	chronic lung diseases such as asthma, chronic obstructive pulmonary disease/Chronic bronchitis or other chronic lung problems

5	chronic heart diseases such as Coronary heart disease (heart attack or myocardial infarction)
6	congestive heart failure or other chronic heart problems
7	stroke, arthritis or rheumatism
8	osteoporosis or other bone/joint diseases
9	any neurological or psychiatric problems such as depression, alzheimer's/dementia, unipolar/bipolar disorders, convulsions, parkinson's, etc.
10	high cholesterol

Table S3: Regional categories considered in the study.

North	Jammu and Kashmir, Himachal Pradesh, Punjab, Chandigarh, Uttarakhand, Haryana, Delhi, Rajasthan
Central	Uttar Pradesh, Chhattisgarh, Madhya Pradesh
East	Bihar, West Bengal, Jharkhand, Odisha
North-East	Sikkim, Arunachal Pradesh, Nagaland, Manipur, Mizoram, Tripura, Meghalaya, Assam
West	Gujarat, Daman and Diu, Dadra and Nagar Haveli, Maharashtra, Goa
South	Andhra Pradesh, Karnataka, Lakshadweep, Kerala, Tamil Nadu, Puducherry, Andaman and Nicobar, Telangana

Description S1: The Fairlie decomposition:

The Fairlie decomposition, which is an extended version of the Blinder-Oaxaca decomposition, is a non-linear regression based model to decompose binary variables. The covariates showing positive contributions infer a narrowing, while those showing negative contributions infer a widening of the morbidity gap between men and women.

According to standard Blinder-Oaxaca decomposition, the morbidity gap between men and women is the difference in the value of the dependent variable – say multimorbidity prevalence, i.e. from no morbidity to two or more morbidities – can be expressed as

$$a^{-f} - a^{-m} = \left[(b^{-f} - b^{-m})\hat{\beta}^{f}\right] + \left[b^{-m}(\hat{\beta}^{f} - \hat{\beta}^{m})\right]$$

where b^{-k} is a row vector of mean values of the independent covariates (k) and $\hat{\beta}^{k}$ is a vector of coefficient estimates of regression models, an extension of this decomposition for a non-linear equation, $\mathrm{a} = \mathrm{z}(b\hat{\beta})$, can be written as

$$a^{-f} - a^{-m}\left[\sum_{i=1}^{N^f}\frac{z\left(b_i^f\hat{\beta}^f\right)}{N^f} - \sum_{i=1}^{N^m}\frac{z\left(b_i^m\hat{\beta}^f\right)}{N^m}\right] + \left[\sum_{i=1}^{N^m}\frac{z\left(b_i^m\hat{\beta}^f\right)}{N^m} - \sum_{i=1}^{N^m}\frac{z\left(b_i^m\hat{\beta}^m\right)}{N^m}\right]$$

An equally valid expression for decomposition is

$$a^{-f} - a^{-m} = \left[\sum_{i=1}^{N^f}\frac{z\left(b_i^f\hat{\beta}^m\right)}{N^f} - \sum_{i=1}^{N^m}\frac{z\left(b_i^m\hat{\beta}^m\right)}{N^m}\right] + \left[\sum_{i=1}^{N^f}\frac{z\left(b_i^f\hat{\beta}^f\right)}{N^f} - \sum_{i=1}^{N^f}\frac{z\left(b_i^f\hat{\beta}^m\right)}{N^f}\right]$$

where, a^k is the average probability of the binary outcome of the covariates k and Z is the cumulative distribution function from the logistic family for the covariate. Here, $'f'$ stands for female, $'m'$ stands for male, and $'N'$ stands for sample size. The first terms in Equations (2) and (3) provide an estimate of the contribution of covariates to the morbidity gap for multimorbidity prevalence between men and women.

However, computing the contribution of specific covariates to morbidity gap involves a few steps. Usually, the sample sizes of the two groups are not the same therefore, one needs to follow these steps:

- First, carry out regression for the combined data (male and female together) and calculate the predicted probabilities $\hat{Y}_i$, i.e. multimorbidity prevalence, for each male and female observation in the sample.
- Suppose the female's sample size is bigger than the male's sample size, then we draw a random subsample of females equal in size to the full male Sample (N_m).
- Each observation in the female sample and the male sample was then separately ranked by predicted probabilities and matched by their respective ranking. This procedure matches the female's multimorbidity prevalence, which has characteristics placing them at the bottom (top) of their distribution, with that of the male's multimorbidity, which has characteristics placing them at the bottom (top) of their distribution. Now assume that N_m=N_f and a natural one-to-one matching of male and female observations exists. Also, assume that there are two independent variables that explain the morbidity gap for multimorbidity prevalence (b_1 and b_2).

Now, according to Fairlie (2006), using coefficient estimates from a logit regression for a pooled sample, $\hat{\beta}^{*}$, the independent contribution of b_1 to the morbidity gap can be expressed as

$$b_1 = \frac{1}{N^m}\sum\nolimits_{i=1}^{m} Z(\hat{\alpha}^* + b_1^f\,\hat{\beta}_1^* + b_2^f\hat{\beta}_2^*) - Z\big(\hat{\alpha}^* + b_1^m\hat{\beta}_1^* + b_2^f\hat{\beta}_2^*\big).$$

Similarly, the contribution of b_2 can be expressed as

$$b_2 = \frac{1}{N^m}\sum\nolimits_{i=1}^{m} Z(\hat{\alpha}^* + b_1^m\,\hat{\beta}_1^* + b_2^f\hat{\beta}_2^*) - Z\big(\hat{\alpha}^* + b_1^m\hat{\beta}_1^* + b_2^m\hat{\beta}_2^*\big).$$

The contribution of each variable to the morbidity gap is thus equal to the change in the average predicted probability from replacing the male distribution with the female distribution while holding the distributions of the other variables constant.

However, the assumption of equal sample size is rarely true in practical situations. Since the female sample is substantially larger, a large number of random subsamples of female multimorbidity prevalence (equal size to the total male sample) were drawn to match each of them to the male sample and calculate separate decomposition. Finally, the mean value of all these separate decomposition estimates is used as an approximate decomposition for the entire female sample and the decomposition results were based on 100 replications.