

BMJ Open Association of multimorbidity and physical activity among older adults in India: an analysis from the Longitudinal Ageing Survey of India (2017–2018)

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ABSTRACT

Objective To examine the association of multimorbidity and physical activity among older adults in India.

Design A cross-sectional study was conducted using large representative survey data.

Setting and participants The study used data from the nationally representative 'Longitudinal Ageing Study in India (LASI),' conducted during 2017–2018. The study included a total sample of 65 336 older adults aged 45 years and above in India.

Methods Moderate and vigorous physical activities were measured separately by self-reported questionnaires. Physical activity was calculated as minutes of metabolic equivalent tasks per week. The outcome variable was a categorical variable where 2=the prevalence of more than one morbidity, 1=presence of one morbidity and 0=none. Bivariate analysis and multinomial logistic regression were applied to fulfil the objectives.

Results 27.39% of older adults in India had multimorbidity. 31.02% of older adults did not engage in any moderate physical activities. Also, 59.39% of older adults did not engage in any vigorous physical activities. Older adults reporting low (adjusted relative risk ratio (A RRR): 1.10, 95% CI 1.03 to 1.18) and moderate (A RRR): 1.05, 95% CI 0.98 to 1.13) level of moderate physical activity were significantly more likely to suffer from multimorbidity compared with no involvement in moderate physical activity. However, older adults who reported high (A RRR: 0.79, 95% CI 0.75 to 0.84), moderate (A RRR: 0.88, 95% CI 0.80 to 0.98) and low level of vigorous physical activity (A RRR: 0.94, 95% CI 0.86 to 1.02) had significantly less multimorbidity in comparison to those who never engaged in vigorous physical activity.

Conclusion Lack of physical activity is associated with multimorbidity among older adults. Physical activity promotion should be adopted as a primary strategy in reducing the burden of morbidity and multimorbidity.

INTRODUCTION

Co-occurrence of two or more chronic health conditions in an individual (any one of which should be a long-term physical non-communicable disease or a mental health condition of long duration or a long-term infectious illness)¹ is known as multimorbidity, a rapidly growing concern in public

STRENGTHS AND LIMITATIONS OF THIS STUDY

- ⇒ The study used a nationally representative survey sample of older adults.
- ⇒ This is the first study in India that looked into the amount of time spent in physical activities by older adults in India.
- ⇒ Due to the cross-sectional nature of the study design, the present study could not establish a causal relation.
- ⇒ The study has used a comprehensive list of potentially confounding variables.
- ⇒ The reporting of any morbidity and physical activity was based on the individual's self-reporting information, and hence there is the possibility of reporting biases and underestimation as well.

health.² Multimorbidity at older ages is associated with unhealthy lifestyles.^{3 4} It is also found to have adverse effects on quality of life, mortality rates, functional health, psychological health, cognitive health and healthcare expenditure.^{5–8} Physical activity is recommended as one of the leading lifestyle changes in preventing and managing multiple chronic diseases worldwide.⁹ While some previous studies depicted the high burden of multimorbidity due to physical inactivity,^{10 11} other studies showed no association between physical activity and multimorbidity.^{4 12}

Physical activity (PA) is defined as any bodily movement produced by skeletal muscles that result in energy expenditure, including daily activities like playing, carrying out of household chores, travelling and activities during professional and recreational pursuits.¹³ Regular PA is associated with increased life expectancy and reduced risk of coronary heart disease, heart stroke, diabetes, hypertension and obesity.¹⁴ PA not only helps in the prevention and management of many risk factors, chronic diseases like cardiovascular disease, colon and breast cancer, diabetes and obesity, and functional disabilities associated with old

age, but it may decrease the period of disability at the end of life.^{15 16} PA declines proportionately with age among older adults.¹⁷ Despite their knowledge about the potential personal benefits of participating in PAs, many adults hardly engage in them.¹⁸

Along with the rise in ageing populations in Asian countries, South Asia is also experiencing a growing burden of multimorbidity among the ageing population. The risk factors are mainly due to lifestyle factors such as diet and inactivity.^{19 20} In India, more than half of the burden of non-communicable diseases occurred in the 45+ age group.²¹ A study found that multimorbidity was 23% in the pooled sample of six countries—the highest being in Russia (35%), followed by Mexico (27%), India (24%), Ghana (23%), South Africa (32%) and China (20%).²² According to another study in India, 30.6% of adults aged 70 and above reported more than one chronic condition, while only 1.3% of respondents between 18 and 29 reported the same in comparison.²³ Therefore, India faces a high burden of non-communicable diseases due to rapid urbanisation.²⁴ Looking at the growing concern on multimorbidity in India, there is the necessity for a better understanding of the epidemiology of multimorbidity and the risk factors contributing to it. Studies have primarily examined the association between multimorbidity and socioeconomic status in India.²⁵ PA among older adults is a popular area of research, especially in low-income or middle-income countries of South Asia, where the population demographics are fast changing.²⁶ However, the relationship between multimorbidity and PA levels remains poorly documented among older adults, especially in India, due to the lack of available data. A better understanding of this relationship would facilitate the development of more appropriate action to combat the burden of multimorbidity.

Thus, the current study has aimed to examine the effects of PA on multimorbidity after controlling the role of other socio-demographic factors among older adults aged 45 and above in India.

METHODS

Study population

The study used data from the WAVE 1 of the Longitudinal Ageing Survey in India (LASI) data.²⁷ It is a nationally representative survey of 72 250 older adults aged 45 and above, and their spouses irrespective of their ages, including 31 464 elderly aged 60 and above and 6 749 oldest-old persons aged 75 and above from 35 states and union territories of India (excluding Sikkim).²⁸ The data were collected during the year 2017–2018. It is a full-scale national survey of scientific investigation of India's health, economics and social determinants and consequences of population ageing. The LASI is envisioned to be conducted every 2 years for the next 25 years. It is the world's most extensive and India's first longitudinal ageing study. The LASI has adopted a multistage stratified

area probability cluster sampling design to select its required sample.²⁸

In this study, individuals below the age of 45 have been excluded. After dropping a lot of missing values, the study has a total sample of 65 336 aged 45 and above. Considering the age group of 45–59 years is essential to study ageing and health transition from prime adult ages as it represents pre-ageing and pre-retirement phases. The details of the study design, sampling procedure and data collection methods can be obtained from the official report of LASI.²⁸

Variable description

Dependent variable

A score was calculated from the 12 morbidities reported by the participants. It was then categorised into 2=multimorbidity, 1=one morbidity and 0=none. The question asked for each of the illnesses was, 'Has any health professional ever told you that you have a (particular) disease?' and each response was coded as yes and no.²⁸ The morbidities reported are shown in the online supplemental appendix list.

Explanatory variables

Self-reported questionnaires were used in a face-to-face interview where responses were recorded with the help of computer-assisted personal interviews. The questions were asked separately for both moderate and vigorous PAs. The development of the PA indicators were based on the WHO Global recommendations.²⁹ Before the survey was carried, the LASI pilot survey was done successfully in 2010.³⁰

The calculation of the weekly time devoted to PA for each surveyed individual was based on metabolic equivalent tasks (METs), which reflects the estimates of the ratio of energy expended during a particular PA to energy expended while sitting quietly. The number of weekly hours and minutes a subject dedicated to each type of activity was multiplied by the MET value, that is, moderate (four METs) and vigorous (eight METs) PAs assigned to that activity based on the International Physical Activity Questionnaire criteria.³¹ Total PA scores in MET min/week were calculated by summing the MET values. The MET values of moderate and vigorous PA were finally categorised separately into 0 (never involved), low (<599 MET-min/week), moderate (600–1499 MET-min/week) and high (≥ 1500 MET-min/week). The question through which PA was assessed was 'How often do you take part in moderate physical activities such as cleaning the house, washing clothes by hand, fetching water or wood, drawing water from a well, gardening, bicycling regularly, walking at a moderate pace, dancing, floor or stretching exercises (everyday, more than once a week, once a week, one to three times a month or hardly ever or never)?'. If the respondents reported yes, then the question 'How much time did you usually spend doing any moderate activity on an average in a day' was asked.²⁷

Table 1 Demographic and socioeconomic characteristics for older adults (aged 45+ years) in India, LASI (2017–2018)

Demographic and socioeconomic characteristics	No morbidity (43.00%)	Any morbidity (29.61%)	Two or more than two (27.39%)	Total participant (N=65 336)	% out of total sample
Age group					
45–59	48.89	28.48	22.63	33 978	49.84
60–74	38.15	30.28	31.57	24 634	38.89
75+	33.67	32.28	34.05	6 724	11.27
Sex					
Female	41.26	29.81	28.93	34 977	54.2
Male	45.05	29.37	25.57	30 359	45.8
Place of residence					
Rural	46.34	30.38	23.27	42 314	68.7
Urban	35.65	27.91	36.43	23 022	31.3
Education level					
No education	45.33	30.12	24.55	38 187	61.67
Primary education	39.76	29.89	30.36	14 814	20.45
Secondary education	36.31	28.4	35.28	5 854	7.74
Higher secondary	40.43	26.86	32.71	6 481	10.14
Caste					
ST	59.24	27.25	13.51	11 335	8.61
SC	44.84	31.4	23.76	10 926	9.20
OBC	43.01	28.85	28.14	24 544	45.34
None of the above	36.44	30.38	33.18	18 531	26.85
Religion					
Hindu	44.16	29.67	26.17	47 941	82.13
Muslim	35.63	29.61	34.76	7 771	11.34
Others	41.11	28.86	30.03	9 621	6.52
Marital status					
Never married	58.97	24.32	16.71	822	1.19
Currently married	44.04	29.43	26.53	48 993	73.78
Wid/div/sep/des	39.15	30.41	30.44	15 519	25.03
Wealth quintile					
Poorest	50.55	30.65	18.79	12 894	20.91
Poorer	44.87	30.7	24.43	13 149	21.28
Middle	44.19	29.61	26.21	13 119	20.32
Richer	39.64	29.49	30.87	13 169	19.46
Richest	34.3	27.25	38.45	13 005	18.03
Work status					
Not working	33.61	30.78	35.61	17 310	27.62
Currently working	51.92	29.18	18.9	30 079	46.24
Worked before	37.13	29.14	33.73	17 947	26.15
Living arrangements					
Living alone	38.1	32.24	29.66	2 305	3.7
Living with spouse and others	44.02	29.43	26.56	47 710	72.25
Living without spouse and others	40.69	29.75	29.56	15 321	24.05
Engaged in moderate physical activity					

Continued

**Table 1** Continued

Demographic and socioeconomic characteristics	No morbidity (43.00%)	Any morbidity (29.61%)	Two or more than two (27.39%)	Total participant (N=65 336)	% out of total sample
Never involved	40.84	29.33	29.83	20 918	31.02
Low (<599 MET-min/week)	42.07	29.94	27.99	8 830	13.24
Moderate (600–1499 MET-min/week)	42.6	31.74	25.65	7 608	11.44
High (1500 and more MET-min/week)	44.89	29.16	25.95	27 980	44.29
Engaged in vigorous physical activity					
Never involved	38.65	29.67	31.68	39 693	59.39
Low (<599 MET-min/week)	43.84	30.36	25.79	4 717	7.37
Moderate (600–1499 MET-min/week)	46.95	30.08	22.96	2 879	4.1
High (1500 and more MET-min/week)	51.07	29.23	19.69	18 047	29.15

LASI, Longitudinal Ageing Survey in India ; MET, metabolic equivalent tasks ; OBC, Other Backward Class ; SC, Scheduled Caste ; ST, Scheduled Tribe .

A similar question was asked for vigorous PAs: ‘How often do you take part in sports or vigorous activities, such as running or jogging, swimming, going to a health center or gym, cycling, digging with a spade or shovel, heavy lifting, chopping, farm work, fast cycling, cycling with loads (everyday, more than once a week, once a week, one to three times a month, hardly ever or never)’. The second question asked for those reporting yes ‘On the days you did any vigorous activity, how much time did you usually spend doing it?’.²⁷

Other explanatory variables

The demographic and socioeconomic variables considered for this study are sex (male and female), place of residence (rural and urban), marital status (currently married, widowed/divorced/separated and never married), education (illiterate, primary, secondary, higher secondary and above), work status was categorised as working, retired and not working. Living arrangement was categorised as living alone, living with spouse and others, living without spouse and others. The age group was classified as (45–59, 60–74, 75 and above). The monthly per capita expenditure (MPCE) quintile was measured using household consumption data. Sets of 11 and 29 questions on the spending on food and non-food items, respectively, were used to canvas the sample households. The variable was then divided into five quintiles, that is, from poorest to richest. Religion was categorised as Hindu, Muslim and Others, the social groups as Scheduled Castes (SC), Scheduled Tribes (ST), Other Backward Classes (OBC) and others. \

Patient and public involvement

No patients were involved in this study.

Statistical analysis

Bivariate analysis was presented to show the association between multimorbidity and other covariates. Multinomial logistic regression analyses were used to examine

the extent to which vigorous and moderate PA level was associated with multimorbidity. The first model was run to investigate the association between moderate PA level and multimorbidity. The second model was run to examine the association between vigorous PA level and multimorbidity. The third model was statistically adjusted for other demographic and socioeconomic factors.

RESULTS

Table 1 presents the weighted characteristics of the study sample by morbidity status, the total sample and its percentage. Out of 65 336 participants, 29.61% had one morbidity and 27.39% had multimorbidity. The prevalence of one morbidity and multimorbidity increased from younger to the older age groups. Female older adults had a higher share in multimorbidity (28.93%) than men (25.57%). The older adults living in urban areas had a higher prevalence of multimorbidity (36.43%) than those living in rural areas (23.27%). Older adults from ST (13.51%) had the lowest prevalence of multimorbidity among all the caste groups, and Hindus (26.17%) had the lowest among religions. About 30.44% of older adults who were widowed, divorced or separated suffered from multimorbidity. The multimorbidity status among older adults showed an increasing trend with a rising MPCE quintile. The working older adults had the lowest prevalence of multimorbidity (18.9%) compared with those who had never worked and who had worked before.

The proportion of older adults with increasing moderate PA levels had a lower prevalence of multimorbidity. The older adults who were never engaged and with a low level of PA had a higher prevalence of multimorbidity, that is, 29.83% and 27.99%. Similarly, the older adults involved in a high level of vigorous PA had the lowest prevalence of multimorbidity (19.69%). In comparison, those who never engaged in vigorous activities had the highest prevalence of multimorbidity (31.68%).

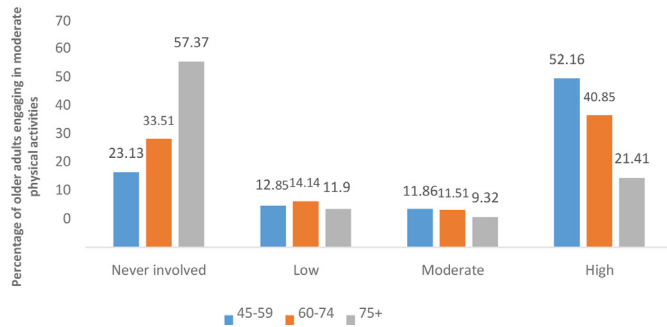


Figure 1 Percentage distribution of older adults engaged in moderate physical activities by age groups in India, LASI (2017–2018).

Figure 1 presents the distribution of moderate PA of older adults by age group. The percentage of older adults who were never involved in moderate PA was the highest for the age 75 and above (57.37%) and lowest for 45–59 (23.13%). All moderate PA levels were highest for the individuals aged 45–59 and the lowest for the age group 75 and above. The highest difference was observed for a high level of moderate PA where for the age group 45–59 it was 52.16% and for 75 and above it was only 21.41%.

Figure 2 presents the distribution of older adults engaged in different vigorous activity levels. The older adults who never engaged in any vigorous activities were highest for the age group 75 and above that is, 84.13%, while it was lowest for those aged 45–59 (49.64%). The percentage of older adults aged 75 and above was lowest in all kinds of vigorous PA levels while it was highest for 45–59.

Table 2 shows the results of the multinomial logistic regression models on multimorbidity. Model 1 presents the association of multimorbidity and moderate PA level for older adults. It was found that older adults who were engaged in a high level of moderate PA were significantly less likely to have one morbidity in comparison with those who were never engaged in any (unadjusted relative risk ratio (UA RRR)): 0.95, 95% CI 0.91 to 0.99). On the other hand, the RRR of multimorbidity was significantly lower

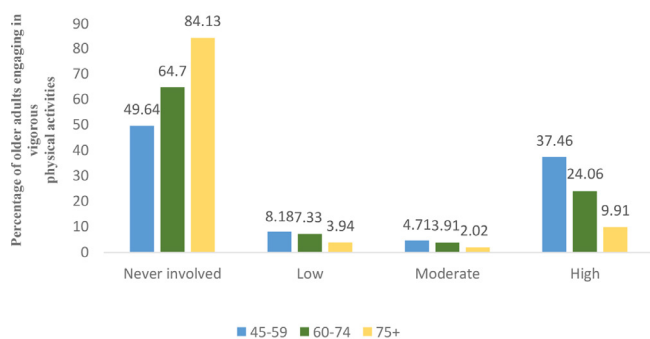


Figure 2 Percentage distribution of older adults engaged in vigorous physical activities by age groups in India, LASI (2017–2018).

for older adults engaged in high, moderate and low levels of moderate PA level than those who were never involved.

Model 2 shows the association of multimorbidity and vigorous PA level for older adults. For vigorous activity level, the prevalence of multimorbidity was significantly less likely for those engaging in high level than those who were never involved (UN RRR 0.44; 95% CI –0.42 to 0.46). Similarly, the older adults who engaged in moderate PA level (UN RRR 0.59; 95% CI –0.54 to 0.65) and low vigorous PA level (UN RRR 0.72; 95% CI –0.67 to 0.77) were also significantly less likely to report multimorbidity than those who never engaged. The results for one morbidity showed similar results with multimorbidity, where the likelihood of having one morbidity decreased significantly with vigorous PA level. Model 3 shows the association of multimorbidity and for both moderate and vigorous PA levels for older adults for sex, age, residence, educational status, caste, religion, marital status, living arrangements, work status and wealth quintile. The results from the adjusted model suggest that the older adults who were engaged in moderate (adjusted RRR (A RRR)=1.10; 95% CI 1.03 to 1.18) and low levels of moderate PA (A RRR=1.05; 95% CI 0.98 to 1.13) were significantly more likely to have multimorbidity. The results showed the same for one morbidity also. However, the older adults who were engaged in all kinds of vigorous PA were significantly less likely to have multimorbidity. In the case of one morbidity, only those engaging in a high level of vigorous activity were significantly less likely to have multimorbidity.

DISCUSSION

Using LASI data on older adults, this study has found 27.39% of older adults in India to have multimorbidity. To our knowledge, the present study is the first attempt in India to investigate the association between multimorbidity and the level of PA among older adults aged 45 and above. In this analysis of older adults, our study depicts an inverse association between multimorbidity and PA level for both moderate and vigorous activity. Results suggest that a higher level of PA significantly lowers the likelihood of multimorbidity among older adults. Our findings are consistent with a study that demonstrated an inverse dose-response association between PA levels and multimorbidity using frequency of vigorous, moderate and mild PA.³² In another study for older adults aged 65 and above, it was found that the absence of 13 chronic conditions was associated with those who engaged in moderate-intensity PA lasting 15 min per day at least three times a week¹⁰

The study also found that multimorbidity was inversely associated with PA among older adults after controlling for sex, age, residence, educational status, caste, religion, marital status, living arrangements, work status and wealth quintile. Similar results were found in another study where multimorbidity was inversely associated with PA in the youngest and oldest age groups after controlling for

Table 2 Logistic regression estimates for the prevalence of multimorbidity among older adults aged 45 years and above, Longitudinal Ageing Survey in India (2017–2018)

No morbidity (base outcome)	Model 1		Model 2		Model 3	
	Unadjusted RRR	95% CI	Unadjusted RRR	95% CI	Adjusted RRR	95% CI
One morbidity						
Moderate physical activity						
Never involved						
Low (<599 MET-min/week)	0.97	0.91 to 1.03			1.14	0.98 to 1.11
Moderate (600–1499 MET-min/week)	1.02	0.96 to 1.09			1.11***	1.04 to 1.19
High (1500 and more MET-min/week)	0.95**	0.91 to 0.99			1.07***	1.02 to 1.12
Multimorbidity						
Moderate physical activity						
Never involved						
Low (<599 MET-min/week)	0.93**	0.87 to 0.99			1.10***	1.03 to 1.18
Moderate (600–1499 MET-min/week)	0.87***	0.81 to 0.92			1.05*	0.98 to 1.13
High (1500 and more MET-min/week)	0.76***	0.73 to 0.79			0.98	0.93 to 1.04
One morbidity						
Vigorous physical activity						
One morbidity						
Never involved						
Low (<599 MET-min/week)			0.89***	0.83 to 0.95	1.01	0.94 to 1.09
Moderate (600–1499 MET-min/week)			0.85***	0.78 to 0.92	1.01	0.92 to 1.11
High (1500 and more MET-min/week)			0.72***	0.69 to 0.75	0.92***	0.88 to 0.97
Multimorbidity						
Vigorous physical activity						
Never involved						
Low (<599 MET-min/week)			0.72***	0.67 to 0.77	0.94*	0.86 to 1.02
Moderate (600–1499 MET-min/week)			0.59***	0.54 to 0.65	0.88***	0.80 to 0.98
High (1500 and more MET-min/week)			0.44***	0.42 to 0.46	0.79***	0.75 to 0.84

®=Reference category.

P value: ***<0.01, **<0.05 and *<0.1.

Model 3 adjusted for sex, age, place of residence, educational status, caste, religion, marital status, living arrangements, work status, wealth quintile.

MET, metabolic equivalent tasks ; RRR, relative risk ratio.

long-term activity limitations, self-perceived health status, age, sex, educational level and employment status.³³ However, the likelihood of multimorbidity increased with the level of moderate PA after adjusting with the other covariates, which needs further investigation. The findings of this study are in concordance with existing literature that women and older age groups tend to have a higher prevalence of multimorbidity.^{3 25 34 35} Older age

groups having a higher rate of multimorbidity than the younger age groups might be explained due to the fact that susceptibility to stressful events throughout a lifetime disrupts the physiological balance and hence expedites the onset of morbid conditions³⁶

Moreover, the study has also documented the higher prevalence of multimorbidity among the higher socio-economic groups, which is also consistent with other

studies in India.^{22 26 27} Those residing in urban areas, higher education status, the wealthiest, the high caste groups were more likely to have multimorbidity. This may be explained due to the adoption of unhealthy lifestyles among the higher socioeconomic groups leading to obesity, high-risk waist-hip ratio and elevated lipids, which are also major risk factors of morbidity conditions.^{37 38} Additionally, self-report-based results of the low prevalence of multimorbidity among less educated and poor older persons are likely to have a substantial burden of undiagnosed chronic diseases.³⁴

The present study has several limitations, including its cross-sectional design, which cannot establish a causal inference between multimorbidity and time use in PAs. The reporting of any morbid condition was based on self-reported information, and hence there is the possibility of reporting bias and underestimation as well. Some respondents might not have had the disease due to treatment at the time of the survey, and some might not have consulted any medical professional. Moreover, the data on PA might have errors due to recall and reporting biases.

CONCLUSION

The present study found a negative association between PA and multimorbidity in older adults. Older adults spending more time in vigorous activities had lower odds of multimorbidity. The WHO recommends that older adults should do at least 150 min of moderate-intensity PA during the week or at least 75 min of vigorous-intensity PA during the week or an equivalent combination of both.⁹ Therefore, the promotion of PA should be adopted as a primary strategy in reducing the burden of morbidity and multimorbidity.

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Data availability statement Data are available in a public, open access repository. The study is based on LASI data which is available on reasonable request through <https://www.ipsindia.ac.in/content/lasi-wave-1>.

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REFERENCES

- MacMahon S. *Multimorbidity: a priority for global health research*. London: UK Acad Med Sci, 2018.
- Valderas JM, Starfield B, Sibbald B, *et al*. Defining comorbidity: implications for understanding health and health services. *Ann Fam Med* 2009;7:357–63.
- Mini GK, Thankappan KR. Pattern, correlates and implications of non-communicable disease multimorbidity among older adults in selected Indian states: a cross-sectional study. *BMJ Open* 2017;7:e013529.
- Fortin M, Haggerty J, Almirall J, *et al*. Lifestyle factors and multimorbidity: a cross sectional study. *BMC Public Health* 2014;14:686.
- Pefoyo AJK, Bronskill SE, Gruneir A, *et al*. The increasing burden and complexity of multimorbidity. *BMC Public Health* 2015;15:415.
- Su P, Ding H, Zhang W, *et al*. The association of multimorbidity and disability in a community-based sample of elderly aged 80 or older in Shanghai, China. *BMC Geriatr* 2016;16:178.
- Fortin M, Lapointe L, Hudon C, *et al*. Multimorbidity and quality of life in primary care: a systematic review. *Health Qual Life Outcomes* 2004;2:51–12.
- Pati S, Swain S, Metsemakers J, *et al*. Pattern and severity of multimorbidity among patients attending primary care settings in Odisha, India. *PLoS One* 2017;12:e0183966.
- World Health Organization. *Global recommendations on physical activity for health*. World Health Organization, 2010.
- Kaplan MS, Newsom JT, McFarland BH, *et al*. Demographic and psychosocial correlates of physical activity in late life. *Am J Prev Med* 2001;21:306–12.
- Ryan A, Murphy C, Boland F, *et al*. What is the impact of physical activity and physical function on the development of multimorbidity in older adults over time? a population-based cohort study. *J Gerontol A Biol Sci Med Sci* 2018;73:1538–44.
- Hudon C, Soubhi H, Fortin M. Relationship between multimorbidity and physical activity: secondary analysis from the Quebec health survey. *BMC Public Health* 2008;8:304.
- World Health Organization. *Physical activity factsheet*, 2016.
- Lee I-M, Shiroma EJ, Lobelo F, *et al*. Effect of physical inactivity on major non-communicable diseases worldwide: an analysis of burden of disease and life expectancy. *Lancet* 2012;380:219–29.
- Hubert HB, Bloch DA, Oehlert JW, *et al*. Lifestyle habits and compression of morbidity. *J Gerontol A Biol Sci Med Sci* 2002;57:M347–51.
- Kadariya S, Aro AR. Barriers and facilitators to physical activity among urban residents with diabetes in Nepal. *PLoS One* 2018;13:e0199329.
- Nooyens ACJ, Visscher TLS, Schuit AJ, *et al*. Effects of retirement on lifestyle in relation to changes in weight and waist circumference in Dutch men: a prospective study. *Public Health Nutr* 2005;8:1266–74.
- Giuli C, Papa R, Mocchegiani E, *et al*. Predictors of participation in physical activity for community-dwelling elderly Italians. *Arch Gerontol Geriatr* 2012;54:50–4.
- Boutayeb A, Boutayeb S. The burden of non communicable diseases in developing countries. *Int J Equity Health* 2005;4:2.
- Singh K, Patel SA, Biswas S, *et al*. Multimorbidity in South Asian adults: prevalence, risk factors and mortality. *J Public Health* 2019;41:80–9.
- Chatterji S, Kowal P, Mathers C, *et al*. The health of aging populations in China and India. *Health Aff* 2008;27:1052–63.
- Agrawal S, Agrawal PK. Association between body mass index and prevalence of multimorbidity in Low- and middle-income countries: a cross-sectional study. *Int J Med Public Health* 2016;6:73–83.
- Pati S, Agrawal S, Swain S, *et al*. Non communicable disease multimorbidity and associated health care utilization and expenditures in India: cross-sectional study. *BMC Health Serv Res* 2014;14:451.
- Patel V, Chatterji S, Chisholm D, *et al*. Chronic diseases and injuries in India. *Lancet* 2011;377:413–28.



- 25 Banjare P, Pradhan J. Socio-Economic inequalities in the prevalence of multi-morbidity among the rural elderly in Bargarh district of Odisha (India). *PLoS One* 2014;9:e97832.
- 26 Shaheen M, Puri S, Tandon N. Physical activity measurement in elderly: the Indian scenario. *J Phys Act Res* 2016;1:9–14.
- 27 International Institute for Population Sciences (IIPS). Longitudinal ageing study in India (LASI), 2020. Available: <https://www.iipsindia.ac.in/content/LASI-data>
- 28 International Institute for Population Sciences (IIPS), National Programme for Health Care of Elderly (NPHCE), MoHFW, Harvard T. H. Chan School of Public Health (HSPH) and the University of Southern California (USC) International Institute for Population S HTHCS of PH (HSPH) and the U of SC (USC). *Longitudinal ageing study in India (LASI) wave 1, 2017–18, India report*, 2020.
- 29 Ministry of Health and Family welfare NHP. *Healthy living; physical activity*. New Delhi: Government of India, 2018. <https://www.nhp.gov.in/healthyliving/physical%02activity>
- 30 Longitudinal Aging Study in India. Pilot Wave. Harvard school of public health, International Institute of population sciences, Mumbai, India, and Rand Corporation. Mumbai, 2011. Available: <https://mmicdata.rand.org/megametadadata/?section=study&studyid=36>
- 31 Forde DC. *Scoring the International physical activity questionnaire (IPAQ)*. Univ Dublin.
- 32 Dhalwani NN, O'Donovan G, Zaccardi F, et al. Long terms trends of multimorbidity and association with physical activity in older English population. *Int J Behav Nutr Phys Act* 2016;13:8.
- 33 Cimarras-Otal C, Calderón-Larrañaga A, Poblador-Plou B, et al. Association between physical activity, multimorbidity, self-rated health and functional limitation in the Spanish population. *BMC Public Health* 2014;14:1170.
- 34 Arokiasamy P, Uttamacharya JK. Multi-morbidity, functional limitations, and self-rated health among older adults in India: cross-sectional analysis of LASI pilot survey, 2010. *Sage Open* 2015;5:2158244015571640.
- 35 Jerliu N, Toçi E, Burazeri G, et al. Prevalence and socioeconomic correlates of chronic morbidity among elderly people in Kosovo: a population-based survey. *BMC Geriatr* 2013;13:1–9.
- 36 Violan C, Foguet-Boreu Q, Flores-Mateo G, et al. Prevalence, determinants and patterns of multimorbidity in primary care: a systematic review of observational studies. *PLoS One* 2014;9:e102149.
- 37 Blakely T, Hales S, Kieft C, et al. The global distribution of risk factors by poverty level. *Bull World Health Organ* 2005;83:118–26.
- 38 Gupta PC, Pednekar MS. Re: jumping the gun: the problematic discourse on socioeconomic status and cardiovascular health in India. *Int J Epidemiol* 2014;43:276–8.