# Evolving Landscape of Diabetes Epidemic in Southeast Asia: Insights from National Family Health Survey

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## Abstract

**Background:** Limited evidence on diabetes prevalence trends from the Indian subcontinent prompted this study to estimate the trends in diabetes prevalence using the National Family Health Survey (NFHS) data. **Method:** A cross-sectional survey carried out between 2015–2016 (NFHS-4) and 2019–2021 (NFHS-5) in a nationally representative sample of adults (aged 20 to 54 years) was used. Diabetes was defined as the presence of: diagnosed diabetes (self-reported), fasting plasma glucose (FPG) ≥ 126 mg/dl, or a random plasma glucose (RPG) ≥200 mg/dl. "Fasting" was defined as the last food intake >8 hours and "random" as irrespective of the last meal. Diagnosed diabetes was defined as the presence of "self-reported diabetes" and undiagnosed diabetes was defined as FPG > 126 mg/dl or RPG ≥200 mg/dl. **Findings:** The crude prevalence of total diabetes increased from 3.5% (95% confidence interval (CI): 3.46–3.55) in 2015–2016 to 3.99% (95% CI: 3.94–4.04) in 2019–2021, a relative change of 14%. The increase was more in the poorest (1.77% vs 2.48%; $P < 0.001$) as compared to the rich (5.35%% vs· 5.43%; $P = 0.847$), rural areas (2.71% vs 3.38%; $P < 0.001$) as compared to urban (4.95% vs. 5.26%; $P = 0.051$), in normal weight individuals (1.87% vs. 2.16%; $P < 0.001$) as compared to obese (7.12% vs. 7.03%; $P = 0.384$). **Interpretation:** While the absolute prevalence of diabetes is highest amongst individuals residing in urban areas belonging to the rich wealth centile, the relative increase in the prevalence is disproportionately higher in those residing in rural areas, belonging to the poorest wealth centiles and having normal weight.

**Keywords:** Diabetes, India, prevalence, Southeast Asia, trends

## Introduction

The global prevalence of diabetes continues to grow at an alarming rate, and it is estimated that by 2045, 700 million people will be living with diabetes. Of these, 153 million will be living in the Southeast Asian Region (SEAR) alone, with the maximum contribution by India.[1] India is one of the member countries of the World Health Organization SEAR. It belongs to a low- to middle-income country with a heterogeneous income and literacy structure and its administrative structure comprises 29 states and 7 union territories.[2] Despite having a maximum number of individuals with diabetes, the data on its prevalence using a nationally representative sample are limited.[3,4] In addition, the estimates of trends in diabetes prevalence are limited from the Indian subcontinent.[5-9] The current study aimed to estimate the prevalence and trend of total, undiagnosed, and diagnosed diabetes using data from the fourth and fifth rounds of the National Family Health Survey (NFHS).

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## Methodology

### The NFHS-4 and 5

NFHS is a multiround national survey carried out every five years with the objective of generating national and state-level data on health and family welfare and emerging health issues. Beginning from 1992 to 1993, a total of five rounds have been carried out. In addition to the health and family welfare parameters, NFHS-4 (2015–2016) and NFHS-5 (2019–2021) also collected data on non-communicable diseases.[10,11] A multistage stratified, probability proportional to size systematic sampling method was used to identify households to be interviewed across 707

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districts, seven union territories, and 29 states.[12,13] Data collection was done by an in-home interview by trained field workers using a computer-assisted personal interviewing technique and four uniform survey schedules/questionnaires for: households, women, men, and biomarkers. Household questionnaires were used to identify eligible women (age 15–49 years) and men (age 15–54 years) for individual interviews and biomarkers assessment. While the data for women were collected at district levels by interviewing all eligible women, for men, it was collected at the state level by interviewing eligible men in 15% of the randomly selected households. The response rate was 97% and 92% in NFHS-4 and 5, respectively.[12,13]

To access and analyse the data, permission was sought from the Demographic and Health Survey Program (DHS) and ethical clearance was sought from the institutional ethics committee (IEC-113/03.03.2023). NFHS uses a standardized questionnaire to collect information on age, sex, place of residence, ethnicity, and smoking. The wealth index was ascertained by giving scores derived using principal component analysis to each household based on the number and kinds of consumer goods they own. National wealth quintiles were compiled by assigning the household score to each usual (*de jure*) household member, ranking each person in the household population by their score, and then dividing the distribution into five equal categories (poorest, poorer, middle, richer, richest), each with 20% of the population. In addition, the NFHS-4 and NFHS-5 had the following provisions to ascertain the glycaemic status: a) question pertaining to the presence of diabetes "Do you currently have diabetes?", b) measurement of capillary plasma glucose, and c) ascertainment of fasting state by the response to the question "When did you last ate?".

## Definition of diabetes

### *Diagnosed diabetes*

Diagnosed diabetes was defined as "self-reported" diabetes, determined by a yes response to the following question: "Do you currently have diabetes?"

### *Undiagnosed diabetes*

It was defined as fasting plasma glucose ≥126 mg/dl or random plasma glucose (RPG) ≥200 mg/dl in an individual without self-reported diabetes. "Fasting" was defined as the last food intake >8 hours before the blood glucose level estimation and "Random" as irrespective of the last meal. The fasting state was ascertained by the response to the question, "When did you last ate?" Individuals where the fasting state could not be ascertained were considered to provide the random sample for plasma glucose estimation. Blood glucose levels were estimated in a finger stick capillary blood specimen using FreeStyle Optium H in NFHS-4 and Accucheck Performa glucometer in NFHS-5, both based on the glucose dehydrogenase method.

### *Total diabetes*

Total diabetes was defined as the presence of either diagnosed diabetes (self-reported) or undiagnosed diabetes.

## Anthropometry

Height was measured using Seca 213 stadiometer, weight using Seca 874 digital scale, and waist circumference (mid-point between the lower rib cage and iliac crest) using Gulick tapes. Obesity was defined as a body mass index (BMI) of ≥25 kg/m$^2$ and, overweight as 23.0–24.9 kg/m$^2$. The data on height and weight were only available for the female participants from the dataset.

## Healthcare access

Participants in NFHS were asked questions to assess health insurance coverage and frequency of contact with the healthcare system. The healthcare access was estimated by the presence of health insurance coverage and seeing a healthcare provider in the past 12 months.

## Analytical sample

For the estimation of prevalence and its trends of diagnosed diabetes, individuals < 20 years of age and pregnant females were excluded (the weighted analytical sample for NFHS-4 and NFHS-5 was 644,342 and 663,195, respectively). For undiagnosed diabetes, those with self-reported diabetes and missing plasma glucose were also excluded (the weighted analytical sample for NFHS-4 and NFHS-5 was 611,249 and 608,494, respectively). Lastly, for the estimation of total diabetes, prevalence individuals <20 years of age, pregnant females, and missing plasma glucose were excluded (weighted analytical sample for NFHS-4 and NFHS-5 was 624,706 and 624,107, respectively) [Figures 1 and 2].

## Stastical analysis

NFHS-4 and NFHS-5 data were used to calculate the prevalence and proportion estimates for total, undiagnosed, and diagnosed diabetes in the overall sample and further stratified by age, gender, wealth index, place of residence, and BMI. The prevalence is reported as the number of diabetes cases per 100 persons, while the proportion as a percentage along with 95% CI. The change in prevalence from NFHS-4 to NFHS-5 was estimated using a binary logistic regression model, adjusted for age and gender. Appropriate published sample weights were used to restore the representativeness of the sample. In brief, national and sample weights were used for analysis to generate nationally representative data. All comparisons were done at a significance level of <0.05 in a two-tailed test. Statistical analyses were performed using Statistical Package of Social Sciences (SPSS) version 23 (IBM Corp., Armonk, NY)

# Results

In NFHS-4, there were 644,342 eligible participants in the age group of 20–54 years (85.5%: females; 55.3%: <35 years of age). Of these, 63.8% resided in rural areas, and 35.2% belonged to the poorest or poor wealth index [Table 1]. Similarly, in NFHS-5, of the eligible 663,195 participants in the age group of 20–54 (87.1%: females; 53.6%: <35 years of age), 66.1% were from the rural area while 36.7% belonged to poorest or poor wealth index [Table 1]. Of the total individuals 24.4%

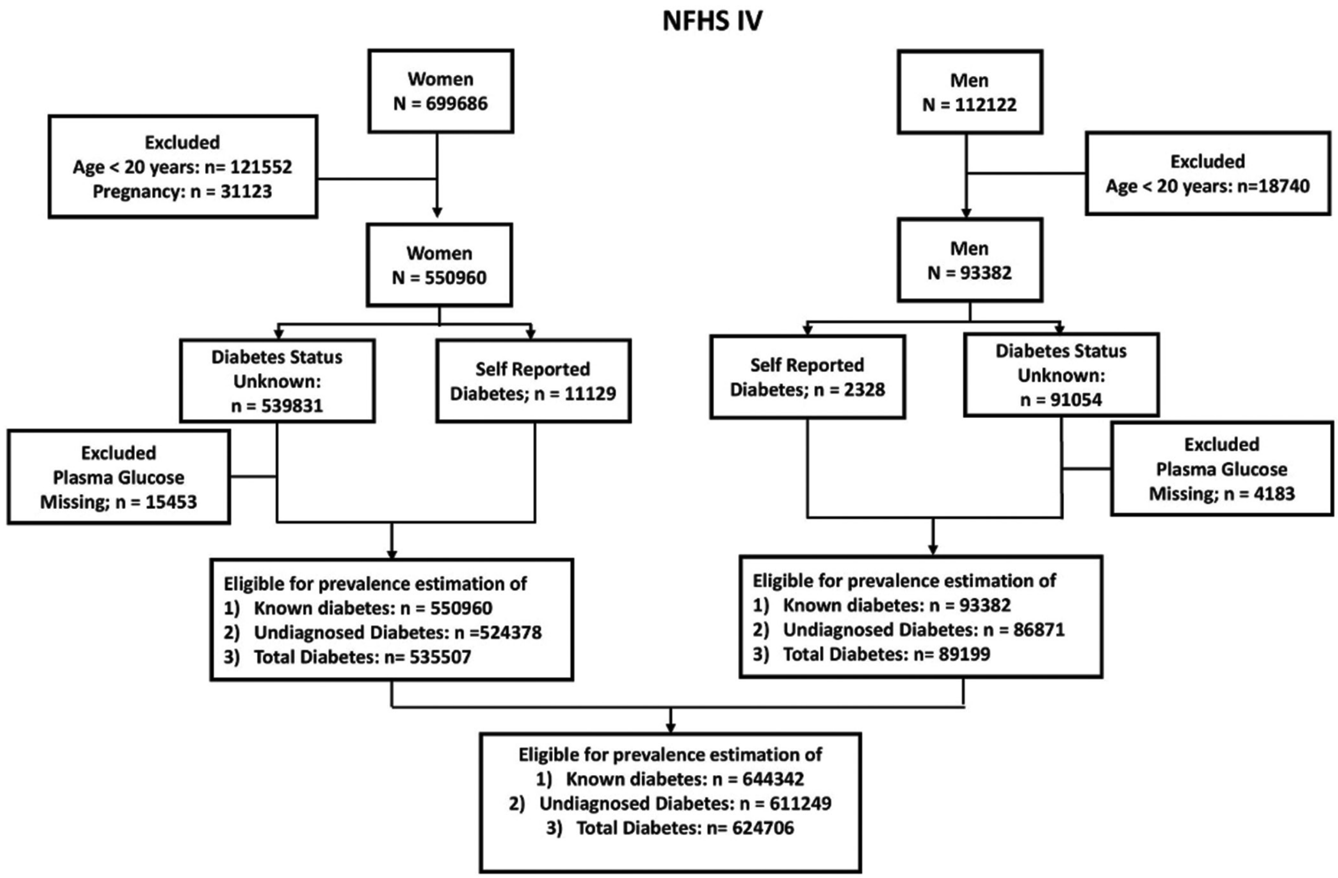


**Figure 1:** Selection of study participants from National Family Health Survey IV conducted in India in 2015–2016

**Table 1: Participant's characteristics of NFHS-4 and NFHS-5**

| | NFHS-4 | | NFHS-5 | | *P* |
|---|---|---|---|---|---|
| | *n* | % | *n* | % | |
| Gender | | | | | |
| Male | 93,382 | 14.5 | 85,454 | 12.9 | <0.001 |
| Female | 550,960 | 85.5 | 577,741 | 87.1 | |
| Age groups | | | | | |
| 20–24 | 125,861 | 19.5 | 122,359 | 18.4 | <0.001 |
| 25–29 | 121,926 | 18.9 | 123,015 | 18.5 | |
| 30–34 | 108,332 | 16.8 | 110,419 | 16.6 | |
| 35–39 | 103,777 | 16.1 | 109,777 | 16.6 | |
| 40–44 | 89,844 | 13.9 | 92,507 | 13.9 | |
| 45–49 | 85,892 | 13.3 | 96,423 | 14.5 | |
| 50–54 | 8,711 | 1.4 | 8,695 | 1.3 | |
| Wealth index | | | | | |
| Poorest | 105,984 | 16.4 | 114,968 | 17.3 | <0.001 |
| Poorer | 120,974 | 18.8 | 128,451 | 19.4 | |
| Middle | 132,016 | 20.5 | 136,555 | 20.6 | |
| Richer | 140,603 | 21.8 | 142,488 | 21.5 | |
| Richest | 144,765 | 22.5 | 140,734 | 21.2 | |
| Residence | | | | | |
| Urban | 233,283 | 36.2 | 224,876 | 33.9 | <0.001 |
| Rural | 411,059 | 63.8 | 438,320 | 66.1 | |

and 13.9% in NFHS-4 ($n$ = 530221), and 28.2% and 15.2% in NFHS-5 ($n$ = 544436) were obese and overweight, respectively.

## National trends in prevalence of total diabetes

The crude prevalence of total diabetes for men and women combined was estimated to be 3.50% (95% CI: 3.46,3.55) in NFHS-4 and 3.99 (95% CI: 3.94,4.04) in NFHS-5, an absolute increase of 0.48% [aOR: 1.12; 95% CI: 1.10,1.14] and a relative increase of 14%. This increase was similar in both diagnosed diabetes [aOR: 1·09; 95% CI: 1.07,1.12] as well as undiagnosed diabetes [aOR: 1.09;95% CI: 1.06,1.12] and was more in men [aOR: 1·18; 95% CI: 1·13,1.24] as compared to women [aOR1.10; 95% CI: 1·08,1.13]. Amongst the age groups, an increase in prevalence was seen from 30 years of age onward, with a maximum increase seen in the 50–54-year age group [aOR: 1.32; 95% CI: 1.21,1.45]. Across the wealth indexes, except for the richest, all other indexes showed an increase in the prevalence of total diabetes, with a maximum relative increase of 40.1% seen in the poorest category [aOR: 1.40;95% CI: 1.32,1.49]. In addition, the individuals living in urban areas had a similar prevalence of diabetes in NFHS-4 and NFHS-5, while those residing in rural areas showed a relative increase of 24.7% [aOR: 1.23; 95% CI: 1.20,1.26]. Lastly, except for obese individuals, an increase in the prevalence of total diabetes was seen in overweight [aOR: 1.06; 95% CI: 1.00,1.12], normal [aOR: 1.14;95% CI: 1.09,1.19], and underweight [aOR: 1.12; 95% CI: 1.02–1.23] individuals [Table 2]. As compared to the normal weight individuals, the odds ratio for having diabetes in obese were

**Table 2: National trends in prevalence of diabetes mellitus**

| | NFHS-4 Per 100 persons (95% CI) | NFHS-5 Per 100 persons (95% CI) | RC[||] (%) | Unadjusted OR (95% CI) | | *P* | Adjusted OR* (95% CI) | | *P* |
|---|---|---|---|---|---|---|---|---|---|
| Total Diabetes | 3.50 (3.46–3.55) | 3.99 (3.94–4.04) | 14.·0 | 1.14 | (1.12–1.16) | <0.001 | 1.12 | (1.10–1.14) | <0.001 |
| Known Diabetes | 2.08 (2.05–2.12) | 2.35 (2.31–2.39) | 17.9 | 1.13 | (1.10–1.15) | <0.001 | 1.09 | (1.07–1.12) | <0.001 |
| Undiagnosed Diabetes | 1.38 (1.35–1.41) | 1.52 (1.49–1.56) | 8.4 | 1.10 | (1.07–1.14) | <0.001 | 1.09 | (1.06–1.12) | <0.001 |
| Gender | | | | | | | | | |
| Women | 3.30 (3.25–3.35) | 3.74 (3.69–3.79) | 13.3 | 1.13 | (1.11–1.16) | <0.001 | 1.10† | (1.08–1.13) | <0.001 |
| Men | 4.70 (4.57–4.84) | 5.70 (5.54–5.87) | 21.2 | 1.22 | (1.17–1·27) | <0.001 | 1.18† | (1.13–1.24) | <0.001 |
| Wealth Index | | | | | | | | | |
| Poorest | 1.77 (1.69–1.85) | 2.48 (2.38–2.57) | 40.1 | 1.41 | (1.32–1.49) | <0.001 | 1.40 | (1.32–1.49) | <0.001 |
| Poorer | 2.24 (2.15 – 2.32) | 3.00 (2.90–3.09) | 33.9 | 1.35 | (1.28–1.42) | <0.001 | 1.33 | (1.27–1.40) | <0·001 |
| Middle | 3.03 (2.93–3.12) | 3.88 (3.77–3.98) | 28.1 | 1.29 | (1.23–1.34) | <0.001 | 1.24 | (1.19–1.29) | <0·001 |
| Richer | 4.53 (4.42–4.64) | 4.89 (4.77–5.00) | 7.9 | 1.08 | (1.04–1.12) | <0.001 | 1.04 | (1.01–1.08) | 0.012 |
| Richest | 5.35 (5.23–5.46) | 5.43 (5.31–5.55) | 1.49 | 1.01 | (0.98–1.05) | 0.332 | 1.03 | (0.96–1.03) | 0.847 |
| Age Group | | | | | | | | | |
| 20–24 | 0.83 (0.77–0.87) | 0.94 (0.88–0.99) | 13.3 | 1.13 | (1.04–1.23) | 0.004 | 1.14‡ | (1.05–1.24) | 0.002 |
| 25–29 | 1.38 (1.31–1.44) | 1.42 (1.35–1.48) | 2.89 | 1.02 | (0.95–1.10) | 0.436 | 1.03‡ | (0.96–1.10) | 0.341 |
| 30–34 | 2.25 (2.16–2.34) | 2.49 (2.39–2.58) | 10.6 | 1.10 | (1.04–1.17) | <0.001 | 1.11‡ | (1.05–1.17) | <0.001 |
| 35–39 | 3.63 (3.51–3.74) | 4.15 (4.02–4.26) | 14.3 | 1.14 | (1.09–1.20) | <.001 | 1.15‡ | (1.10–1.20) | <0.001 |
| 40–44 | 5.83 (5.67–5.99) | 6.56 (6.39–6.72) | 12.5 | 1.13 | (1.09–1.17) | <0.001 | 1.13‡ | (1.09–1.18) | <0.001 |
| 45–49 | 8.57 (8.38–8.76) | 9.24 (9.05–9.43) | 7.8 | 1.08 | (1.05–1.12) | <0.001 | 1.09‡ | (1.05–1.12) | <0.001 |
| 50–54 | 11.92 (11.24 –12.63) | 15.23 (14.46–16.03) | 27.7 | 1.32 | (1.21–1.45) | <0.001 | 1.32‡ | (1.21–1.45) | <0.001 |
| Residence | | | | | | | | | |
| Urban | 4.95 (4.85–5.04) | 5.26 (5.15–5.35) | 6.3 | 1.06 | (1.03–1.09) | <0.001 | 1.02 | (1.00–1.05) | 0.051 |
| Rural | 2.71 (2.66–2.76) | 3.38 (3.32–3.43) | 24.7 | 1.25 | (1.22–1.28) | <0.001 | 1.23 | (1.20–1.26) | <0.001 |
| BMI§ | | | | | | | | | |
| Underweight | 1.26 (1.18–1.32) | 1.39 (1.29–1.48) | 10.3 | 1.10 | (1.01–1.20) | 0.029 | 1.12 | (1.02–1.23) | 0.007 |
| Normal | 1.87 (1.81–1.92) | 2.16 (2.10–2.22) | 15.5 | 1.16 | (1.11–1.21) | <0.001 | 1.14 | (1.09–1.19) | <0.001 |
| Overweight | 3.48 (3.35–3.61) | 3.75 (3.62–3.88) | 7.7 | 1.08 | (1.02–1.13) | 0.005 | 1.06 | (1.00–1.12) | 0.033 |
| Obese | 7.12 (6.97–7.25) | 7.03 (6.90–7.15) | -1.2 | 0.98 | (0.95–1.01) | 0.362 | 0.98 | (0.95–1.01) | 0.384 |

*Adjusted for age and gender; all variables entered simultaneously· †Adjusted for age; all variables entered simultaneously· ‡Adjusted for gender, all variables entered simultaneously· §Only available for females. ||RC: Relative change

4.03 (3.88–4.18; $P < 0.001$) and 3.42 (3.30–3.53; $P < 0.001$) in NFHS-4 and NFHS-5, respectively.

## National trends in prevalence of diagnosed diabetes

The crude prevalence of diagnosed diabetes for men and women was 2.08% (95% CI: 2.05–2.12) in NFHS-4 and 2.35% (95% CI: 2.31–2.09) in NFHS-5. There was an increase in prevalence by 0.15% [aOR: 1.09 (95% CI: 1.07,1.12)], representing a relative increase of 10.8% [Table 3]. The increase in prevalence was more in men [aOR: 1.21 (95% CI: 1.14,1.28)] as compared to women [aOR: 1.07 (95% CI: 1.04,1.10)], started showing an upward trend from the age of 30 years, with a maximum increase seen in individuals of the age group of 50–54 years [aOR: 1.36 (95% CI: 1.22,1.52)]. Across the wealth indexes, the richest showed a decrease in the prevalence of diagnosed diabetes [aOR: 0.93 (95% CI: 0.89–0.97)], while those belonging to middle [aOR: 1.33 (95% CI: 1.25,1.40)], poor [aOR: 1.39 (95% CI: 1.30,1.49)], and poorest [aOR: 1.37 (95% CI: 1.27,1.48)] showed an increase. Furthermore, while individuals residing in urban areas had a similar prevalence in NFHS-4 and NFHS-5, those residing in rural areas showed a relative increase of 26.7% [aOR: 1.24 (95% CI: 1.20,1.28)]. Lastly for BMI categories, individuals having undernutrition [aOR: 1·17 (95% CI: 1.04,1.31)], normal BMI [aOR: 1.14 (95% CI: 1.08,1.20)], and overweight [aOR: 1.09 (95% CI: 1.07,1.12)] showed an increase, and in those with obesity, it remained unchanged [aOR: 0.95 (95% CI: 0·92,0.99)].

## National trends in prevalence of undiagnosed diabetes

The crude prevalence of undiagnosed diabetes for men and women was 1.38% (95% CI: 1.35,1.41) in NFHS-4 and 1.52% (95% CI: 1.49,1.56) in NFHS-5 [Table 4]. The prevalence increased by 0.14% [aOR: 1.09; 95% CI: 1.06,1.12] representing a relative increase of 10.1% from NFHS-4 to NFHS-5. Amongst individuals having undiagnosed diabetes, 70.5% and 71.8% were detected by RPG ≥ 200 mg/dl in NFHS-4 and NFHS-5, respectively. Of the total individuals with diabetes, the proportion of undiagnosed diabetes cases decreased from 38.5% (95% CI: 37.9%, 39.2%) in NFHS-4 to 37.3% (95% CI: 36.7%, 37.9%) in NFHS-5 ($P = 0·034$).

The increase in the prevalence of undiagnosed diabetes was similar in men [aOR: 1.08; 95% CI: 1.01,1.15] and

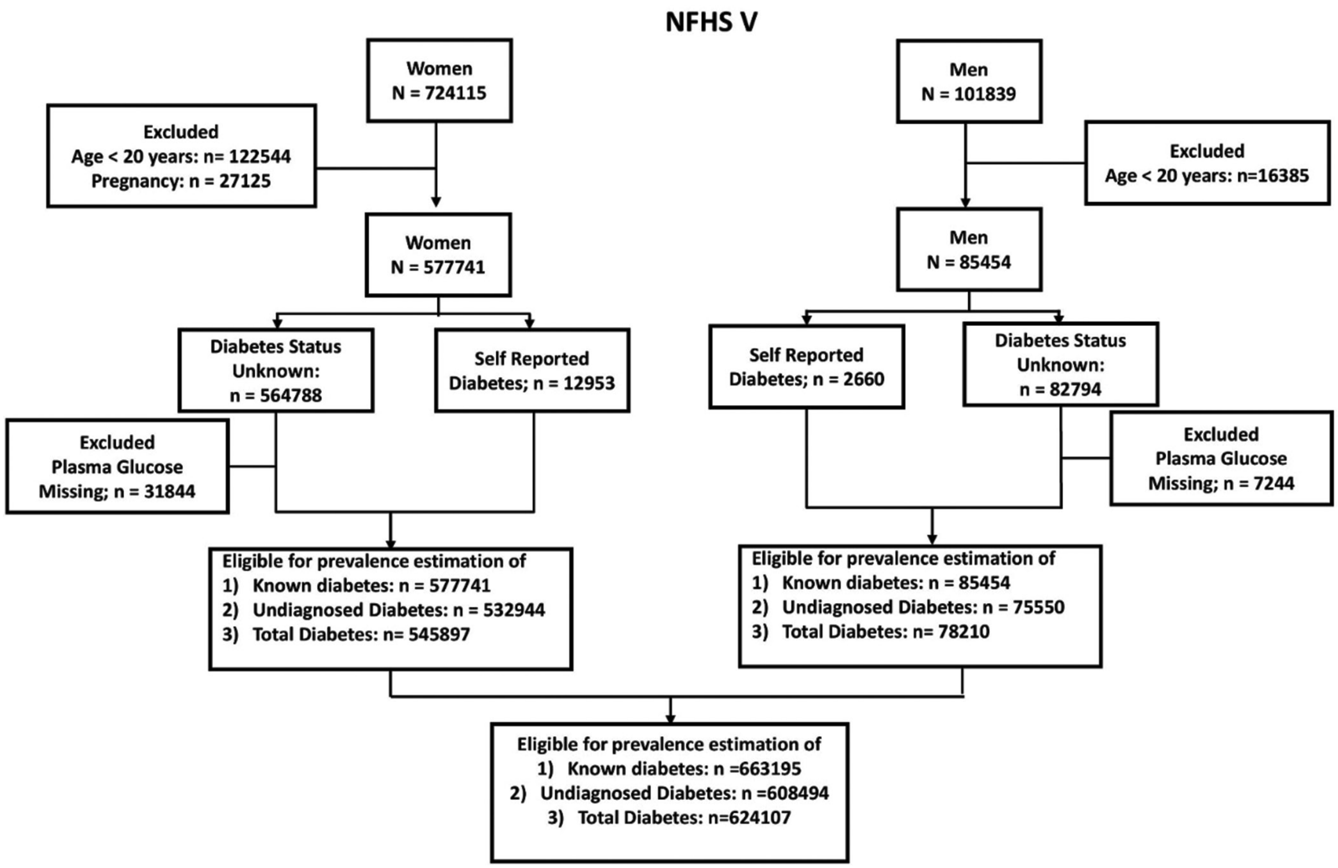


**Figure 2:** Selection of study participants from National Family Health Survey V conducted in India in 2019–2021

women [aOR: 1.09; 95% CI: 1.06,1.13]. Across age groups, the increase was seen in individuals belonging to age groups of 30–34 years [aOR: 1.10; 95% CI: 1.01,1.12], 35–40 years [aOR: 1.14; 95% CI: 1.07,1.22], and 40–45 years [aOR: 1.15; 95% CI: 1.08,1.22]. Amongst wealth indexes, the increase was seen only in individuals belonging to the poorest [aOR: 1.38; 95% CI: 1.26,1.51], poor [aOR: 1.21; 95% CI: 1.12,1.30], or middle [aOR: 1.08; 95% CI: 1.02,1.16] category. Lastly, individuals with a normal BMI [aOR: 1.13; 95% CI: 1.05,1.20] and living in rural areas [aOR: 1.16; 95% CI: 1.12,1.21] showed an increase in prevalence.

Amongst undiagnosed diabetes, 29.8% (95% CI: 28.8%, 30.7%) and 33.3% (95% CI: 32.2%, 34.3%) were covered by health insurance in NFHS-4 and NFHS-5, respectively ($P \leq 0{\cdot}001$). Furthermore, 18.3% (95% CI: 16.4%, 20.4%) and 37.0% (95% CI: 34.3%, 39.8%) had visited a doctor or other healthcare provider in the last 12 months in NFHS-4 and NFHS-5, respectively ($P \leq 0{\cdot}001$).

## Discussion

The findings from NFHS-4 and NFHS-5 revealed an increasing trend in diabetes prevalence amongst individuals between the ages of 20 and 54 years. This upward trend was seen from 30 years of age onward and was highest amongst the poorest, residing in rural areas, and who were either normal or overweight. The increase in prevalence was equally contributed by diagnosed and undiagnosed diabetes. In addition, a substantial proportion of individuals remained undiagnosed despite access to healthcare.

As per the International Diabetes Federation estimate, one in every seven adults with diabetes belongs to India, and the estimated number of adults living with diabetes is projected to increase to 151.5 million by 2045.[1] Given the magnitude of the global burden of diabetes that the Indian subcontinent contributes, it is imperative to understand the trends in its prevalence. Using data from a nationally representative family health survey, the current study demonstrated that the absolute increase in diabetes prevalence from 2015–2016 to 2019–2021 was 0·48%.[12,13] This is a substantial increase for a country with a projected population of 1·5 billion by 2036, of which 52% will be between 20 and 54 years of age.[2] An increasing prevalence and a high incidence of dysglycemia represent a huge economic burden for a country whose expenditure on diabetes represents only 1% of the total spending worldwide.[14]

More alarming are the population sub-groups in which the increase in diabetes prevalence was seen. It started increasing from a relatively younger age of 30 years with an absolute prevalence of 2.49%, 4.15%, and 6.56% in the age groups of 30–34, 35–39, and 40–44, respectively, in NFHS-5. Diabetes is characterized by the development of vascular complications

**Table 3: National trends in prevalence of diagnosed diabetes**

| | NFHS-4 Per 100 persons (95% CI) | NFHS-4 Per 100 persons (95% CI) | RC‖ (%) | Unadjusted OR (95% CI) | | *P* | Adjusted OR* (95% CI) | | *P* |
|---|---|---|---|---|---|---|---|---|---|
| Diagnosed Diabetes | 2.08 (2·05–2·12) | 2.35 (2.31–2.39) | 10.8 | 1.13 | 1.10–1.15 | <0.001 | 1.09 | 1.07–1.12 | <0.001 |
| Gender | | | | | | | | | |
| Women | 2.02 (1·98–2·05) | 2.24 (2.20–2.28) | 10.8 | 1.11 | 1.08–1.14 | <0.001 | 1.07† | 1.04–1.10 | <0.001 |
| Men | 2.49 (2·39–1·59) | 3.11 (2.99–3.23) | 24.8 | 1.25 | 1.18–1.32 | <0.001 | 1.21† | 1.14–1.28 | <0.001 |
| Wealth index | | | | | | | | | |
| Poorest | 0.99 (0.92–1·04) | 1.36 (1.29–1.42) | 37.3 | 1.38 | 1.27–1.49 | <0.001 | 1.37 | 1.27–1.48 | <0.001 |
| Poorer | 1.18 (1.12–1·24) | 1.67 (1.60–1.74) | 41.5 | 1.41 | 1.32–1.51 | <0.001 | 1.39 | 1.30–1.49 | <0.001 |
| Middle | 1.63 (1.55–1·69) | 2.25 (2.17–2.33) | 38.1 | 1.39 | 1.31–1.47 | <0.001 | 1.33 | 1.25–1.40 | <0.001 |
| Richer | 2.71 (2.62–2·79) | 2.92 (2.83–3.00) | 7.7 | 1.07 | 1.03–1.12 | <0.001 | 1.03 | 0.98–1.08 | 0.152 |
| Richest | 3.47 (3.37–3·56) | 3.32 (3.22–3.41) | –4.3 | 0.95 | 0.91–0.99 | 0.028 | 0.93 | 0.89–0.97 | 0.001 |
| Age Group | | | | | | | | | |
| 20–24 | 0.43 (0.39–0·46) | 0.53 (0.49–0.57) | 23.2 | 1.23 | 1.10–1.38 | <0.001 | 1.24‡ | 1.10–1.39 | <0.001 |
| 25–29 | 0.77 (0.72–0·82) | 0.74 (0.69–0.78) | – 3.8 | 0.95 | 0.87–1.04 | 0.334 | 0.95‡ | 0.87–1.05 | 0.358 |
| 30–34 | 1.29 (1.22–1·36) | 1.40 (1.33–1.47) | 8.5 | 1.08 | 1.01–1.16 | 0.026 | 1.08‡ | 1.01–1.16 | 0.024 |
| 35–39 | 2.07 (1.98–2·15) | 2.31 (2.21–2.39) | 11.5 | 1.11 | 1.05–1.18 | <0.001 | 1.11‡ | 1.05–1.18 | <0.001 |
| 40–44 | 3.51 (3.38–3·62) | 3.80 (3.67–3.92) | 8.2 | 1.08 | 1.03–1.14 | 0.001 | 1.08‡ | 1.03–1.13 | 0.001 |
| 45–49 | 5.41 (5.26–5·56) | 5.84 (5.69–5.98) | 7.9 | 1.08 | 1.04–1.12 | <0.001 | 1.08‡ | 1.04–1.12 | <0.001 |
| 50–54 | 7.17 (6.64–7·73) | 9.55 (8.94–10.18) | 33.2 | 1.36 | 1.22–1.52 | <0.001 | 1.36‡ | 1.22–1.52 | <0.001 |
| Residence | | | | | | | | | |
| Urban | 3.07 (2.99–3·13) | 3.16 (3.08–3.23) | 2.9 | 1.03 | 0.99–1·06 | 0.064 | 0.98 | 0.95–1.02 | 0.445 |
| Rural | 1.53 (1.49–1·57) | 1.94 (1.90–1.98) | 26.7 | 1.27 | 1.22–1.31 | <0.001 | 1.24 | 1.20–1.28 | <0.001 |
| BMI Category§ | | | | | | | | | |
| Underweight | 0.72 (0.67–0·77) | 0.83 (0.75–0.90) | 15.2 | 1.14 | 1.02–1.28 | 0.020 | 1.17 | 1.04–1.31 | 0.007 |
| Normal | 1.18 (1.13–1·22) | 1.36 (1.31–1.41) | 15.3 | 1.16 | 1.10–1.22 | <0.001 | 1.14 | 1.08–1.20 | <0.001 |
| Overweight | 2.20 (2.09–2·30) | 2.41 (2.30–2.51) | 9.5 | 1.10 | 1.03–1.17 | 0.004 | 1.07 | 1.00–1.15 | 0.030 |
| Obese | 4.38 (4.26–4·49) | 4.22 (4.11–4.31) | –3.6 | 0.96 | 0.92–0.99 | 0.030 | 0.95 | 0.92–0.99 | 0.016 |

*Adjusted for age and gender; all variables entered simultaneously· †Adjusted for age; all variables entered simultaneously· ‡Adjusted for gender, all variables entered simultaneously· §Only available for females. ‖RC: Relative change

over time, which in turn depends on the duration of diabetes and glycaemic control. The affliction of young individuals with diabetes in a country with a projected life expectancy of 72 years by 2035 will translate into substantial disease-related morbidity. The recent guidelines on the management of diabetes by the Indian Council of Medical Research (ICMR) are in accordance with this and have suggested screening for diabetes from 30 years of age onwards.[15] The second worrisome finding was the highest increase in the prevalence of diabetes in individuals with normal BMI, followed by underweight and overweight, while obese individuals had a similar prevalence. This is partly explained by the well-validated existence of the Asian-Indian phenotype, characterized by an excess of visceral fat at any given BMI, which may suggest that the Asian-Indians should be considered inherently at a high risk of diabetes.[16,17] In addition, BMI as a measure of obesity does not provide information about intrabdominal fat distribution, which has a relatively more contribution to the pathogenesis of dysglycemia.[18] Furthermore, the existence of unique cluster of combined insulin resistance and deficient diabetes in the Asian-Indians, which has an intermediate BMI between severe insulin-deficient diabetes and insulin resistance obese diabetes supports the finding of the Asian-Indians at risk of developing dysglycemia at a lower BMI.[19] An increase in diabetes prevalence was also seen in underweight individuals. While the exact reason behind this cannot be ascertained with certainty, it is likely to represent reverse causality. The third perturbing finding was that of a higher relative increase in diabetes prevalence by 24.7% in individuals residing in rural areas. In addition, urban areas did not show an increase suggesting a plateauing of diabetes prevalence. Around two-thirds of the Indian population reside in rural areas, a situation which is unlikely to change much by 2035 (urban population of 31.14% in 2011 and estimated to be 39.58% in 2036). This emphasizes the need to tailor the screening and management strategies to target the rural population.

While the absolute prevalence was highest in individuals belonging to the richest and richer wealth index, the maximum increase in diabetes prevalence was seen in the poorest and poor, i.e., a relative increase of 40.1% and 33.9%, respectively. In addition, those belonging to the richest and richer wealth centile did not show an increase from NFHS-4 to NFHS-5, suggesting a plateauing in this group. While the exact reasons behind an increase in prevalence in rural areas and the poor could not be determined from the current study, it is likely the result of the economic transition and associated

**Table 4: National trends in prevalence of undiagnosed diabetes**

| | NFHS-4 Per 100 persons (95% CI) | NFHS-4 Per 100 persons (95% CI) | RC‖ (%) | Unadjusted OR (95% CI) | | *P* | Adjusted OR* (95% CI) | | *P* |
|---|---|---|---|---|---|---|---|---|---|
| Undiagnosed Diabetes | 1.38 (1.35–1.41) | 1.52 (1.49–1.56) | 10.1 | 1.10 | (1.07–1.14) | <0.001 | 1.09 | (1.06 –1.12) | <0.001 |
| Gender | | | | | | | | | |
| Women | 1.25 (1.22–1.280 | 1.41 (1.37–1.43) | 11.7 | 1.12 | 1.08–1.16 | <0.001 | 1.09 | 1.06–1.13† | <0.001 |
| Men | 2.15 (2.05–2.25) | 2.39 (2.28–2.49) | 10.5 | 1.11 | 1.04–1.18 | 0.002 | 0.08 | 1.01–1.15† | 0.020 |
| Age Group | | | | | | | | | |
| 20–24 | 0.38 (0.34–0.41) | 0.37 (0.33–0.40) | –2.5 | 0.97 | 0.85–1.11 | 0.704 | 0.98 | 0.86–1.12‡ | 0.820 |
| 25–29 | 0.59 (0.54–0.63) | 0.64 (0.59–0.68) | 8.6 | 1.09 | 0.98–1.20 | 0.105 | 1.10 | 0.99–1.22‡ | 0.069 |
| 30–34 | 0.93 (0.87–0.99) | 1.02 (0.96–1.08) | 9.2 | 1.09 | 1.00–1.19 | 0.041 | 1.10 | 1.01–1.20‡ | 0.026 |
| 35–39 | 1.53 (1.45–1.611) | 1.74 (1.66–1.82) | 12.9 | 1.13 | 1.06–1.22 | <0.001 | 1.14 | 1.07–1.22‡ | <0.001 |
| 40–44 | 2.·31 (2.21–2.41) | 2.64 (2.52–2.74) | 13.5 | 1.14 | 1.07–1.21 | <0.001 | 1.15 | 1.08–1.22‡ | <0.001 |
| 45–49 | 3.17 (3.05–3.29) | 3.22 (3.10–3.34) | 1.5 | 1.01 | 0.96–1.07 | 0.599 | 1.02 | 0.96–1.08‡ | 0.399 |
| 50–54 | 4.78 (4.32–5.28) | 5.51 (5.00–6.05) | 14.9 | 1.16 | 1.00–1.34 | 0.044 | 1.16 | 1.00–1.34‡ | 0.044 |
| Wealth index | | | | | | | | | |
| Poorest | 0.78 (0.72–0.83) | 1.08 (1.01–1.13) | 33.1 | 1.39 | 1.27–1.52 | <0.001 | 1.38 | 1.26–1.51 | <0.001 |
| Poorer | 1.04 (0.98–1.10) | 1.28 (1.21–1.34) | 20.4 | 1.22 | 1.13–1.32 | <0.001 | 1.21 | 1.12–1.30 | <0.001 |
| Middle | 1.38 (1.31–1.44) | 1.56 (1.49–1.62) | 12.1 | 1.12 | 1.05–1.20 | <0.001 | 1.08 | 1.02–1.16 | 0.010 |
| Richer | 1.77 (1.69–1.84) | 1.84 (1.76–1.91) | 4.1 | 1.04 | 0.98–1.10 | 0.163 | 1.01 | 0.96–1.08 | 0.515 |
| Richest | 1.76 (1.69–1.83) | 1.82 (1.74–1.89) | 2.9 | 1.03 | 0.97–1.09 | 0.318 | 1.03 | 0.97–1.09 | 0.247 |
| Residence | | | | | | | | | |
| Urban | 1.78 (1.72–1.83) | 1.85 (1.79–1.90) | 3.9 | 1.04 | 0.99–1.08 | 0.091 | 1.01 | 0.97–1.06 | 0.460 |
| Rural | 1.17 (1.13–1.20) | 1.38 (1.33–1.41) | 16.5 | 1.18 | 1.13–1.22 | <0.001 | 1.16 | 1.12–1.21 | <0.001 |
| BMI Category§ | | | | | | | | | |
| Underweight | 0.54 (0.49–0.58) | 0.55 (0.49–0.61) | 3.3 | 1.03 | 0.90–1.18 | 0.633 | 1.05 | 0.92–1.21 | 0.431 |
| Normal | 0.69 (0.65–0.72) | 0.79 (0.75–0.82) | 13.6 | 1.14 | 1.07–1.22 | <0.001 | 1.13 | 1.05–1.20 | <0.001 |
| Overweight | 1.30 (1.21–1.38) | 1.33 (1.25–1.40) | 2.1 | 1.02 | 0.93–1.11 | 0.629 | 1.00 | 0.92–1.10 | 0.849 |
| Obese | 2.82 (2.73–2.91) | 2.84 (2.75–2.92) | 0.43 | 1.00 | 0.95–1.05 | 0.854 | 1.00 | 0.95–1.05 | 0.861 |

Adjusted for age and gender; all variables entered simultaneously· #Adjusted for age; all variables entered simultaneously· ^Adjusted for gender, all variables entered simultaneously· + Only available for females. ‖RC: Relative change

lifestyle changes. The fifth worrisome finding was the equal contribution of undiagnosed diabetes and diagnosed diabetes to an overall increase in diabetes prevalence. This suggests that the existing screening strategies for diabetes have not been able to tackle the challenge of undetected diabetes, which contributes to almost one-third of the total diabetes prevalence, i.e. 38.5% and 37.3% in NFHS-4 and NFHS-5, respectively. Interestingly, the relatively higher proportion of undiagnosed diabetes could not be completely explained by poor access to healthcare as 37.0% of the individuals with undiagnosed diabetes have self-reported visits to a healthcare facility in the previous 12 months. In addition, the number of individuals with undiagnosed diabetes visiting a healthcare facility in the last year increased substantially from 18.3% in NFHS-4 to 37.0% in NFHS-5. This suggests that in addition to poor access to healthcare, there is a considerable lost oppurunity for diabetes detection. In this regard, findings from the current study will suggest that a uniform screening recommendation for all adults of ≥30 years of age visiting a healthcare facility can potentially detect a substantial number of individuals with diabetes. Lastly, while the increase in the prevalence of diabetes was highest in individuals residing in rural areas, belonging to the poorest wealth centiles and normal weight, the absolute prevalence was highest amongst those with traditional risk factors, i.e., obese (7.03%), urban residence (4.95%), rich (5.43%), and advanced age (9.24%). However, since the former constitute a larger percentage of the total population, they are likely to contribute substantially more to the total number of adults with diabetes.[2]

The findings from the current study are in agreement with previous studies. In the cardio-metabolic risk reduction in South Asia (CARRS) study, while the prevalence of self-reported and total diabetes showed a relative increase of 9% and 1%, that of undiagnosed diabetes showed a decline of 16%. This discrepancy in undiagnosed diabetes could be due to the fact that CARRS was conducted in the urban cities of Chennai, Delhi, and Karachi where the access to health services and infrastructure is comparatively better.[20] Nandita A *et al*. from Tamil Nadu ($n$ = 9848) reported that individuals residing in villages showed an increase in the prevalence of diabetes by 34%, while the city dwellers had a non-significant increase of 8%.[5] Another study by V Mohan *et al*. ($n$ = 26,001) demonstrated an increase of 6.0% in the prevalence of diabetes from 2000 to 2004 in the city of Chennai, with diabetes detected at a relatively younger age.[6] In another study from Chennai ($n$ = 1262), the lower-income group showed a much higher increase in diabetes prevalence (135%) as compared to the middle-income group (24%).[7] Overall, while the absolute prevalence of diabetes has differed amongst various studies because of methodological differences, all have shown a similar trend of an increasing diabetes prevalence which is disproportionately affecting poor, normal-weight individuals residing in the rural area.

Primary prevention, early diagnosis, prompt treatment, and timely achievement of treatment targets are the cornerstones for reducing dysglycemia-related morbidity and mortality. In this regard, the findings from the current study have multiple implications. The findings of an increasing prevalence in individuals with non-traditional risk factors, a high absolute prevalence in those with traditional risk factors, and an upward trend in prevalence from 30 years age of onward suggest that a universal screening strategy for diabetes in individuals of age ≥ 30 years irrespective of their risk factors can help in timely detection of diabetes. The recent ICMR guidelines recommendation of 30 years as the age for initiating screening therefore is a step in the right direction.[15] The second implication pertains to the finding of a substantial proportion of undiagnosed diabetes despite an improving access to healthcare represents a lost opportunity. This will suggest that a universal screening of all individuals presenting to the healthcare facilities (irrespective of the reason) for the presence of diabetes can help in reducing the burden of undiagnosed diabetes. In this regard, the incorporation of non-communicable disease detection into the primary healthcare system as part of the National Programme for Prevention and Control of Non-Communicable Diseases is a well appreciated step.[21] The third implication pertains to the poor insurance coverage of individuals with diabetes. Diabetes is a chronic disease and is a long-lasting financial burden for the affected individual and their family members. In this regard, the Government of India’s “Ayushman Bharat Scheme” which provides insurance coverage for inpatient treatment of diabetes-related morbidity and provision of affordable medicines via “Bhartiya Jan Ashudhi Pariyojna” are the steps in the right direction.[22,23] However, insurance cover for outpatient treatment and diabetes-related investigations is also required, as majority of the diabetes treatment is done on an outpatient basis. Lastly, the reasons behind the rising diabetes prevalence in individuals not having traditional risk factors need to be elucidated to identify modifiable risk factors to prevent the diabetes onset.

Our study has several strengths. The data were derived from a nationally representative sample in contrast to other studies which have focussed on individual cities or states. In addition, a comprehensive evaluation was done for individuals with undiagnosed diabetes, and data collection was done using standard methods. However, our study has several limitations. First, the analysis was limited to 20–54-year-old non-pregnant women and men. Second, the dataset had a disproportionately higher representation of women, making it non-representative of the entire nation and less representative of men. Third, the diagnosis of diabetes relied on the estimation of capillary blood glucose, and different glucometers were used in the sequential NFHS surveys. In addition, the fasting state was self-reported. Furthermore, RPG was used to define diabetes in individuals in a non-fasting state or missing data on the fasting state. This is likely to underestimate the true prevalence of diabetes. Fourth, the distinction between type 1 and type 2 diabetes could not be made out. Lastly, 70% of undiagnosed diabetes were detected based on RPG, representing a potential bias, and factors that could have potentially affected glucose measurement like intercurrent illness and physical activity were not considered.

## Conclusion

While the absolute prevalence of diabetes is highest amongst individuals residing in urban areas belonging to the rich wealth centile, the relative increase in the prevalence is disproportionately higher in those residing in rural areas, belonging to the poorest wealth centiles and having normal weight. Of total diabetes, about one-third of the individuals remain undiagnosed.

### Data sharing

The current study is a secondary analysis of data obtained from the National Family Health Survey. The dataset can be retrieved after due approval from the “Demographic and Health Survey Program”.

### Authors contribution

R.G. analyzed the data, contributed to the discussion, wrote the initial draft, and edited the manuscript. A.U. analyzed the data and contributed to the discussion. S.K. researched data and contributed to the discussion. R.K. researched and analyzed the data, and reviewed and edited the manuscript. R.K. is the guarantor of this work and, as such, takes responsibility for the integrity of the data and the accuracy of the data analyses.

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### Conflicts of interest

There are no conflicts of interest.

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