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BMI mediates the association of family medical history with self-reported hypertension and diabetes among older adults: Evidence from baseline wave of the longitudinal aging study in India

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ABSTRACT

Background: This study explored the association between family history of hypertension and diabetes with their diagnosis among older Indian adults. The study further examined the role of body mass index (BMI) as a potential mediator in these associations.
Methods: Data from the Longitudinal Ageing Study in India (LASI, 2017–18), wave-1 were used. The sample for the study included 31,464 older adults aged 60 years and above. Descriptive statistics and bivariate analysis has been conducted to assess the prevalence of self-reported hypertension and diabetes. Further, multivariable logistic regression models were used to test the research hypotheses of this study. The Karlson–Holm–Breen (KHB) mediation analysis was conducted to recover the direct and indirect effects of BMI in the association of family medical history and diagnosis of hypertension and diabetes.
Results: A proportion of 32.70% of older adults were diagnosed with hypertension and 14.23% of older adults were diagnosed with diabetes. A proportion of 19.48% and 14.69% of older adults had a family history of hypertension and diabetes, respectively. Also, 16.57% and 5.53% of older adults were overweight and obese, respectively in the current study. Older adults who had family history of hypertension had higher odds of being diagnosed with hypertension [aOR: 2.23, CI: 2.07–2.39] than those who had no such family history. This association was mediated by BMI (percent mediated: 6.31%). Similarly, older adults who had family history of diabetes had higher odds of being diagnosed with diabetes [aOR: 2.63, CI: 2.41–2.88] than those who had no such family history. This association was mediated by BMI (percent effect mediated: 6.66%).
Conclusion: The study highlights the relevance of using family medical history data along with information on BMI as potential source for the control and management of hypertension and diabetes among older population.

1. Background

Rapid population ageing has become a public policy concern in developing countries. Since the resources to meet the geriatric healthcare needs and other supplements are limited in developing countries, there is an urgent call for taking policy initiatives at the earliest (World Health Organization, 2015). Along with this demographic transition, epidemiological transition is also taking place at a much faster pace where the non-communicable diseases (NCDs) are expected to have major share of the disease burden (Gyasi & Phillips, 2020; Yiengprugsawan et al., 2016). Thus, the combined demographic and epidemiologic transition may significantly increase the healthcare costs and may lead to premature mortality. A multi-country study indicated that the premature mortality contributed by NCDs is the highest in low- and middle-income countries (LMICs), where a large share of the population resides (Allen et al., 2017; Kishore & Reddy, 2014).

Studies indicated that hypertension and diabetes are among the most important NCDs-related risk factors in LMICs including India (Gupta & Xavier, 2018; Kishore & Reddy, 2014). Evidence also indicated that the increased prevalence of diabetes and hypertension is challenging rural health issue in developing countries and argued for initiatives to improve detection, treatment and other prevention strategies (Fottrell et al., 2018). A study conducted in the Indian context indicated that the public health system lacked diagnostics and specialist services whereas

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the private health system was too expensive for addressing NCDs (Jayanna et al., 2019). Another recent study conducted in Indian context that aimed to provide suitable recommendations for the national program for prevention and control of cancer, diabetes and cardiovascular disease and stroke (NPCDCS) showed that besides healthcare access, screening and diagnostic factors, there should be intervention through behaviour change initiatives (e.g., smoking and drinking cessations) to address the concern (Ramani & Suresh, 2020).

Research shows that although life expectancy has increased, age-related physiological, neurological and mental changes may significantly challenge healthy ageing (World Health Organization, 2015). A longitudinal study that extensively used clinical data showed that the development of hypertension and diabetes predicts each other over time. The development of hypertension was characterized by the sharp increase in blood pressure (BP) whereas the insulin resistance feature was associated with the development of pre-diabetes, which is especially critical for individuals who gain weight over time (Tsimihodimos et al., 2018). Research also suggested that higher baseline body mass index (BMI) even within the normal range was associated with an elevated risk of hypertension and the result was consistent even after adjusting for diabetes (Gelber et al., 2007). A prospective study conducted in Cuba showed that hypertension, diabetes and higher BMI lead to premature mortality, especially due to cardiovascular diseases (CVDs) (Rojas et al., 2021). A study that compared two groups of population based on age criterion and measured the white matter hyperintensity (WMH) progression revealed that comorbid hypertension, obesity and diabetes mellitus significantly increased the ageing process (King et al., 2014).

The development of diabetes and hypertension may be attributed to genetic predisposition. There is strong evidence for the high risk of hypertension and diabetes among individuals with the family medical history of hypertension and diabetes (Annis et al., 2005; Krtalic et al., 2019; Lin et al., 1993). Therefore, the family medical history data may be used as a tool for the risk management of diabetes and hypertension. A study conducted in Gambia using middle aged adults revealed that the family medical history data should be utilized as a source of early intervention to control NCDs including hypertension, diabetes and obesity (Sande et al., 2001). However, there is a dearth of studies that focus on the linkage between family medical history of CVDs and their diagnosis in older adults, especially in LMICs where the prevalence of CVDs is higher. In this context, the present study aimed to explore the association between family history of hypertension and diabetes with their diagnosis among older adults in India. The study also examined the role of BMI as a potential mediator of the association between the family history of hypertension and diabetes with their diagnosis (Fig. 1).

2. Methods

2.1. Data

2.1.1. Study design and sample

A cross-sectional study design was adopted. We used data for the study from the longitudinal ageing study in India (LASI), baseline wave, that were collected during 2017–18. The LASI is a nationally representative survey of over 72000 individuals aged 45 and above and their spouses regardless of age, across all states and union territories of India. The main objective of the survey was to study the health status and the socioeconomic well-being of older adults in India. The present study is conducted on eligible respondents aged 60 years and above. The total sample for the present study included 31,464 older adults aged (men-15,098 and women-16,366) (Fig. 2).

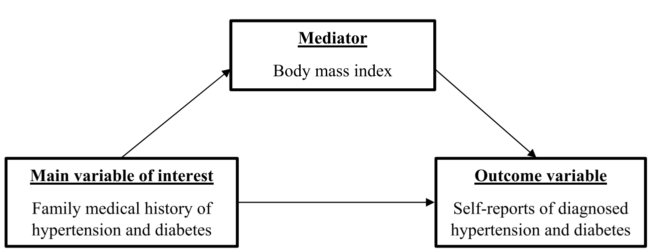

Fig. 1. Conceptual model of the study.

2.1.2. Data collection procedure

The LASI survey adopted a three-stage sampling design in rural areas and a four-stage sampling design in urban areas. In each state/union territory (UT), the first stage involved the selection of primary sampling units (PSUs), that is, sub-districts (Tehsils/Talukas), and the second stage involved the selection of villages in rural areas and wards in urban areas in the selected PSUs. In rural areas, households were selected from selected villages in the third stage. However, sampling in urban areas involved an additional stage. Specifically, in the third stage, one census enumeration block (CEB) was randomly selected in each urban area. In the fourth stage, households were selected from this CEB. The goal was to select a representative sample in each stage of sample selection. Further, an individual survey schedule was administered to each consenting respondent aged 45 and above and their spouses (irrespective of age) in the sampled households. In addition, the LASI includes an individual module on biomarkers and direct health examination. The detailed methodology, with the complete information on the survey design and data collection, is provided in the survey report (International Institute for Population Sciences (IIPS), 2020). The survey agencies that conducted the field survey for the data collection have collected prior consent from the respondents. The Indian Council of Medical Research (ICMR) extended the necessary guidelines and ethics approval for undertaking the LASI survey.

2.3. Measures

2.3.1. Outcome variables

Self-reports of diagnosed hypertension and diabetes were the outcome variables in the study. These chronic conditions were assessed using the question "has any health professional ever diagnosed you with the following chronic conditions or diseases?" The responses were no and yes; and therefore, considered as self-reported conditions. Studies conducted among community-dwelling older adults suggest that patients' self-report of chronic diseases are fairly accurate except some diseases like arthritis (Kriegsman, Penninx, Van Eijk, Boeke, & Deeg, 1996).

2.4. Explanatory variables

2.4.1. Key explanatory variables

The family history of hypertension and diabetes was measured using the question "We would like to know about the medical history of your family. Could you tell me if your father, mother, brother, sister, children, grandchildren, has ever been diagnosed with the following diseases? Please only refer to blood-related family members". If the individual reported the history of disease among any of the above mentioned family members, they were considered as having family history of respective disease and otherwise, no.

Another key explanatory variable which was considered in the mediation analysis was body mass index (BMI) of older adults. BMI was recoded as underweight (less than 18.5 kg/m^2), normal (18.5–24.9 kg/m^2), overweight (25–29.9 kg/m^2) and obese (30 kg/m^2 and above) (Zhang et al., 2020).

2.5. Other covariates

2.5.1. Socio-demographic characteristics

Age was categorized into age groups of 60–69 years, 70–79 years,

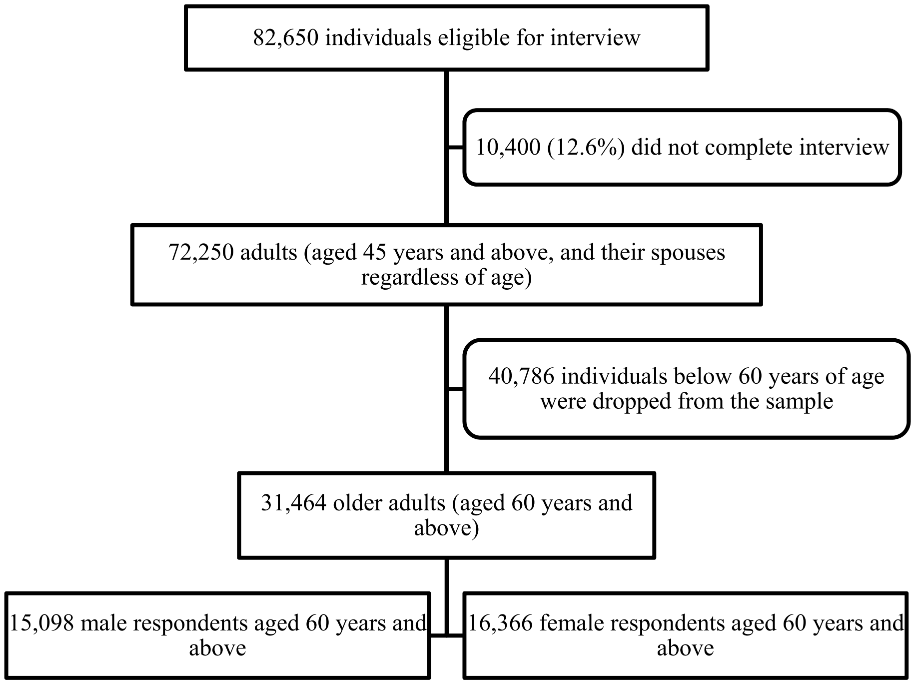

Fig. 2. Flowchart of the sample selection criteria in this study.

and 80+ years. Sex was coded as male and female. Marital status was coded as currently in union, widowed and others. Others included those who were divorced/separated/never married. Educational status was coded as no education/primary, secondary and higher. Work status was coded as never worked, currently not working, working, and retired.

2.5.2. Health and behavioral factors

The following variables were included in the analysis due to their association with outcome variables as previously reported in the literature (Joshi & Parikh, 2007; Kumar et al., 2022; Manchanda & Madan, 2014; Mishra et al., 2022; Venkataraman et al., 2013). Moderate physical activity was measured through the question, "How often do you do activities such as cleaning house, washing clothes by hand, fetching water or wood, drawing water from a well, gardening, bicycling at a regular pace, walking at a moderate pace, dancing, floor or stretching exercises? The responses were every day, more than once a week, once a week, one to three times in a month and hardly ever or never, The variable was dichotomized to yes (every day, more than once a week, once a week, one to three times in a month), and no (hardly ever or never). Similarly, the question through which vigorous physical activity was assessed was "How often do you take part in sports or vigorous activities, such as running or jogging, swimming, going to a health centre or gym, cycling, or digging with a spade or shovel, heavy lifting, chopping, farm work, fast bicycling, cycling with loads"? Vigorous physical activity was categorized as yes (every day, more than once a week, once a week, one to three times in a month), and no (hardly ever or never).

The yoga/meditation variable was generated using the survey question, "How often do you engage in the activities such as yoga, meditation, asana, pranayama or similar?" The variable was dichotomized as yes (every day, more than once a week, once a week, one to three times in a month), and no (hardly ever or never). The heavy episodic alcohol drinking use was assessed with the question, "In the last 3 months, how frequently on average, have you had at least 5 or more drinks on one occasion?", and defined as yes if the response was "one to three days per month, one to four days per week, five or more days per week, or daily". Similarly, current tobacco use was sourced from two items, (1) "Do you currently smoke any tobacco products (cigarettes, *bidis*, cigars, hookah, cheroot, etc.)?" and (2) "Do you use smokeless tobacco (such as chewing tobacco, *gutka*, *pan masala*, etc.)?" Both the variables were dichotomized to yes and no. Finally, self-rated health was available on a scale of five which represents very good, good, fair, poor and very poor, which was recoded as good, representing very good, good and fair; and poor, representing poor and very poor.

2.5.3. Household/community characteristics

The monthly per-capita consumption expenditure (MPCE) quintile was assessed using household consumption data. Sets of 11 and 29 questions on the expenditures on food and non-food items, respectively, were used to canvas the sample households. Food expenditure was collected based on a reference period of seven days, and non-food expenditure was collected based on reference periods of 30 days and 365 days. Food and non-food expenditures have been standardized to the 30-day reference period. The MPCE is computed and used as the summary measure of consumption (International Institute for Population Sciences (IIPS), 2020). The variable was divided into five quintiles, i.e., from poorest to richest. Religion was recoded as Hindu, Muslim and Others. Caste was recoded as Scheduled Caste (SC), Scheduled Tribe (ST), Other Backward Classes (OBC), and others (Srivastava et al., 2021). The caste system in India has its roots in the earlier *varna* (color) system that represented a social hierarchy based on notions of purity and pollution. This system has evolved over time into or combined with the *jati* system. Today, The SC and ST are considered the most disadvantaged social groups in the country. OBC refers to the large intermediate group of the population who are more advantaged than SC/ST, but less advantaged compared to the others category which mainly consists of the upper castes and the socioeconomically advantaged. The place of residence was coded as urban and rural. The region was coded as North, Central, East, Northeast, West, and South.

2.5.4. Statistical analyses

In this study, descriptive statistics and bivariate analysis has been conducted to assess the prevalence of self-reported hypertension and diabetes. Further, multivariable logistic regression models were used to test the hypotheses of this study. The results are presented in the form of adjusted odds ratio (aOR) with 95% confidence interval (CI). Individual weights were used to make the estimates nationally representative.

For the mediation analysis of BMI in the observed associations of family history of disease and hypertension and diabetes, the total effect in the observed association was divided into direct effects and indirect or mediating effects using Karlson–Holm–Breen (KHB) method (Karlson et al., 2012; Karlson & Holm, 2011). The direct effect is the association of family medical history with diagnosis of hypertension and diabetes after controlling for BMI and other covariates. The indirect effect refers to the mediation effect of BMI in the association of family medical history with disease diagnosis. The KHB method is a recently developed method for assessing mediating effects that allow total effects to be divided into direct and indirect (i.e., mediation) effects for both discrete and continuous variables. The mediation percentage (the indirect effect divided by the total effect) is interpreted as the percentage of the association explained by the mediator variable. The mediated percentage was only considered significant when the total and indirect effects were significant. Moreover, the KHB method allows researchers to include other confounding variables (as concomitants) into the models without the scale identification issue to control the decomposition of any potential confounding factors. The KHB method was increasingly used in recent population-based studies (Kendig et al., 2017; Malaju et al., 2022; Muhammad et al., 2022) and is implemented by a user-written *khb* command in Stata which applies decomposition properties of linear models to the *logit* model. For all the analyses, STATA version 14.2 has been used.

3. Results

Table 1 presents the sample characteristics and the prevalence estimates of hypertension and diabetes among older adults by their background characteristics. A proportion of 32.70% of older adults were diagnosed with hypertension and 14.23% of older adults were diagnosed with diabetes. A proportion of 19.48% and 14.69% of older adults had a family history of hypertension and diabetes, respectively. In the study, 11.29% of older participants were aged 80 years and above, 52.60% were females and 36.20% were widowed. A proportion of 31.10% and 9.51% were engaged in vigorous and moderate physical activities, respectively. 13.71% did yoga and related activities, 5.35% reported heavy episodic alcohol and 25.46% were current tobacco users in the study. Also, 16.57% and 5.53% of older adults were overweight and obese, respectively in the current study.

A proportion of 51.75% of older adults had a family history of hypertension were diagnosed with hypertension, compared to 28.33% of those who had no such family history, and 24.14% of older adults had a family history of diabetes were diagnosed with diabetes, compared to 11.93% of those who had no such family history.

Table 2 provides the multivariable regression estimates of family history of disease and diagnosis of hypertension and diabetes. Older adults who had a family history of hypertension had higher odds of being diagnosed with hypertension [aOR: 2.08, CI: 1.81–2.40] in comparison to those who had no family history of hypertension. Similarly, older adults who had a family history of diabetes had higher odds of being diagnosed with diabetes [aOR: 2.67, CI: 2.19–3.26] in comparison to those who had no family history of diabetes. Moreover, older adults who were overweight [aOR: 1.88, CI: 1.63–2.17] or obese [aOR: 2.66, CI: 2.03–3.48] had higher odds of being diagnosed with hypertension compared to their counterparts with normal BMI. Also, older adults who were overweight [aOR: 1.80, CI: 1.50–2.15] or obese [aOR: 1.88, CI: 1.37–2.59] had higher odds of being diagnosed with diabetes compared to their counterparts with normal BMI.

Table 3 presents the mediated multivariable regression estimates of hypertension and diabetes. Older adults who had family history of hypertension had higher odds of being diagnosed with hypertension [aOR: 2.23, CI: 2.07–2.39] than those who had no such family history. This association was mediated by BMI (percent mediated: 6.31%). Similarly, older adults who had family history of diabetes had higher odds of being

Table 1
Sample distribution and prevalence of self-reported diagnosis of hypertension and diabetes by background characteristics among older adults.

Variables	Distribution		Hypertension		Diabetes	
	Frequency	cw%	rw%	p-value	rw%	p-value
Family history of hypertension				<0.001		
No	24,977	80.52	28.33			
Yes	6,487	19.48	51.75			
Family history of diabetes						<0.001
No	26,701	85.31			11.93	
Yes	4,763	14.69			24.14	
Age (in years)				<0.001		<0.001
60–69	18,974	58.51	31.20		14.51	
70–79	9,101	30.20	35.24		15.44	
80+	3,389	11.29	34.45		9.81	
Sex				<0.001		<0.001
Male	15,098	47.50	27.95		14.61	
Female	16,366	52.60	37.10		13.94	
Marital status				<0.001		<0.001
Currently in union	19,920	61.63	30.65		14.81	
Widowed	10,719	36.20	36.80		13.37	
Others	825	2.17	25.96		13.48	
Educational status				<0.001		<0.001
No/primary	23,289	74.02	29.10		10.15	
Secondary	5,741	18.24	41.83		24.55	
Higher	2,434	7.74	47.18		29.87	
Work status				<0.001		<0.001
Never worked	8,315	26.43	43.29		18.25	
Not working	11,467	36.45	32.91		13.64	
Working	9,397	29.87	20.69		8.51	
Retired	2,282	7.25	43.61		26.41	
Vigorous physical activity				<0.001		<0.001
No	21,653	68.90	36.07		15.46	
Yes	9,545	31.10	25.38		11.49	
Moderate physical activity				<0.001		<0.001
No	28,198	90.49	37.15		20.48	
Yes	2,812	9.51	32.23		13.57	
Yoga/ meditation				<0.001		<0.001
No	26,457	86.29	31.42		13.39	
Yes	4,726	13.71	41.13		19.50	
Heavy episodic alcohol				<0.001		<0.001
No	29,163	94.65	33.48		14.58	
Yes	2,044	5.35	19.95		8.17	
Current tobacco use				<0.001		<0.001
No	20,024	74.54	37.29		17.13	
Yes	5,994	25.46	25.19		9.55	
Body mass index				<0.001		<0.001
Normal	14,528	51.02	30.63		12.82	
Underweight	6,524	26.89	18.15		4.23	
Overweight	5,120	16.57	50.46		27.98	
Obese	1,633	5.53	66.39		34.09	
Self-rated health				<0.001		<0.001
Good	23,341	75.79	29.99		12.60	
Poor	7,457	24.21	41.39		19.56	
MPCE quintile				<0.001		<0.001
Poorest	6,829	21.70	25.97		9.90	
Poorer	6,831	21.71	28.75		10.34	
Middle	6,590	20.95	31.60		12.63	
Richer	6,038	19.19	37.72		18.21	
Richest	5,175	16.45	42.78		22.58	
Caste				<0.001		<0.001
SC	5,140	18.91	27.73		9.74	
ST	5,173	8.12	18.44		6.12	
OBC	11,886	45.23	33.13		15.92	
Others	9,265	27.74	39.85		17.02	
Religion				<0.001		<0.001

(*continued on next page*)

Table 1 (*continued*)

Variables	Distribution		Hypertension		Diabetes	
	Frequency	cw%	rw%	p-value	rw%	p-value
Hindu	25,871	82.20	31.69		14.08	
Muslim	3,548	11.30	37.00		13.27	
Others	2,045	6.50	39.49		18.10	
Place of residence				<0.001		<0.001
Urban	22,196	29.45	47.08		26.15	
Rural	9,268	70.55	26.90		9.37	
Region				<0.001		<0.001
North	3,960	12.59	38.67		12.61	
Central	6,593	20.95	21.41		8.27	
East	7,439	23.64	30.56		10.04	
Northeast	935	2.97	37.17		8.92	
South	5,401	22.68	39.71		23.92	
West	7,136	17.17	35.69		16.98	
Total	31,464	100	32.70		14.23	

Notes: Frequencies are unweighted; cw%: weighted column percentage distribution of sample; rw%: weighted row percentage prevalence to account for national population estimates; SC: Scheduled Caste, ST: Scheduled Tribe, OBC: Other Backward Class, MPCE: Monthly per capita consumption expenditure.

diagnosed with diabetes [aOR: 2.63, CI: 2.41–2.88] than those who had no such family history. This association was mediated by BMI (percent effect mediated: 6.66%).

4. Discussion

The current study explored the association between family medical history of hypertension and diabetes and their diagnosis considering BMI as a potential mediator. The results indicated that the prevalence of hypertension and diabetes among Indian older adults were about 33% and 14%, respectively. The prevalence rate was comparable with other contemporary studies conducted in India. However, these studies highlight the different level of the prevalence of these condition by socioeconomic, demographic and regional variations, which is a public health policy concern to be addressed (Chauhan et al., 2021; Jana & Chattopadhyay, 2022). A study indicated that both diabetes and hypertension are the common pair of multi morbidity prevalence among older adults (Anushree & Mishra, 2022). A large-scale study using data of 1.3 million adult population indicated that the prevalence of hypertension and diabetes is common among middle aged and older adults and urge the importance of prevention, timely detection and treatment (Geldsetzer et al., 2018). Recent studies also indicated that the actual prevalence of diabetes and hypertension are likely to be higher due to a high rate of their unidentified cases in India (Bhatia et al., 2021; Joshi et al., 2012). We urge for better policy and program implementation to manage hypertension and diabetes since they are the major contributors to health loss (Bromfield & Muntner, 2013; Lin et al., 2020; Tandon et al., 2018).

The findings revealed that older adults with the history of hypertension and diabetes among their blood related family members were more likely to be diagnosed with hypertension and diabetes. Previous studies have established similar associations in various contexts (Liu et al., 2015; Sakurai et al., 2013; Shukuri et al., 2019). Similarly, a study conducted in Japan indicated that family history of hypertension is likely to influence adults to undergo for a genetic testing (Takeshima et al., 2017). Therefore, family medical history may be considered as an inexpensive genomic information for the management of diabetes and hypertension (Annis et al., 2005). Furthermore, older adults in this study with increased BMI had higher odds of being diagnosed with hypertension and diabetes. Consistent with the current findings, past research established that low body weight is an independent protective factor for hypertension (Tang et al., 2022), whereas overweight/obesity are risk factors for hypertension and diabetes (Chen et al., 2018; Medhi et al., 2021; Min & Cho, 2018; Tang et al., 2022). Similarly, studies indicated

Table-2

Multivariable logistic regression estimates of self-reported diagnosis of hypertension and diabetes by socioeconomic and health characteristics among older adults.

Variables		Hypertension	Diabetes
		aOR (95% CI)	aOR (95% CI)
Family history of hypertension	No	Ref.	
	Yes	2.08*** (1.81–2.40)	
Family history of diabetes	No		Ref.
	Yes		2.67*** (2.19–3.26)
Age	60–69	Ref.	Ref.
	70–79	1.20** (1.07–1.36)	1.06 (0.87–1.28)
	80+	1.33* (1.06–1.66)	0.68* (0.48–0.97)
Sex	Male	Ref.	Ref.
	Female	1.12 (0.98–1.28)	0.64*** (0.54–0.77)
Marital status	Currently in union	Ref.	Ref.
	Widowed	0.71 (0.42–1.20)	1.37 (0.63–2.98)
	Others	0.47* (0.26–0.86)	1.36 (0.58–3.18)
Education	No/primary	Ref.	Ref.
	Secondary	1.39*** (1.18–1.64)	1.56*** (1.25–1.95)
	Higher	1.38** (1.10–1.74)	1.40* (1.07–1.83)
Work status	Never worked	Ref.	Ref.
	Not working	0.85* (0.74–0.98)	0.84 (0.69–1.02)
	Working	0.61*** (0.51–0.72)	0.50*** (0.39–0.64)
	Retired	0.93 (0.74–1.17)	0.94 (0.70–1.24)
Vigorous physical activity	No		
	Yest	0.88 (0.77–1.01)	0.95 (0.79–1.15)
Moderate physical activity	No		
	Yes	1.01 (0.81–1.25)	0.96 (0.73–1.27)
Yoga/meditation	No		
	Yes	1.22** (1.06–1.41)	1.16 (0.95–1.41)
Heavy episodic alcohol	No		
	Yes	0.80 (0.64–1.02)	0.78 (0.56–1.08)
Current tobacco use	No		
	Yes	0.84** (0.75–0.95)	0.85* (0.72–1.00)
Body mass index	Normal		
	Underweight	0.57*** (0.50–0.65)	0.35*** (0.28–0.44)
	Overweight	1.88*** (1.63–2.17)	1.80*** (1.50–2.15)
	Obese	2.66*** (2.03–3.48)	1.88*** (1.37–2.59)
Self-rated health	Good	Ref.	Ref.
	Poor	1.72*** (1.53–1.93)	1.93*** (1.66–2.26)
MPCE quintile	Poorest	Ref.	Ref.
	Poorer	1.13 (0.96–1.33)	0.90 (0.72–1.14)
	Middle	1.22* (1.04–1.44)	1.00 (0.79–1.25)
	Richer	1.36*** (1.15–1.61)	1.31* (1.02–1.69)
	Richest		

(*continued on next page*)

Table-2 (*continued*)

Variables		Hypertension aOR (95% CI)	Diabetes aOR (95% CI)
		1.40*** (1.17–1.67)	1.46** (1.14–1.88)
Religion	Hindu	Ref.	Ref.
	Muslim	1.21* (1.04–1.40)	0.89 (0.73–1.08)
	Others	1.21* (1.02–1.44)	1.17 (0.94–1.46)
Caste	SC	Ref.	Ref.
	ST	0.69*** (0.55–0.86)	0.82 (0.58–1.15)
	OBC	1.03 (0.87–1.23)	1.25 (1.00–1.56)
	Others	1.09 (0.92–1.31)	1.11 (0.87–1.40)
Place of residence	Urban	Ref.	Ref.
	Rural	0.76*** (0.68–0.86)	0.61*** (0.52–0.72)
Region	North	Ref.	Ref.
	Central	0.62*** (0.53–0.72)	0.97 (0.78–1.22)
	East	0.96 (0.82–1.11)	1.11 (0.90–1.36)
	Northeast	1.17 (0.97–1.40)	0.85 (0.65–1.11)
	West	1.05 (0.88–1.24)	1.94*** (1.57–2.40)
	South	1.06 (0.90–1.25)	1.54*** (1.25–1.89)

Notes: * if p-value <0.05, ** if p-value <0.005, *** if p-value <0.001; aOR: OR adjusted for all the covariates, CI: confidence interval, SC: Scheduled Caste, ST: Scheduled Tribe, OBC: Other Backward Class, MPCE: Monthly per capita consumption expenditure.

Table 3
Direct and indirect effects of family history of hypertension and diabetes with diagnosed hypertension and diabetes.

	Hypertension aOR (95% CI)	Diabetes aOR (95% CI)
Family history of hypertension		
Total effect	2.23*** (2.07–2.39)	
Direct effect	2.12*** (1.97–2.27)	
Indirect effect of body mass index	1.05*** (1.04–1.07)	
Family history of diabetes		
Total effect		2.63*** (2.41–2.88)
Direct effect		2.47*** (2.26–2.70)
Indirect effect of body mass index		1.07*** (1.05–1.09)
PEM	6.31	6.66

Notes: aOR: OR adjusted for age, sex, education, marital status, work status, physical activity (vigorous and moderate), yoga/meditation, tobacco use, alcohol use, self-rated health, MPCE quintiles, religion, caste, place of residence and regions.
PEM: Percent of effect mediated.

that lower body weight may significantly reduce the risk of diabetes and hypertension (Amador et al., 2006; Pinto & Beltrán-Sánchez, 2015). Further research indicated that in comparison to normal BMI, relatively obese individuals were at a high risk for comorbidity, particularly in case of hypertension and diabetes (Kivimäki et al., 2022; Min & Cho, 2018).

The results also showed significant mediation effects of BMI in the observed associations. The findings are consistent with studies conducted among middle aged and older adults suggesting that BMI is associated with hypertension and it mediates the association of socioeconomic status and incidence of hypertension (Channanath et al., 2015; Rana et al., 2020; Shihab et al., 2012). A previous study conducted in Cuba indicated a high risk of CVDs-related mortality as a result of these associations (Rojas et al., 2021). Another study showed that there is strong mediation effect of childhood insulin level with the childhood BMI status and that ultimately increases the risk of hypertension during adulthood and later life (Zhang et al., 2016). It is also shown that the higher prevalence of hypertension and diabetes among those with overweight/obesity could be determined by dyslipidemia which is attributed to the elevated levels of cholesterol or fats (lipids) (Tang et al., 2022). Therefore, the role of health risk behaviour, food intake, and other genetic factors needs to be explored further to better understand BMI classification and hypertension and diabetes. Also, policies and programs should be developed in terms of controlling/managing of burden of obesity as a potentially modifiable risk factor of hypertension and diabetes as found in previous studies (Gill et al., 2021; Masaki et al., 1997). Such lifestyle-related modifiable factors may include physical activity engagement and cessation of health risk behaviour as well, which need to be further investigated.

The findings further suggest that hypertension increased with age, which is consistent with existing literature. Generally, high blood pressure among older adults is associated with the structural changes in the arteries and increases the risk of other NCDs (Pinto, 2007). However earlier detection and proper management of hypertension may reduce unnecessary health outcomes. The results indicated that older adults aged 80 years and above had a lower likelihood of diabetes than older adults aged 60–69 years. Though ageing is considered as a potential risk factor of diabetes (Fazeli et al., 2020), prevalence of diabetic system among young adults is common. Studies related to the screening of diabetes reiterate the importance of timely identification and follow-up interventions to reduce CVDs and mortality risks (Sattar et al., 2019; US Preventive Services Task Force, 2021). The results also indicated that female older adults had lower odds of diabetes, which is in line with the previous evidence (Nordström et al., 2016). A study conducted in Australian context showed that gender-specific determinants of the incidence of diabetes is important and is a challenging task for healthcare professionals and diabetes management policy intervention (Grant et al., 2009).

The findings also indicated that older adults who had higher education were more likely to diagnose with hypertension than older adults with no schooling. There is mixed evidence of the association between educational attainment and prevalence of hypertension (Bosu et al., 2019; Lloyd-sherlock et al., 2014; Wang et al., 2006). A study based on hypertensive outpatients indicated that most hypertensive patients had higher levels of education and concluded that education may be associated with greater awareness and healthcare utilization (Tedesco et al., 2001). Research also suggests that population with educational advantage are more likely to diagnose hypertension as they utilise healthcare more than less educated ones do (Sun et al., 2022), which might have led to high prevalence of hypertension among more educated older adults in the present study. Similarly, it is revealed that diabetes prevalence was higher among more educated older adults which is consistent with a previous study using data from 29 LMICs (Seiglie et al., 2020). A study conducted in Korea revealed that educational attainment moderates the association between diabetes and adverse health outcomes (Kim, 2016), indicating the need for developing policies that reach out to uneducated population and make them aware of healthcare services for hypertension and diabetes. Compared to older adults who never worked in their lifetime, those who were currently working and not working were unlikely to diagnose with hypertension and diabetes. A systematic review of longitudinal studies found varying evidence of the association between work status and the incidence of diabetes and hypertension stressing the relevance of contextual factors (Rumball-smith et al., 2014; Xue et al., 2020).

Among the behavioral factors, it was found that neither vigorous nor moderate physical activity had any effect on hypertension and diabetes. A review identified that physical activity had an inconsistent effect in determining hypertension (Bosu et al., 2019). However, there is strong evidence from literature that physical activity engagement significantly reduces the hypertension among middle aged and older adults (Ben-Sira & Oliveira, 2007; Stewart et al., 2005; You et al., 2018). Similarly previous studies indicated a protective effect of physical activity engagement against diabetes (Demakakos et al., 2010; Kumar et al., 2022; Taylor, 2014). Contrarily, the current study also indicated that older adults engaged in yoga/meditation had higher odds of reporting hypertension. Literature indicated a significant positive effect of yoga in managing hypertension (Cohen, 2013; Hagins et al., 2013). The finding might be explained by the possible reverse causality where hypertensive older adults are recommended to engage in physical activity including yoga. The results revealed that alcohol drinking had no significant effect on hypertension and diabetes whereas tobacco users had a lower likelihood of reporting hypertension and diabetes. Contrary to our findings, studies indicated that both alcohol consumption and tobacco use increased the prevalence and incidence of hypertension and other CVDs (Mukamal, 2006; Venkataraman et al., 2013). However, studies indicated that the frequency of alcohol consumption and drinking (light, moderate and heavy) may have differential effects on the incidence of hypertension and diabetes (Ding et al., 2020; Djousse et al., 2007; Rimm et al., 1995; Shi et al., 2013). This needs to be further investigated.

It was further revealed that older adults with poor SRH had high odds of reporting hypertension and diabetes, which is in line with the existing literature (Noh et al., 2019; Wennberg et al., 2013; Yang et al., 2021). Older adults from higher economic background had a higher likelihood of hypertension and diabetes. In line with this, it was found that there is a concern of the "disease of affluence", which indicates the possibility of high prevalence of NCDs among individuals from better socioeconomic background (Ezzati et al., 2005). This is also possible due to the educational advantage among the population with better socioeconomic status as they are likely to utilise healthcare facilities (Awoke et al., 2017; Figar et al., 2006). Therefore, the prevalence of unidentified NCDs among population from lower socioeconomic background may remain as an unaddressed policy concern. The findings also indicated that rural residents were less likely to diagnose with hypertension and diabetes than urban residents, which is similar to recent study conducted in the Indian context (Chauhan et al., 2021). However, another recent study on the prevalence of hypertension and diabetes among Indian adult population found mixed evidence on the rural vs urban difference in the prevalence of hypertension and diabetes (Geldsetzer et al., 2018) which suggests the need for further investigation.

The use of nationally representative large sample data of older adults is the major strength of the study. The large number of confounding factors considered in the current study increases the validity of the findings. However, the study is not free from limitations. Firstly, we measured the family medical history based on self-reported data, which may be subject to recall bias and reporting error. Similarly, the outcome measures of diagnosis of hypertension and diabetes are reported by respondents and there is recent evidence that both the diseases are underdiagnosed and untreated among older Indian adults (Mohanty et al., 2021; Swami et al., 2015). This needs to be addressed in future studies considering the measured hypertension and diabetes in association with family medical history. Secondly, we used several self-reported measures as potential predictor variables. For example, SRH is a good proxy used for measuring overall health status, however, the self-reporting may be influenced by the subjectivity of respondents. Further, the KHB mediation analysis was not controlled for the effects of exposure-mediator interaction and other interactions on outcome variables (Coman et al., 2017; Rijnhart et al., 2021). The causal effects in the mediation modeling along with the other possible pathways in the observed associations need to be considered in future studies. Finally, the study considers the mediation effect of BMI and future research should consider other potential mediators of hypertension and diabetes including metabolic factors, for which information was not available in the LASI dataset.

5. Conclusion

The findings revealed that older adults with the history of hypertension and diabetes among their blood related family members are more likely to diagnose with hypertension and diabetes. The study also revealed a significant mediation effect of BMI between the association of family history of hypertension and diabetes with their diagnosis among older individuals. The study highlights the relevance of using family medical history data along with information on BMI as potential source for the control and management of hypertension and diabetes among older population.

Ethics approval and consent to participate

The survey agencies that conducted the field survey for the data collection have collected prior informed consent (written and verbal) from all the participants. The Indian Council of Medical Research (ICMR) extended the necessary guidance and ethical approval for conducting the LASI survey.

All methods were carried out in accordance with relevant guidelines and regulations by the ICMR.

Consent for publication

Not applicable.

Data sharing statement

The study uses secondary data which is available on request through https://www.iipsindia.ac.in/content/lasi-wave-i.

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Contributor statement

Conceived and designed the research paper: TM and SIR; analyzed the data: TM; Wrote the manuscript: CVI and TM; Refined the manuscript: TM and SIR. All authors read, reviewed and approved the manuscript.

Declaration of competing interest

The authors declare that there is no competing interest.

Data availability

The study uses secondary data which is available on request through https://www.iipsindia.ac.in/content/lasi-wave-i

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