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ORIGINAL ARTICLE

# Mapping multimorbidity from diabetes mellitus and its association with depressive symptoms among older people of India: a cross-sectional study from a nationally representative survey

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**Abstract**

**Background** India is the second major epicenter of diabetes mellitus (DM) prevalence after China and predicted to overtake China by 2045. DM is associated with multimorbidity which has tremendous impact on mental health. However, little is known about patterns of morbidities and their associations with depression.

**Objective** The purpose of this article is to ascertain multimorbidity in the DM population and to assess the relationship between multimorbidity and depressive symptoms.

**Methods** A cross-sectional analysis was conducted using data from the "Longitudinal Ageing Study in India (LASI)," a national representative survey. Regression analysis was used to investigate the relationship between multimorbidity and depressive symptoms. The mean difference of depressive symptoms with multimorbidity was calculated using one-way ANOVA.

**Results** The total population included in the study was 8855. Around 72.8% had multimorbidity, out of which 43%, 20.4%, and 9.4% fall under single, double, and triple or more than triple morbidity category, respectively. The odds of having depression in single morbidity (AOR, 1.24), double morbidity (AOR, 1.34), and triple or more morbidity (AOR, 1.51), poor self-rated health (AOR, 1.45), unenrolled in health insurance policy (AOR, 1.21), hospitalized in the past 12 months (AOR, 1.12), and taking insulin injections (AOR, 1.24) were significantly higher. There were significant mean differences in depression with different categories of multimorbidity conditions ($F = 19.63$, $p = 0.000$).

**Conclusion** Higher rate of multimorbidity among DM patients was recorded. Multimorbidity substantially increases the risk of acquiring depression. Timely identification and appropriate management multimorbidity of diabetes are important for reducing to incidence of depression and better quality of life and functionality.

**Keywords** Diabetes mellitus · Multimorbidity · Depression · India

## Introduction

Diabetes mellitus (DM) is regarded as one of the most prevalent forms of non-communicable diseases [1]. In the last 40 years, the number of cases with DM have expanded substantially, to more than 460 million people today [2], and is now one of the serious health issues, especially among older people [3]. According to estimates, there are 135.6 million (19.3%) older adults worldwide who have DM and are anticipated to increase to 276.2 million by 2025 and 195.2 million by 2030 [3]. The prevalence of DM has increased much more quickly in developing countries like India compared to high-income countries [3–5]. International DM Federation (IDF), 2019, reported that India is the second major epicenter of DM prevalence (77 million) in the last decade after China (116.4 million) [2]. However, trends predict that by 2045 India will become the main contributor for DM prevalence among elderly population [2, 6]. It is considered as the global leading causes of mortality with an estimated 1.5 million death each year and the number of deaths is escalating per year which is suggestive of an increasing and diversifying co-/multimorbidity in diabetic people [7, 8]. Multimorbidity means more than two chronic conditions occurring in the same person at the same time, which is becoming more of an issue particularly in countries where the population is rapidly aging [2, 9]. Comorbidity

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and multimorbidity conditions are common and growing rapidly among people with DM [2, 8–11] and is linked with adverse health outcomes: decreased quality of life [12, 13], impaired functional status [13], psychological distress [14], long hospital stays [13, 15], high cost [12–15], and high mortality [13]. It also affects processes of care and may result in complex self-care needs [16] which further elevate burden on limited healthcare resources of the country [15]. Moreover, large evidences report that a significant proportion of DM patient suffer through depression [9, 17]. The proportion could be further accelerated among DM patient with multimorbid conditions [9, 11]. Depression and multiple medical diseases are closely related conditions that provide tremendous challenges to health systems, especially in low- and middle-income nations where resources to address the issue are scarce [10, 12, 13, 15]. However, the exact epidemiology of diabetic multimorbidity with depression is still unknown. Evidences have shown that the coexistence of depression and multimorbidity can generate a cascade of disturbances that endanger the national healthcare systems of all nations in terms of mortality and disability [12, 15]. Hence, understanding relationship between diabetic multimorbidity and depression is a requisite in the emerging medical field of research.

Researches on diabetic multimorbidity as well as its link with mental health problem is yet to flourish in India [18, 19]. So far, few published papers have investigated the epidemiology of single comorbid conditions among DM people, its impact on physical health. So, there is a dearth of a nationally representative evidence on the epidemiology of diabetic multimorbidity and its association with most common mental health issues like depression which will draw the attention of national concerned authorities for better update and management of DM. Hence, the present study was conducted to determine the multimorbidity associated with DM and to ascertain association between DM multimorbidity and development of depressive symptoms among older people living in India.

## Methods and Materials

### Study design

The first wave of the nationwide survey "Longitudinal Ageing Study in India" (LASI, Wave-1, 2017–2018), which was carried out throughout all of India's states and union territories, provided the data for the current study. LASI, Wave-1, national survey was conducted with the collaboration of various organizations, for instance, Government of India, the Ministry of Health and Family Welfare, coordinated by the International Institute of Population Sciences (IIPS), Mumbai. To choose the appropriate sample, a three- and four-stage sampling design and a multistage stratified area probability cluster sampling design were used. Demographics, household economic position, chronic and symptom-based health issues, mental health, and other aspects of older adult–related information were captured in the LASI survey. Persons above the age of 45 were stated as an eligible candidate for the study. Participants not having DM were exempted from the study, and so the total sample size was 8855. Ethical clearance for LASI survey was taken from various national and international institutions. Detailed procedure of LASI in India was published elsewhere [20].

### Measures

#### Predictive variable

According to the purpose of the current investigation, multimorbidity conditions among DM were the main predictors. Based on eight self-reported diagnosed chronic health problems in the LASI dataset, information was gathered to determine if the respondents with diabetes had multimorbidity. Participants in the LASI questionnaire were questioned, if they ever had a chronic illness officially diagnosed or being told of having a chronic condition by the health professionals with MD, MBBS, BDS, and Ayush only in order to determine the epidemiology of chronic conditions. Comorbidity with DM was initially measured by a one-to-one basis of each eight diseases and then multimorbidity with DM was measured using these chronic diseases. Chronic diseases that were included were cancer, heart disease, hypertension, lung disease, stroke, neurological or psychiatric problems, bone/joint disease, and raised cholesterol. DM patients were categorized as multimorbidity depending on the presence of number of chronic diseases. The answers were recoded as follows: 0 for "no morbidity," 1 for "single morbidity," and 2 for "double morbidity," and 3 for "triple or above triple morbidity." It was then divided into dichotomous variables, with 0 denoting "no multimorbidity" and 1, 2, 3, 4, and 5 combined to denote "multimorbidity" [21]. In this study, multimorbidity was defined as the coexistence of at least one comorbid condition like cancer, hypertension, lung disease, stroke, heart disease, neurological or psychiatric problems, bone/joint disease, and high cholesterol with DM [19].

#### Outcome variable

The shortened set of 10 items of Centre for Epidemiology Studies Depression Scale (CES-D) was used for measurement of depressive symptoms derived from the original 20-items of CES-D [22]. CES-D tool was not designed to clinically diagnose depression. However, it was frequently employed to determine people at risk of depressive symptoms [23]. Similar to the 20-item CES-D tool, the 10-item

CED-D is a 4-point Likert scale with points ranging from 0 to 3 based on the response to the question, "How often did you feel these symptoms during the past week?" The points were as follows: 0 represented rarely or none of the time (< 1 day), 1 represented some or a little of time (1–2 days), 2 represented occasionally or a moderate amount of time (3–4 days), and 3 represented most or all of the time (5–7 days) [22, 23].

Response options covered in this survey were based on the previous study: "rarely or none of the time (< 1 day)" and "sometimes (1 or 2 days)" were scored as zero and "often (3 or 4 days)" and "most or all of the time (5–7 days)" were scored as 1, with items 5 and 8 being scored in reverse. [21, 24]. A total score of 4 or higher is regarded as positive for depressive symptoms. The score ranges from 0 to 10 [21, 24].

#### Other covariates

Other covariates that were included as the predictors for depressive symptoms were age (below 50, 50–59, 60–69, 70–79, and 80 +), place of residence (urban and rural), coverage of health insurance, sex (female and male), education (higher secondary and above, secondary education, and no education), marital status (married and other), caste (Schedule Caste (SC), Schedule Tribe (ST), Other Backward Caste (OBC) and others), self-rated health(Good and poor), hospitalization in the past 12 months (yes and no), and type of medication used for DM (insulin shots and oral medicines or others).

### Statistical analysis

Descriptive statistics as well as bivariate estimations were carried out to be familiar with sample characteristics, estimation of DM, multimorbid conditions, and measurement of depressive symptoms among older people. Sampling weight was utilized while doing univariable and bivariable analysis to make up for uneven probability at different stages of selection and to make up for lack of responsiveness. Multivariable binary logistic regression was performed to identify the association between multimorbidity and depressive symptoms among DM people. Regression analysis findings were displayed as an adjusted (AOR) with a 95% confidence interval (CI). The $p$ values < 0.05 are considered significant. The mean difference in depressed symptoms scores across respondents with varying numbers of morbidity conditions was calculated using a one-way ANOVA. To find the difference between the groups, post hoc analysis (Bonferroni) was used. Using STATA 15.0, all required statistical analysis was completed.

## Results

Nearly (33.7%) belonged to 60–69 age range, followed by 29.4% in the 50–59 age, 21.8% in the 70–79 age, and 14.9% under 50 years age. Of the study participants, 46.6% were men and 53.4% were women. Out of all the respondents, 75.6% were married, while the remaining 24.4% fell into the other category (widowed, divorced, separated, single). More than half (56.3%) of the participants were residing in urban settings. The "OBC" category accounted for the majority of responders (42.5%), followed by others (33.1%), SCs (13.7%), and STs (10.7%). According to wealth quintile category, respondents were divided as poorest (13.5%), poor (16.3%), middle (19.4%), richer (23.2%), and richest (27.6%). Education-wise eligible respondents were categorized as no school education (30.6.%), secondary or less (53%), and higher secondary and above (16.4%). About 70.8% of respondents feel they were in good health, and the remaining were in poor health. Around one-fourth of the respondents (22.9%) had coverage of health insurance policy, while others (77.1) were not insured. Out of the total DM cases, nearly three-fourths (70.5%) were admitted to a hospital in the past 12 months. Similarly, every 1 out of 10 (12.8%) respondents were using insulin injection to manage their sugar level and the rest (87.2%) were on oral medicines and lifestyle modification regime (Table 1).

Nearly three-fourths (72.8%) of the DM patients were diagnosed to have other comorbid conditions. A higher proportion of comorbidity was observed among females (75.6%) than males (69.7%). With time and age, the prevalence of comorbidity increased, rising from 57.9% in those under 50 to 82.2% in those between the ages of 70 and 79. Comorbid condition was higher among the participants who were residing in urban (73.5%)) than rural (72%) areas. A higher proportion of comorbidity was noted while comparing the widowed/divorced/separated/never-married groups to the married ones (74.2% vs. 70.8%). Proportion of comorbid diabetic patients was higher among the participants who never attended school (74.7%) compared with who completed secondary or middle level education (73.1%) and higher secondary and above education. Increasing trend on comorbid condition was observed along with the increasing level of wealth quantiles among eligible participants. There were wide differences on the proportion of comorbid conditions among those who considered their health to be a good situation (68.5%) than those admitting to be in poor health. Participants (77.2%) who were taking insulin injections were observed with higher proportion comorbidity as compared to others (77.2% vs 72.2%) (Table 1).

**Table 1** General profile of diabetic patient (N = 8,855)

| General profile | General characteristics *n*/% | Multimorbidity *n*/% |
|---|---|---|
| Age groups (years) | | |
| < 50 | 1315 (14.9) | 761 (57.9) |
| 50–59 | 2606 (29.4) | 1801 (69.1) |
| 60–69 | 3007 (33.9) | 2307 (76.7) |
| 70–79 | 1927 (21.8) | 1583 (82.2) |
| Sex | | |
| Male | 4128 (46.6) | 2877 (69.7) |
| Female | 4727 (53.4) | 3575 (75.6) |
| Marital status | | |
| Currently married | 6696 (75.6) | 4741 (70.8) |
| Otherwise | 2159 (24.4) | 1711 (79.2) |
| Place of residence | | |
| Rural | 3865 (43.7) | 2783 (72.0) |
| Urban | 4990 (56.3) | 3669 (73.5) |
| Caste | | |
| Scheduled Tribe (ST) | 901 (10.7) | 648 (71.9) |
| Scheduled Caste (SC) | 1160 (13.7) | 816 (70.3) |
| Other Backward Class (OBC) | 3592 (42.5) | 2602 (72.4) |
| None of the above | 2797 (33.1) | 2086 (74.6) |
| Education | | |
| No schooling | 2707 (30.6) | 2024 (74.7) |
| Secondary or less | 4695 (53.0) | 3432 (73.1) |
| Higher secondary and above | 1453 (16.4) | 996 (68.5) |
| Income quintile | | |
| Poorest | 1192 (13.5) | 845 (70.9) |
| Poorer | 1447 (16.3) | 1045 (72.2) |
| Middle | 1716 (19.4) | 1205 (70.2) |
| Richer | 2052 (23.2) | 1508 (73.5) |
| Richest | 2448 (27.6) | 1849 (75.5) |
| Self-rated health | | |
| Good | 6270 (70.8) | 4298 (68.5) |
| Poor | 2585 (29.2) | 2154 (83.3) |
| Covered with health insurance | | |
| Yes | 2026 (22.9) | 1432 (70.7) |
| No | 6751 (77.1) | 4969 (73.6) |
| Hospitalized in the past 12 months | | |
| Yes | 2609 (70.5) | 1823 (69.9) |
| No | 6246 (29.5) | 4629 (74.1) |
| Type of medicine used | | |
| Insulin shots | 1133 (12.8) | 875 (77.2) |
| Oral medicines or others | 7716 (87.2) | 5572 (72.2) |

Out of total diabetic patients, hypertension (66.6%) was the commonest comorbid condition, followed by chronic bone/joint disease (22.5%), raised cholesterol (11.7%), chronic heart disease (10.8%), chronic lung disease (8.7%), stroke (4.9%), neurological and psychiatry problems (3.5%), and finally cancer (1.21%). Similarly, one-fourth of the diabetic cases (27.2%) had no comorbidities, while the rest (72.8%) had comorbid issues. Out of the total comorbid respondents (72.8%), 43%, 20.4%, and 9.4% fell under single, double, and triple or more than triple morbidity category, respectively. Depression was the most common among the respondents with cancer comorbidity, followed by neurological or psychiatric issues (51.2%), stroke (44.4%), chronic lungs diseases (40.5%), chronic heart diseases (38.7%), hypertension (37.7%), chronic bone/joint disease (37.7%), and high cholesterol (36.3%). Similarly, the proportion of depression among the DM population was escalated with the increased number of morbidity conditions from 30.4% in "no morbidity" to 35.5% in "triple or more than triple morbidity" (Table 2).

**Table 2** Morbidity and depression profile with DM (*N* = 8855)

| Comorbid diseases with DM | Frequency (%) | Depression (%) |
|---|---|---|
| Hypertension | 3236 (66.6) | 1219 (37.7) |
| Cancer | 59 (1.21) | 31 (52.5) |
| Chronic lung diseases | 422 (8.7) | 171 (40.5) |
| Chronic heart diseases | 525 (10.8) | 203 (38.7) |
| Stroke | 239 (4.9) | 106 (44.4) |
| Chronic bone/joint disease | 1092 (22.5) | 412 (37.7) |
| High cholesterol | 568 (11.7) | 206 (36.3) |
| Neurological or psychiatric problems | 172 (3.5) | 88 (51.2) |
| Multimorbidity with DM | | |
| No morbidity | 2403 (27.2) | 731 (30.4) |
| Single morbidity | 3810 (43) | 1363 (35.8) |
| Double morbidity | 1808 (20.4) | 687 (38) |
| Triple or more triple than morbidity | 834 (9.4) | 362 (43.4) |
| Total | **8855 (100)** | **3143 (35.5)** |

Table 3 presents the findings of a logistic regression study, which aimed at determining the degree of association among different morbidity categories of diabetic patients and the impact of socioeconomic position during the life course on depression in India's elderly population. The association between number of morbidities among DM and depression was directly positive and statistically significant. The odds of having depression among DM cases had significantly increased with increasing number of morbidities, for example, single morbidity (AOR, 1.24; CI, 1.102, 1.389), double morbidity (AOR, 1.34; CI, 1.155, 1.523), and triple or more than triple morbidity (AOR, 1.51; CI, 1.264, 1.800). A unit increase in education resulted in a statistically significant decrease in depressive symptoms for instance, secondary or less (AOR, 0.87; CI, 0.782, 0.975), higher secondary and above (AOR, 0.75; CI, 0.634, 0.876). Participants who perceived health as poor had higher chance of having depressive symptoms (AOR, 1.45; CI, 1.309, 1.608). When compared

**Table 3** Odds ratio for DM comorbid condition and socioeconomic status associated with depressive symptoms ($N = 8855$)

| Variable | Level | AOR with 95% CI |
|---|---|---|
| Multi morbidity with DM | No morbidity | Reference |
| | Single morbidity | 1.24*** (1.102, 1.389) |
| | Double morbidity | 1.34*** (1.155, 1.523) |
| | Triple or more than triple morbidity | 1.51*** (1.264, 1.800) |
| Age | < 50 | **Reference** |
| | 50–59 | 0.98 (0.857, 1.154) |
| | 60–69 | 0.89 (0.770, 1.039) |
| | 70–79 | 1.07 (0.904, 1.265) |
| Sex | Male | **Reference** |
| | Female | 1.05(0.945, 1.163) |
| Marital status | Married | **Reference** |
| | Others | 1.35 (0.827, 2.191) |
| Residence | Rural | **Reference** |
| | Urban | 0.98 (0.890, 1.081) |
| Caste | Scheduled Tribe (ST) | **Reference** |
| | Scheduled Caste (SC) | 0.96 (0.793, 1.153) |
| | Other Backward Class (OBC) | 0.99 (0.848, 1.162) |
| | None of the above | 0.94 (0.8014, 1.112) |
| Education | No schooling | **Reference** |
| | Secondary or less | 0.87* (0.782, 0.975) |
| | Higher s secondary and above | 0.75*** (0.634, 0.876) |
| Income quintile | Poorest | **Reference** |
| | Poorer | 0.99 (0.842, 1.177) |
| | Middle | 0.99 (0.843, 1.164) |
| | Richer | 1.03 (0.882, 1.209) |
| | Richest | 0.95 (0.811, 1.114) |
| Self-rated health | Good | **Reference** |
| | Poor | 1.45*** (1.309, 1.608) |
| Enrolled in health insurance | Yes | **Reference** |
| | No | 1.21** (1.082, 1.351) |
| Hospitalized in the past 12 months | Yes | 1.12* (1.015, 1.242) |
| | No | **Reference** |
| Type of medicine used | Yes | 1.24** (1.086, 1.421) |
| | No | **Reference** |

*$p < 0.05$, **$p < 0.005$, ***$p < 0.001$

to health-insured individuals, those without coverage had a considerably higher risk of having depression (AOR, 1.21; CI, 1.082, 1.351). Similarly, respondents who were hospitalized in the past 12 months had higher risk of acquiring depression (AOR, 1.12; CI, 1.015, 1.242) with regard to those DM patients who were not hospitalized. Greater number of odds of depression (AOR, 1.24; CI, 1.086, 1.421) was found among the respondents who were currently taking insulin injections for DM (Table 3).

Table 4 evaluates the mean difference of depression among DM cases with different category of morbidity conditions. The mean difference in depression of DM cases with different category of morbidity conditions was found statistically significant ($p = 0.000$) with $F$ value 19.63. Post hoc analysis depicts that there is a significant mean difference between double morbidity and no morbidity, triple or more than triple morbidity and no morbidity, triple or more than triple morbidity, and single morbidity and triple or more than triple morbidity and double morbidity.

## Discussion

The present study was conducted with an aim to characterize diabetic comorbidities and find out the association of DM multimorbidities with depression among older people of India by using a nationally representative data. Furthermore, this study explored the mean difference of depression

**Table 4** One-way ANOVA for mean difference of depressive score among different groups of multimorbidity with DM

| Multimorbidity with diabetic cases | M ± SD of depressive score | *F* value | *p* value |
|---|---|---|---|
| No morbidity | $3.2 \pm 1.7^{ab}$ | 19.63 | 0.0000 |
| Single morbidity | $3.3 \pm 1.7^{c}$ | | |
| Double morbidity | $3.5 \pm 1.9^{ad}$ | | |
| Triple or more than triple morbidity | $3.8 \pm 2.1^{bcd}$ | | |

Bonferroni (post hoc analysis). [a]Mean difference = 0.30 with $p = 0.000$ (double morbidity vs no morbidity). [b]Mean difference = 0.60 with $p = 0.000$ (triple or more than triple morbidity vs no morbidity). [c]Mean difference = 0.50 with $p = 0.000$ (triple or more than triple morbidity vs single morbidity). [d]Mean difference = 0.30 with $p = 0.000$. Triple or more than triple morbidity vs double morbidity

among the respondents with various diabetic comorbidities. Majority of the DM patient had suffered with several other chronic illnesses. The most prevalent comorbid condition was hypertension. Number of comorbidities, hospitalization due to disease condition, taking insulin shots to control blood glucose level, coverage of health insurance policy, and self-understood health level were significantly associated with the depressive symptoms among DM cases.

Every three out of four diabetic cases (72.8%) had at least one comorbid condition like hypertension, high cholesterol, stroke, and lung disease. This result is marginally less than the results of the numerous studies conducted worldwide, for instance, in Ontario, Canada (90%) [25]; Aragon, Spain (87%) [26]; Nijmegen region, Netherlands (84%) [27]; Bhubaneswar, India (84%) [28]; and 49 states in the US (88.5%) [11]. In contrary to these findings, the result of present paper was greater than in a study employed in Harari, Ethiopia (55.8%) [29], and Scotland (42.2%) [30]. The differences recorded across studies might be due to the variances in the target population and geographical location. Moreover, the context of socio-demographic variations and methodologies used might be ascribed for the differences. The present study highlighted that the most common comorbidity associated with DM was hypertension (66.6%) followed by chronic bone/joint disease and raised cholesterol. Similar representation was noticed in the large volume studies conducted in various parts of world like Canada [25], the Netherlands [27], the US [11], and Ethiopia [29]. Likewise, Indian studies performed in the different settings by Pati et al. [28] and Yadav et al. [31] were also in line with the current study findings by revealing a high prevalence of hypertension among DM patients.

Increased number of comorbidities among diabetic patients also increased the depressive episodes which was recorded in the present study. This observation underpins the results from various studies conducted in the past years [12, 32–34] which highlighted the relationship between DM and depression which is closely interconnected and both demonstrate a negative bidirectional association. Diabetic comorbidities also increase the chance and severity of depression which leads to non-adherence to DM self-care including medication compliance, dietary restrictions, and blood glucose monitoring [33].

The current study found that multimorbidity considerably enhanced the likelihood that diabetes subjects will have depressed symptoms [32]. DM patient with triple or more than triple morbidity had 1.5 times greater chance of developing depressive symptoms as compared to those without multimorbidity. A number of studies conducted in the past years reported the inextricable relationship between depression and multimorbidity [21, 33–36]. Findings showed that the chance of acquiring depressive symptoms dramatically increase as the number of morbidities rise. Alike our findings, Yunming et al., [35] have reported that triple or more than triple chronic conditions escalated the risk of having depression. Another study by Anderson et al. recorded that depression was greater than two times more prevalent among people with diabetic comorbidities [34]. There was significant mean difference of depressive symptoms among the diabetic multimorbidity category in our study which was similar to studies performed in Canada and Spain [25, 26]. The findings of every study listed above strengthen the significant link between DM and rising morbidities and susceptibility to mental health issues.

Poor self-rated health was one of the most reliable and positive related markers for predicting depressive symptoms over the course of an individual's life [36–38]. Reducing the multimorbidity associated with diabetes and improving educational attainment are important factors in influencing self-reported health because they lessen negative outcomes and improve quality of life [38].

Those receiving insulin injections to control their blood glucose levels had a higher odd of experiencing depressive symptoms, which was in line with the results from Korea [39]. A review paper published in 2016 also strengthen the results of the present study by revealing that insulin treatment was closely linked with the large prevalence of depressive syndromes compared with those without insulin therapy [40]. Respondents without coverage of health insurance and hospitalized in past 12 months were more likely to face depressive episodes. The possible reason for this could be due to financial limitation and out of pocket expenditure faced by patient during the treatment. The number of comorbidities among the DM patients was a major risk factor of indoor and outdoor health-care utilization [41].

The present paper had certain strengths as well as limitations. The primary strength of this paper was the national representativeness because the findings generated in this

study was based on rigorous national level survey which fosters generalization of the findings throughout India. The association between multimorbidity on diabetes patient and depression had not been extensively studied, as far as we are aware, but this is the first of its kind in India. Specifically, it examines the relationship between depressed symptoms and diabetic multimorbidity. Similarly, major limitation of this study was the establishment of causal inferences to DM multimorbidity and depressive symptoms because we adopted the cross-sectional study which limit the establishment of causal inference. Secondly, morbidity status among DM patients was measured by self-reported chronic diseases pattern which increases the chance of self-declaration bias due to under-reporting of diagnosis or forgetfulness. Finally, only eight chronic conditions apart from DM were used to determine the associated comorbidity and multimorbidity condition based on the indicator availability in the Longitudinal Ageing Study of India.

Current study provides novel insights from the various perspective. Firstly, so far most of the studies has been mapping the multimorbidity by combining all the common chronic conditions. However, this study comes with different concept by gauging presence of multimorbidity conditions from diabetes landscape and measuring the association of multimorbidity with depressive symptoms among older adults of India. Secondly, this paper has compared the mean differences in depressive symptoms based on the different category of multimorbidity on diabetes patient by applying one-way ANOVA which has not been done in the Indian context. We find that multimorbidity among DM patient is a key factor to determine depressive symptoms at later life and the number of multimorbidity among DM patients increases the chances of having depressive symptoms.

## Conclusion

Multimorbidity conditions among DM patients were highly predominant. The commonest form of comorbid condition in the patients with DM are hypertension, followed by bone and joint diseases. The numbers of co-/multimorbidities, hospitalization due to health condition, taking insulin to control blood glucose level, coverage of health insurance policy, and self-reported health status were the major risk factors for depressive symptoms among diabetic cases. Further research is mandatory to identify more granular association and trajectories of developing depression to extend quality care in clinical settings and strategic planning in public health delivery system.

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**Author contributions** GK conceptualized and wrote the initial draft. Y.S conceptualized the study and provided critical insights and manuscript revision, and AKJ conducted statistical analysis and manuscript revision. GK, AKJ, and Y.S reviewed and approved the final version of the manuscript.

**Data availability** This study uses secondary data which is publicly available on request to IIPS, Mumbai, through https://www.iipsindia.ac.in/content/LASI-data.

## Declarations

**Ethical clearance** The present investigation leveraged a secondary data which involved human subjects. The Indian Council for Medical Research (ICMR) granted ethical permission for the study, and all procedures were carried out in compliance with applicable laws and regulations. Prior to the interview, informed consent was sought from every participant.

**Ethical approval and consent to participant** This study utilized secondary data, which is freely available in public domain. Therefore, ethical approval and consent to participate are not required.

**Competing interests** The authors declare no competing interests.

## References

1. WHO EMRO | DM | DM | NCDs [Internet]. [cited 2023 Oct 2]. Available from: https://www.emro.who.int/noncommunicable-diseases/DM/index.html.
2. Saeedi P, Petersohn I, Salpea P, Malanda B, Karuranga S, Unwin N, et al. Global and regional DM prevalence estimates for 2019 and projections for 2030 and 2045: results from the International DM Federation DM Atlas, 9th edition. DM Res Clin Pract [Internet]. 2019 Nov 1 [cited 2023 Oct 2];157. Available from: https://pubmed.ncbi.nlm.nih.gov/31518657/.
3. Sinclair A, Saeedi P, Kaundal A, Karuranga S, Malanda B, Williams R. DM and global ageing among 65–99-year-old adults: findings from the International DM Federation DM Atlas, 9th edition. DM Res Clin Pract [Internet]. 2020 Apr 1 [cited 2023 Oct 21];162. Available from: https://pubmed.ncbi.nlm.nih.gov/32068097/.
4. DM [Internet]. [cited 2023 Oct 2]. Available from: https://www.who.int/news-room/fact-sheets/detail/DM.
5. Pradeepa R, Mohan V. Epidemiology of type 2 DM in India. Indian J Ophthalmol [Internet]. 2021 Nov 1 [cited 2023 Oct 2];69(11):2932–8. Available from: https://pubmed.ncbi.nlm.nih.gov/34708726/.
6. 9th edition | IDF DM Atlas [Internet]. [cited 2023 Oct 21]. Available from: https://DMatlas.org/atlas/ninth-edition/.
7. Nowakowska M, Zghebi SS, Ashcroft DM, Buchan I, Chew-Graham C, Holt T, et al. The comorbidity burden of type 2 DM mellitus: patterns, clusters and predictions from a large English primary care cohort. BMC Med [Internet]. 2019 Jul 25 [cited 2023 Oct 21];17(1). Available from: https://pubmed.ncbi.nlm.nih.gov/31345214/.

8. Pearson-Stuttard J, Holloway S, Polya R, Sloan R, Zhang L, Gregg EW, et al. Variations in comorbidity burden in people with type 2 DM over disease duration: a population-based analysis of real world evidence. EClinicalMedicine [Internet]. 2022 Oct 1 [cited 2023 Oct 21];52. Available from: https://pubmed.ncbi.nlm.nih.gov/35942273/.
9. Barnett K, Mercer SW, Norbury M, Watt G, Wyke S, Guthrie B. Epidemiology of multimorbidity and implications for health care, research, and medical education: a cross-sectional study. Lancet (London, England) [Internet]. 2012 [cited 2023 Oct 2];380(9836):37–43. Available from: https://pubmed.ncbi.nlm.nih.gov/22579043/.
10. Cicek M, Buckley J, Pearson-Stuttard J, Gregg EW. Characterizing multimorbidity from type 2 DM: insights from clustering approaches. Endocrinol Metab Clin North Am [Internet]. 2021 Sep 1 [cited 2023 May 11];50(3):531–58. Available from: https://pubmed.ncbi.nlm.nih.gov/34399960/.
11. Iglay K, Hannachi H, Howie PJ, Xu J, Li X, Engel SS, et al. Prevalence and co-prevalence of comorbidities among patients with type 2 DM mellitus. Curr Med Res Opin [Internet]. 2016 Jul 2 [cited 2023 Oct 21];32(7):1243–52. Available from: https://pubmed.ncbi.nlm.nih.gov/26986190/.
12. Fortin M, Bravo G, Hudon C, Lapointe L, Almirall J, Dubois MF, et al. Relationship between multimorbidity and health-related quality of life of patients in primary care. Qual Life Res [Internet]. 2006 Feb [cited 2023 Oct 21];15(1):83–91. Available from: https://pubmed.ncbi.nlm.nih.gov/16411033/.
13. Salive ME. Multimorbidity in older adults. Epidemiol Rev [Internet]. 2013 Jan 1 [cited 2023 Oct 21];35(1):75–83. Available from: https://pubmed.ncbi.nlm.nih.gov/23372025/.
14. Fortin M, Bravo G, Hudon C, Lapointe L, Dubois MF, Almirall J. Psychological distress and multimorbidity in primary care. Ann Fam Med [Internet]. 2006 Sep [cited 2023 Oct 21];4(5):417–22. Available from: https://pubmed.ncbi.nlm.nih.gov/17003141/.
15. Glynn LG, Valderas JM, Healy P, Burke E, Newell J, Gillespie P, et al. The prevalence of multimorbidity in primary care and its effect on health care utilization and cost. Fam Pract [Internet]. 2011 Oct [cited 2023 Oct 21];28(5):516–23. Available from: https://pubmed.ncbi.nlm.nih.gov/21436204/.
16. Bayliss EA, Steiner JF, Fernald DH, Crane LA, Main DS. Descriptions of barriers to self-care by persons with comorbid chronic diseases. Ann Fam Med [Internet]. 2003 [cited 2023 Oct 21];1(1):15–21. Available from: https://pubmed.ncbi.nlm.nih.gov/15043175/.
17. Rajput R, Gehlawat P, Gehlan D, Gupta R, Rajput M. Prevalence and predictors of depression and anxiety in patients of DM mellitus in a tertiary care center. Indian J Endocrinol Metab [Internet]. 2016 Nov 1 [cited 2023 Oct 21];20(6):746. Available from: https://www.ncbi.nlm.nih.gov/pmc/articles/PMC5105554/
18. Fortin M, Lapointe L, Hudon C, Vanasse A. Multimorbidity is common to family practice: is it commonly researched? Can Fam Physician [Internet]. 2005 Feb 1 [cited 2023 Oct 21];51(2):244–5. Available from: https://www.cfp.ca/content/51/2/244.
19. Soji DJ, Lordson J, Mini GK. Multimorbidity patterns among rural adults with Type-2 DM mellitus: A cross-sectional study in Kerala, India. WHO South-East Asia J public Heal [Internet]. 2021 Jan 1 [cited 2023 Oct 21];10(1):32–6. Available from: https://pubmed.ncbi.nlm.nih.gov/35046156/.
20. Perianayagam A, Bloom D, Lee J, Parasuraman S, Sekher T V., Mohanty SK, et al. Cohort profile: the longitudinal ageing study in India (LASI). Int J Epidemiol [Internet]. 2022 Aug 1 [cited 2023 Oct 21];51(4):E167–76. Available from: https://pubmed.ncbi.nlm.nih.gov/35021187/.
21. Singh S, Shri N, Dwivedi LK. An association between multimorbidity and depressive symptoms among Indian adults based on propensity score matching. Sci Rep [Internet]. 2022 Dec 1 [cited 2023 Oct 21];12(1). Available from: https://pubmed.ncbi.nlm.nih.gov/36109532/.
22. Radloff LS. The CES-D Scale: a self-report depression scale for research in the general population. Appl Psychol Meas [Internet]. 1977 [cited 2023 Oct 21];1(3):385–401. Available from: http://conservancy.umn.edu/handle/11299/98561.
23. Park SH, Lee H. Is the center for epidemiologic studies depression scale as useful as the geriatric depression scale in screening for late-life depression? A systematic review. J Affect Disord [Internet]. 2021 Sep 1 [cited 2023 Oct 21];292:454–63. Available from: https://pubmed.ncbi.nlm.nih.gov/34144371/.
24. Kumar S, Nakulan A, Thoppil SP, Parassery RP, Kunnukattil SS. Screening for depression among community-dwelling elders: usefulness of the center for epidemiologic studies depression scale. Indian J Psychol Med [Internet]. 2016 Sep 1 [cited 2023 Oct 21];38(5):483–5. Available from: https://pubmed.ncbi.nlm.nih.gov/27833238/.
25. Gruneir A, Markle-Reid M, Fisher K, Reimer H, Ma X, Ploeg J. Comorbidity burden and health services use in community-living older adults with DM mellitus: a retrospective cohort study. Can J DM [Internet]. 2016 Feb 1 [cited 2023 Oct 21];40(1):35–42. Available from: https://pubmed.ncbi.nlm.nih.gov/26778680/.
26. Calderón-Larrañaga A, Abad-Díez JM, Gimeno-Feliu LA, Marta-Moreno J, González-Rubio F, Clerencia-Sierra M, et al. Global health care use by patients with type-2 DM: does the type of comorbidity matter? Eur J Intern Med [Internet]. 2015 Apr 1 [cited 2023 Oct 21];26(3):203–10. Available from: https://pubmed.ncbi.nlm.nih.gov/25765442/.
27. Luijks H, Schermer T, Bor H, van Weel C, Lagro-Janssen T, Biermans M, et al. Prevalence and incidence density rates of chronic comorbidity in type 2 DM patients: an exploratory cohort study. BMC Med [Internet]. 2012 Oct 29 [cited 2023 Oct 21];10(1):1–10. Available from: https://bmcmedicine.biomedcentral.com/articles/https://doi.org/10.1186/1741-7015-10-128.
28. Pati S, Schellevis FG. Prevalence and pattern of co morbidity among type2 diabetics attending urban primary healthcare centers at Bhubaneswar (India). PLoS One [Internet]. 2017 Aug 1 [cited 2023 Oct 21];12(8). Available from: https://pubmed.ncbi.nlm.nih.gov/28841665/.
29. Ejeta A, Abdosh T, Hawulte B, Lamessa A, Fite MB, Fekadu G. dm concordant comorbidities and associated factors among adult diabetic out-patients at Hiwot Fana Specialized University Hospital, Harar, Eastern Ethiopia: a cross-sectional study. DM, Metab Syndr Obes Targets Ther [Internet]. 2021 [cited 2023 Oct 21];14:2281. Available from: /pmc/articles/PMC8149283/
30. Tinetti ME, Fried TR, Boyd CM. Designing health care for the most common chronic condition--multimorbidity. JAMA [Internet]. 2012 Jun 13 [cited 2023 Oct 21];307(23):2493–4. Available from: https://pubmed.ncbi.nlm.nih.gov/22797447/.
31. Yadav D, Mishra M, Tiwari A, Bisen PS, Goswamy HM, Prasad GBKS. Prevalence of dyslipidemia and hypertension in Indian type 2 diabetic patients with metabolic syndrome and its clinical significance. Osong Public Heal Res Perspect [Internet]. 2014 [cited 2023 Oct 21];5(3):169. Available from: https://www.ncbi.nlm.nih.gov/pmc/articles/PMC4147218/
32. Read JR, Sharpe L, Modini M, Dear BF. Multimorbidity and depression: a systematic review and meta-analysis. J Affect Disord [Internet]. 2017 Oct 15 [cited 2023 Oct 21];221:36–46. Available from: https://pubmed.ncbi.nlm.nih.gov/28628766/.
33. Katon WJ. The comorbidity of DM mellitus and depression. Am J Med [Internet]. 2008 Nov [cited 2023 Oct 21];121(11 Suppl 2). Available from: https://pubmed.ncbi.nlm.nih.gov/18954592/.
34. Anderson RJ, Freedland KE, Clouse RE, Lustman PJ. The prevalence of comorbid depression in adults with DM: a meta-analysis.

DM Care [Internet]. 2001 [cited 2023 Oct 21];24(6):1069–78. Available from: https://pubmed.ncbi.nlm.nih.gov/11375373/.
35. Yunming L, Changsheng C, Haibo T, Wenjun C, Shanhong F, Yan M, et al. Prevalence and risk factors for depression in older people in Xi'an China: a community-based study. Int J Geriatr Psychiatry [Internet]. 2012 Jan [cited 2023 Oct 21];27(1):31–9. Available from: https://pubmed.ncbi.nlm.nih.gov/21284042/.
36. Tsai HJ. Nutrition risk, functional dependence, and co-morbidities affect depressive symptoms in Taiwanese aged 53 years and over: a population-based longitudinal study. J Psychosom Res [Internet]. 2013 Aug [cited 2023 Oct 21];75(2):173–7. Available from: https://pubmed.ncbi.nlm.nih.gov/23915775/.
37. Meyer OL, Castro-Schilo L, Aguilar-Gaxiola S. Determinants of mental health and self-rated health: a model of socioeconomic status, neighborhood safety, and physical activity. Am J Public Health [Internet]. 2014 [cited 2023 Oct 21];104(9):1734. Available from: /pmc/articles/PMC4151927/
38. Dasbach EJ, Klein R, Klein BEK, Moss SE. Self-rated health and mortality in people with DM. Am J Public Health [Internet]. 1994 [cited 2023 Oct 21];84(11):1775–9. Available from: https://pubmed.ncbi.nlm.nih.gov/7977916/.
39. Noh JH, Park JK, Lee HJ, Kwon SK, Lee SH, Park JH, et al. Depressive symptoms of type 2 diabetics treated with insulin compared to diabetics taking oral anti-diabetic drugs: a Korean study. DM Res Clin Pract [Internet]. 2005 Sep [cited 2023 Oct 21];69(3):243–8. Available from: https://pubmed.ncbi.nlm.nih.gov/16046024/.
40. Bai X, Liu Z, Li Z, Yan D. The association between insulin therapy and depression in patients with type 2 DM mellitus: a meta-analysis. BMJ Open [Internet]. 2018 Nov 1 [cited 2023 Oct 21];8(11):20062. Available from: https://pubmed.ncbi.nlm.nih.gov/30498035/
41. Ye M, Vena JE, Johnson JA, Shen-Tu G, Eurich DT. Impact of comorbidity on hospitalization and emergency room visits in adults with DM: a longitudinal study of Alberta's tomorrow project. Can J DM [Internet]. 2023 Jun 1 [cited 2023 Oct 21];47(4):359–67. Available from: https://pubmed.ncbi.nlm.nih.gov/37178108/.