BMC Endocrine Disorders

RESEARCH

Open Access

Assessment of sex disparities in prevalence of diagnosed and undiagnosed diabetes mellitus: results from the Bangladesh demographic and health survey data

Shakib Ahmed Suhel[1*], Nayma Akther[2], Shofiqul Islam[3], Nipa Rani Dhor[4], Masud Ahmed[5] and Ahmed Hossain[6]

Abstract

Background The global health concern regarding the low prevalence of diagnosed diabetes mellitus (DDM) is evident, but the prevalence of DDM is increasing. This is attributed to the frequent underestimation of undiagnosed diabetes mellitus (UDM). Given the limited research on this matter in Bangladesh, there is a need to investigate sex differences in both the prevalence and risk factors of DDM among Bangladeshi adults.

Methods This study utilizes the latest data from the Bangladesh Demographic and Health Survey (BDHS) conducted between 2017 and 2018, involving 11,911 adult participants. The research focuses on exploring sex-specific differences in the prevalence of diagnosed diabetes mellitus (DDM) and undiagnosed diabetes mellitus (UDM). Multinomial logistic regression models are applied to examine the sex effect after adjusting socio-demographic, household, and community-related factors associated with these conditions.

Results In the group of 5127 (43%) males, the prevalence of diagnosed diabetes mellitus (DDM) and undiagnosed diabetes mellitus (UDM) stood at 344 (7%) and 94 (2%), respectively. Among 6784 (57%) females, these figures were slightly lower at 424(6%) for DDM and 138 (2%) for UDM. In males aged 30–39, UDM exhibited significantly (RRR: 6.83, 95% CI: 2.01–23.18), associations, in contrast to the nonsignificant association observed for DDM. Unemployed female had a high risk of diagnosed (RRR: 1.28, 95% CI: 1.02–1.6) and undiagnosed (RRR: 1.52, 95% CI: 1.01–2.31) diabetes. Age, hypertension, wealth, overweight status, and residing in Dhaka had significant relationship with DDM and UDM for both males and females.

Conclusions This study reveals that diabetes prevalence in Bangladesh is influenced by various risk factors, with distinct impacts on men and women. Women living in Dhaka who are unemployed are at a significantly higher risk of both diagnosed and undiagnosed diabetes compared to men. To effectively combat the rising diabetes rate, we must implement targeted interventions that address these sex-specific disparities. These interventions should focus on age, wealth, regional variations, and especially on unemployed women in Dhaka, considering their heightened risk.

Keywords Relative Risk Ratio, Sex differences, Diabetes mellitus, Non-communicable diseases, Bangladesh

*Correspondence:
Shakib Ahmed Suhel
shakib.suhel@northsouth.edu
Full list of author information is available at the end of the article

Introduction

Diabetes mellitus (DM) is a complex and widespread metabolic disorder with profound implications for public health, as evidenced by its association with various complications [1, 2]. Type 2 DM is an inflammatory condition that can damage healthy cells and tissues. This leads to a cascade of complications, including cardiovascular disease, neuropathy, retinopathy, and nephropathy, making it a complex disease to manage [1]. Beyond the conventional understanding, the impact of DM extends to ocular health, with associated risk factors for ocular surface disorders among affected individuals [2].

The global burden of DM is particularly relevant to Bangladesh, where the condition poses significant challenges to both productivity and the economy [3]. The nation grapples with a rising prevalence of diabetes, with a substantial proportion remaining undiagnosed [4–6]. Overweight and abdominal obesity have been identified as determinants of undiagnosed DM and pre-diabetes in the Bangladeshi population, further highlighting the multifaceted nature of this health concern [5]. Socioeconomic disparities also play a role in the prevalence of undiagnosed DM, emphasizing the importance of considering broader determinants of health [6]. Globally, the prevalence of DM is escalating, with projections indicating a substantial increase over the next few decades [7]. Understanding the cost-effectiveness of interventions in managing DM becomes imperative, especially given the economic implications of this condition [8, 9].

Hypertension, often coexisting with DM, represents a significant health challenge in Bangladesh [10]. Both hypertension and diabetes share many common risk factors, including obesity, physical inactivity, unhealthy diet, and family history. These shared factors can influence the development of both conditions, making it important to control for hypertension's effects when examining the relationship between sex and diabetes. Moreover, hypertension can act as a confounding factor in diabetes research. This means that the observed association between sex and diabetes might be partially or entirely due to the influence of hypertension. By including hypertension as a covariate in the analysis, researchers can adjust for its effects and obtain a more accurate estimate of the true association between sex and diabetes.

The phenomenon of multimorbidity, wherein individuals experience multiple chronic conditions simultaneously, underscores the need for a holistic approach to healthcare [11]. Lifestyle factors, including physical activity, smoking, and alcohol consumption, intertwine with the incidence of Type 2 DM, emphasizing the importance of a comprehensive understanding of risk factors [12, 13]. Sleep length, a sometimes-disregarded facet of health, has been associated with diabetic patients' adherence to treatment in Bangladesh, illuminating the connections between a number of other health indicators [14]. A prospective longitudinal study further aims to unravel the complexities of uncontrolled hypertension and its adverse clinical events, contributing valuable insights into the management of hypertensive patients [15].

The novelty of this research lies in its focused examination of sex-specific variations in DM prevalence and associated risk factors within Bangladesh. While earlier studies may have touched on these areas, this investigation offers a more detailed analysis using the latest data from the Bangladesh Demographic and Health Survey (BDHS). A key distinction is its emphasis on how diabetes impacts men and women differently, moving beyond general prevalence rates. Furthermore, unlike many studies that limit their scope to diagnosed cases, this research incorporates both diagnosed and undiagnosed diabetes, providing a more comprehensive view of the national diabetes burden.

In addition, the study explores a wide range of sociodemographic, household, and community-based risk factors, pinpointing critical areas for targeted interventions. The Bangladesh-specific focus provides nuanced insights into the unique characteristics and challenges of diabetes management in the country. By addressing these elements, the research contributes valuable knowledge that can guide the development of more effective prevention and control strategies tailored to the Bangladeshi context.

Materials and methods

Study design and setting

We conducted a cross-sectional analysis using data from the BDHS 2017–2018, which took place from October 2017 to March 2018. The BDHS is a nationally representative survey covering all non-institutional housing units in Bangladesh. The survey employed a two-stage sampling method, initially selecting primary sampling units (PSUs) based on the 2011 Bangladesh census [10]. Figure 1 provides a flowchart detailing the process of selecting study participants. A total of 672 PSUs were chosen in the first stage, with 192 from rural areas and 480 from urban areas. In the second stage, 30 households were selected from each PSU, resulting in a total of 11,911 adult participants after excluding individuals with missing blood pressure information and those under 18 years old.

Outcome measure

The main focus of the study was to assess the prevalence of both diagnosed and undiagnosed diabetes mellitus, which was determined based on fasting plasma glucose (FPG) levels. FPG levels were measured using the HemoCue Glucose 201 + blood glucose analyzer system

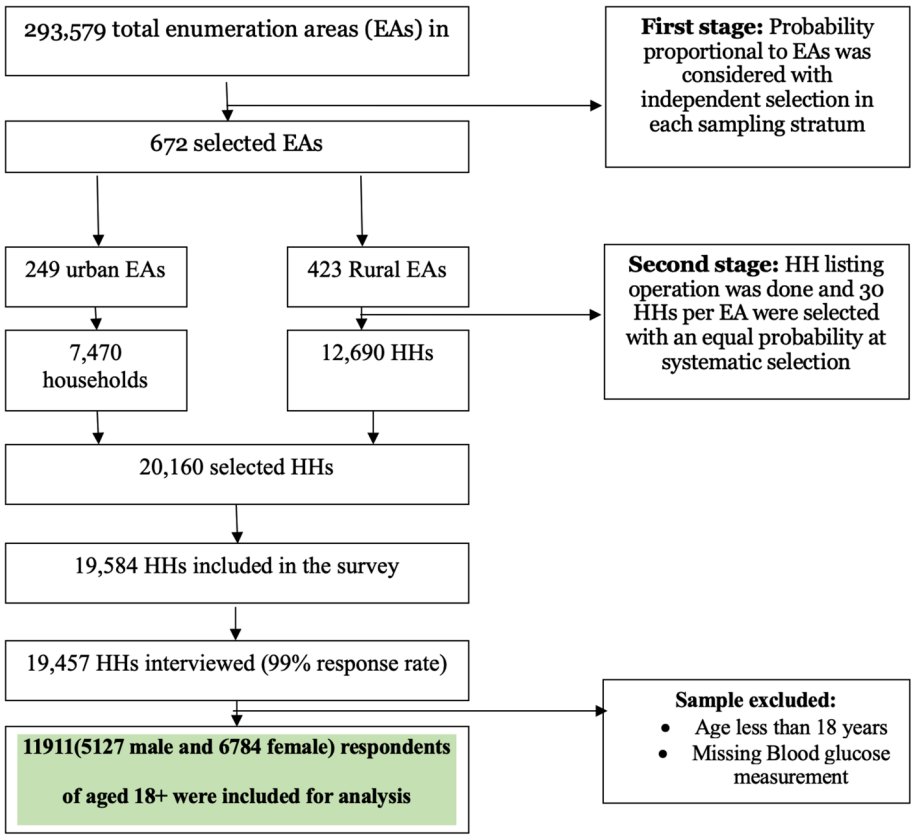

Fig. 1 The flow chart of selecting study participant for analysis

after an overnight fasting period [16]. According to the WHO classification, participants with FPG ≥ 7.0 mmol/L (126 mg/dl) were considered diabetic [17]. Diagnosed diabetes included those with FPG < 7.0 mmol/L taking diabetic medication or having received a diabetes diagnosis from a healthcare professional. Undiagnosed diabetes included those with FPG ≥ 7.0 mmol/L not taking diabetic medication or not being aware of their diabetes status [18].

Independent variables

We included the individual, household, and community levels. Participants' age in years (< 30, 30–39, 40–49, 50–59, 60–69, ≥ 70), sex (Male, Female), marital status (Never married, Married, Widowed/Divorced/Separated), education (No education, Primary, Secondary, and Higher-secondary and above), body mass index (BMI) (Underweight: BMI < 18.5 kg/m2, Normal: BMI 18.5–24.99 kg/m2, Overweight: BMI 25–29.99 kg/m2, and Obese: BMI ≥ 30 kg/m2).The presence of hypertension was defined as a systolic blood pressure ≥ 140 mmHg or a diastolic blood pressure ≥ 90 mmHg, or currently on treatment with antihypertensive medication [19]. The socioeconomic status of each household was measured by an asset index constructed using principal component analysis (PCA) from a household's different assets (e.g., televisions, bicycles, drinking water sources, sanitation facilities, and building materials) [20]. The wealth index is often calculated using Principal Component Analysis (PCA), a statistical technique that reduces the dimensionality of data while retaining most of the variability [21]. The BDHS data had information on household access to electricity, ownership of a car, and type of sanitation, PCA assigned loadings to each of these indicators based on their contribution to the variability in the dataset. The wealth score for each household is computed by summing the weighted contributions of these indicators. A higher index score signifies greater affluence among households. The households were ranked based on their asset scores, ranging from the lowest to the highest, and then divided into five quintiles. The community-level factors included administrative divisions (e.g., Barisal, Chittagong, Dhaka, Khulna, Rajshahi, Rangpur, and Sylhet), and place of residence (e.g., urban and rural) as confounding factors.

Data analysis

For the analysis, we employed the statistical software R 4.1.3. Each individual record in the BDHS was assigned a survey weight, allowing for adjustments to the resulting statistics to ensure broader representation of the population. Categorical data were presented as counts and percentages, while continuous variables were summarized using mean and standard deviation. Baseline characteristics were categorized according to normal, diagnosed, and undiagnosed DM, as well as by subgroups. To identify the associated factors, a multivariable multinomial regression model was employed, adjusting for covariates using logistic RR package in R. Due to the importance of each variable as a covariate, all were included in the regression model simultaneously. Our outcome variable being predicted is nominal and has more than two categories that do not have a given rank or order. We used multinomial logistic regression model because three outcome categories: normal, diagnosed, and undiagnosed diabetes, with the normal category serving as the reference for comparison with the other two. The model's multinomial regression coefficient was exponentiated and presented as relative risk ratios (RRR) along with 95% confidence intervals (CI). Relative risk ratio (RRR) for sex denotes the ratio of the probability of an outcome in the male group to that in the female group [22]. A post-estimation test, variance inflation factor (VIF), was conducted to assess multicollinearity. In this study, statistical significance was set at a p-value < 0.05.

Results

The study enrolled a total of 11,911 participants, with (5127) 43% being male and (6784) 57% female. The sociodemographic and health characteristics were comprehensively analyzed to uncover patterns and associations relevant to the prevalence of diabetes mellitus (DM) within the study cohort.

Characteristics of the study participants

Table 1 provides the characteristics of the study participants with gender variations. Notably, participants aged 60–69 and 70 and above had a higher representation among males, with proportions of 53% and 56%, where 2522 (65%) females belonged to the < 30 age group, respectively. The distribution of education levels showed interesting patterns, the percentage of females with no education was notably higher at 61% compared to males at 39%.A higher60% (4391)percent of males were currently working than females (40%).The middle wealth category had 44% male representation, while the richest category had a higher representation among females (57%).The portion of hypertension was higher among

Table 1 Characteristics of the study participants

Participants, n%	Male (*n*=5143, 43%)	Female (*n*=6784, 57%)	Total
Mean age	**38**	**41**	**39**
Age in years			
<30	1388 (35%)	2522 (65%)	3910 (33%)
30-39	1211 (43%)	1632 (57%)	2843 (24%)
40-49	907 (44%)	1135 (56%)	2042 (17%)
50-59	659 (49%)	677 (51%)	1336 (11%)
60-69	569 (53%)	508 (47%)	1077 (9%)
≥70	393 (56%)	310 (44%)	703 (6%)
Education			
No education	1144 (39%)	1822 (61%)	2966 (25%)
Primary	1595 (44%)	2033 (56%)	3628 (30%)
Secondary	1394 (40%)	2056 (60%)	3450 (29%)
College or higher	994 (53%)	873 (47%)	1867 (16%)
Currently working			
Yes	4391 (60%)	2884 (40%)	4636 (39%)
No	736 (16%)	3900 (84%)	7275 (61%)
Marital status			
Married	862 (70%)	373 (30%)	1235 (10%)
Never married	4149 (43%)	5401 (57%)	9550 (80%)
Widowed/divorced	116 (10%)	1010 (90%)	1126 (9%)
Wealth Status			
Middle	1027 (44%)	1332 (56%)	2359(20%)
Poorer	979 (43%)	1287 (57%)	2266 (19%)
Poorest	979 (42%)	1357 (58%)	2336(20%)
Richer	1020 (44%)	1302 (56%)	2322 (19%)
Richest	1122 (43%)	1506 (57%)	2628(22%)
Hypertension			
No	3941 (43%)	5179 (57%)	9120 (77%)
Yes	1186 (42%)	1605 (58%)	2791 (23%)
BMI			
Normal	3238 (46%)	3742 (54%)	6980(59%)
Underweight	996 (49%)	1036 (51%)	2032 (17%)
Overweight	799 (33%)	1602 (67%)	2401 (20%)
Obese	94 (19%)	404 (81%)	498 (4%)
Residence			
Urban	3241 (42%)	4408 (58%)	7649 (64%)
Rural	1886 (44%)	2376 (56%)	4262 (36%)
Division			
Sylhet	619 (44%)	794 (56%)	1413 (12%)
Barisal	525 (42%)	724 (58%)	1249 (10%)
Chittagong	640 (40%)	971 (60%)	1611 (14%)
Dhaka	648 (43%)	853 (57%)	1501 (13%)
Khulna	735 (44%)	919 (56%)	1654 (14%)
Mymensingh	582 (43%)	762 (57%)	1344 (11%)
Rajshahi	690 (44%)	890 (56%)	1580 (13%)
Rangpur	688 (44%)	871 (56%)	1559 (13%)

females (58%), and a larger percentage of females fell into the overweight BMI category (67%).Urban areas had a higher representation of females (58%), while rural areas had a higher representation of males (44%). Regional differences were also observed, with varying prevalence in different residential regions.

Prevalence of DDM and UDM

Table 2 presents a detailed analysis of the prevalence of diagnosed and undiagnosed diabetes mellitus (DM) across both male and female participants in the study. The findings offer valuable insights into the distribution of DM within different demographic segments. The overall prevalence of diagnosed DM among male participants was 7%, with 2% being undiagnosed. In contrast, female participants exhibited a 6% prevalence of diagnosed DM and a 2% prevalence of undiagnosed DM.

Among the two age group participants 50–59 and 60–69, both males and females showed higher rates of diagnosed and undiagnosed DM, from 10–11% and 2–3% for males, and 9–11% and 2–4% for females, respectively. In the < 30 age group, males had a 4% prevalence of diagnosed DM, whereas females had a 3% prevalence. The ≥ 70 age group exhibited a higher prevalence of diagnosed DM in both genders, with 7% for males and females. College or higher educated female had lower prevalence rates of diagnosed (4%) and undiagnosed (3%) DM compared to males. Females who had no job, they had a higher (7%) prevalence of diagnosed and undiagnosed (3%) DM. The unmarried participants, both male and female, exhibited a higher prevalence of diagnosed DM (7% and 6%, respectively). The richest wealth category showed the highest prevalence of undiagnosed DM (5%) among both genders and diagnosed DM in both males (11%) and females (9%). Participants with hypertension had higher rates of both diagnosed and undiagnosed DM, particularly in females (11% diagnosed, 3% undiagnosed).

Overweight and obese participants, regardless of gender, showed higher prevalence rates of diagnosed and undiagnosed DM. Rural participants, especially females, exhibited higher prevalence rates of diagnosed and undiagnosed DM. Regional variations were observed, with different regions showing distinct patterns in DM prevalence. The table indicates a higher diagnosis rate of diabetes among males compared to females in all divisions. Additionally, individuals residing in the Dhaka division exhibit elevated levels of both diagnosed and undiagnosed diabetes.

Associated factors of DDM and UDM in male

Table 3 provides findings of associated factors of the diagnosed and undiagnosed DM among male participants. The multinomial regression analysis reveals the Relative Risk Ratios (RRR) and 95% Confidence Intervals (CI) for various variables compared to the reference categories. The analysis indicates a clear association between age and the risk of both diagnosed and undiagnosed DM in males. Individuals in older age brackets exhibited notably elevated rates of both diagnosed and undiagnosed diabetes compared to those aged < 30 years. The risk of undiagnosed DM in males aged 30–39 was 6.83 times higher (RRR = 6.83, 95% CI = 2.01–23.18) compared to those under 30 years old. The risk escalates significantly in older males reaching 2.77 for diagnosed (RRR = 2.77, 95% CI = 1.88–4.07) and 10.02 for undiagnosed DM in the 60–69 age group, but males aged 70 and above face the highest risk of undiagnosed DM (RRR = 21.58, 95% CI = 6.08–76.54). Wealth status has a vital role in having been diagnosed with among males. To illustrate, males in the richest category have a substantially higher risk of both diagnosed (RRR: 2.37, 95% CI: 1.64–3.4) and undiagnosed DM (RRR: 3.29, 95% CI: 1.66–6.54) compared to those in the middle wealth status. Hypertension was associated with a risk of diagnosed DM (RRR: 1.44, 95% CI: 1.12–1.85) compared to patients without hypertension. MI had a greater likelihood of having both diagnosed and undiagnosed DM. Underweight males have a 36% less risk of diagnosed DM (RRR: 0.64, 95% CI: 0.44–0.91). Overweight persons had 2.01 times (RRR: 1.25, 95% CI: 3.22) higher risk for undiagnosed. Regional variations are observed in the risk of DM among males. Males' habitat in Dhaka have an increased risk of undiagnosed DM (RRR: 2.21, 95% CI: 1.04–4.71) compared to Sylhet.

Associated factors for DDM and UDM in female

Table 4 highlights that the working status of females had a significant role to diagnosed and undiagnosed DM. Unemployed females had 28% more chances for diagnosed (RRR: 1.28, 95% CI: 1.02–1.6) and 52% undiagnosed (RRR: 1.52, 95% CI: 1.01–2.31) more likely to have been DM. Females in the older age group exhibit an increased risk of DM than those who are less than 30. For example, for those females aged 30–39, their likelihood of having diagnosed (RRR: 2.11, 95% CI: 1.55–2.87) and undiagnosed DM (RRR: 2.49, 95% CI: 1.42–4.36) were 2.11 times and 2.49 times greater compared to less than 30 years. Wealth status is an important determinant. For instance, females in the richest category have a significantly higher risk of both diagnosed (RRR: 1.42, 95% CI: 1.05–1.93) and undiagnosed DM (RRR: 2.63, 95% CI: 1.53–4.53) compared to the middle wealth status. Hypertension is identified as a significant risk factor for both diagnosed (RRR: 1.69, 95% CI: 1.35–2.11) and undiagnosed DM (RRR: 1.4, 95% CI: 0.96–2.04) in females.

Table 2 Prevalence of diagnosed and undiagnosed diabetes mellitus (DM) among male and female participants

	Male			Female		
	Normal	**Diagnosed**	**Undiagnosed**	**Normal**	**Diagnosed**	**Undiagnosed**
Participants, n%	**4689 (91%)**	**344 (7%)**	**94 (2%)**	**6222 (92%)**	**424 6%)**	**138 (2%)**
Age in years						
<30	1326 (96%)	59 (4%)	3(0.2%)	2425 (96%)	77 (3%)	20 (1%)
30-39	1127 (93%)	63 (5%)	21 (2%)	1485 (91%)	109 (7%)	38 (2%)
40-49	818 (90%)	66 (7%)	23 (3%)	1007 (89%)	94 (8%)	34 (3%)
50-59	576 (87%)	63 (10%)	20 (3%)	576 (85%)	76 (11%)	25 (4%)
60-69	494 (87%)	64 (11%)	11 (2%)	451 (89%)	45 (9%)	12 (2%)
≥70	348 (89%)	29 (7%)	16 (4%)	278 (90%)	23 (7%)	9 (3%)
Education						
Primary	1066 (93%)	104 (7%)	27 (2%)	1857 (91%)	132 (6%)	44 (2%)
No education	1464 (92%)	65 (6%)	13 (1%)	1665 (91%)	130 (7%)	27 (1%)
Secondary	1256 (90%)	107 (8%)	31 (2%)	1887 (92%)	127 (6%)	42 (2%)
College or higher	903 (91%)	68 (7%)	23 (2%)	813 (93%)	35 (4%)	25 (3%)
Currently working						
Yes	4025 (92%)	291 (7%)	75 (2%)	2703 (94%)	145 (5%)	36 (1%)
No	664 (90%)	53 (7%)	19 (3%)	3519 (90%)	279 (7%)	102 (3%)
Marital status						
Married	823 (95%)	34 (4%)	5 (1%)	359 (96%)	12 (3%)	2 (1%)
Never married	3761 (91%)	301 (7%)	87 (2%)	4955 (92%)	337 (6%)	109 (2%)
Widowed/divorced	105 (91%)	9 (8%)	2 (2%)	908 (90%)	75 (7%)	27 (3%)
Wealth Status						
Poorest	963 (94%)	52 (5%)	12 (1%)	1235 (93%)	79 (6%)	18 (1%)
Poorer	922 (94%)	49 (5%)	8 (1%)	1227 (95%)	52 (4%)	8 (1%)
Middle	938 (96%)	38 (4%)	3 (0.3%)	1284 (95%)	64 (5%)	9 (1%)
Richer	925 (91%)	78 (8%)	17 (2%)	1182 (91%)	91 (7%)	29 (2%)
Richest	941 (84%)	127 (11%)	54 (5%)	1294 (86%)	138 (9%)	74 (5%)
Hypertension						
No	3666 (93%)	222 (6%)	53 (1%)	4842 (93%)	255 (5%)	82 (2%)
Yes	1023 (86%)	122 (10%)	41 (3%)	1380 (86%)	169 (11%)	56 (3%)
BMI						
Normal	2973 (92%)	218 (7%)	47 (1%)	3499 (94%)	196 (5%)	47 (1%)
Underweight	951 (95%)	39 (4%)	6 (1%)	986 (95%)	47 (5%)	3 (0.3%)
Overweight	688 (86%)	75 (9%)	36 (5%)	1396 (87%)	146 (9%)	60 (4%)
Obese	77 (82%)	12 (13%)	5 (5%)	341 (84%)	35 (9%)	28 (7%)
Residence						
Urban	2988 (92%)	206 (6%)	47 (1%)	4105 (93%)	245 (6%)	58 (1%)
Rural	1701 (90%)	138 (7%)	47 (2%)	2117 (89%)	179 (8%)	80 (3%)
Division						
Sylhet	567 (92%)	42 (7%)	10 (2%)	731 (92%)	52 (7%)	11 (1%)
Barisal	480 (91%)	40 (8%)	5 (1%)	662 (91%)	49 (7%)	13 (2%)
Chittagong	577 (90%)	50 (8%)	13 (2%)	876 (90%)	65 (7%)	30 (3%)
Dhaka	557 (86%)	62 (10%)	29 (4%)	744 (87%)	80 (9%)	29 (3%)
Khulna	675 (92%)	45 (6%)	15 (2%)	852 (93%)	48 (5%)	19 (2%)
Mymensingh	548 (94%)	29 (5%)	5 (1%)	704 (92%)	49 (6%)	9 (1%)
Rajshahi	633 (92%)	45 (7%)	12 (2%)	829 (93%)	46 (5%)	15 (2%)
Rangpur	652 (95%)	31 (5%)	5 (1%)	824 (95%)	35 (4%)	12 (1%)

Table 3 Associated factors of Diagnosed and Undiagnosed DM in Males: Multinomial Regression Analysis

Variables	Male					
	Diagnosed Diabetes mellitus vs. normal			Undiagnosed Diabetes mellitus vs. normal		
	RRR	95%CI		RRR	95%CI	
Age in years (ref: <30)						
30-39	1.17	**0.81**	**1.7**	6.83	**2.01**	**23.18**
40-49	1.73	**1.19**	**2.5**	11	**3.25**	**37.18**
50-59	2.19	**1.5**	**3.2**	12.74	**3.71**	**43.74**
60-69	2.77	**1.88**	**4.07**	10.02	**2.73**	**36.73**
≥70	1.77	**1.1**	**2.87**	21.58	**6.08**	**76.54**
Wealth Status (ref: Middle)						
Poorest	0.97	0.65	1.45	0.75	0.3	1.86
Poorer	0.79	0.51	1.22	0.3	0.08	1.1
Richer	1.53	**1.05**	**2.21**	1.3	0.61	2.78
Richest	2.37	**1.64**	**3.4**	3.29	**1.66**	**6.54**
Hypertension (ref: No)						
Yes	1.44	**1.12**	**1.85**	1.45	0.93	2.26
BMI (ref: Normal)						
Underweight	0.64	**0.44**	**0.91**	0.54	0.22	1.29
Overweight	1.11	0.83	1.49	2.01	**1.25**	**3.22**
Obese	1.28	0.67	2.45	1.79	0.66	4.85
Residence (ref: Rural)						
Urban	0.78	0.6	1	0.82	0.52	1.31
Division (ref: Sylhet)						
Barisal	1.17	0.74	1.86	0.61	0.2	1.85
Chittagong	1.03	0.67	1.59	0.95	0.4	2.21
Dhaka	1.36	0.89	2.07	2.21	**1.04**	**4.71**
Khulna	0.79	0.5	1.23	0.9	0.39	2.07
Mymensingh	0.81	0.49	1.33	0.62	0.21	1.85
Rajshahi	0.99	0.63	1.54	1.13	0.47	2.69
Rangpur	0.68	0.42	1.11	0.47	0.16	1.42

*bold faces are statistically significant with a *p*-value<0.05

Compared to individuals with normal body mass index, participants categorized as overweight had a greater likelihood of having both diagnosed and undiagnosed diabetes. Overweight persons had more likely 47% diagnosed (RRR: 1.47, 95% CI: 1.16–1.86) and 113% undiagnosed (RRR: 2.13, 95% CI: 1.42–3.21) diabetes. Females who lived in Dhaka have 1.48 times and 2.08 times more risk of both diagnosed (RRR: 1.48, 95% CI: 1.02–2.16) and undiagnosed DM (RRR: 2.08, 95% CI: 1.01–4.26) compared to those in Sylhet.

Discussion

This is the first report describing sex-based differences in diabetes prevalence and its determinants in Bangladesh. The findings reveal notable insights into the prevalence of diagnosed and undiagnosed diabetes, as well as its associated risk factors among different demographic groups. There were discernible sex-based differences in diabetes prevalence, with men exhibiting a higher prevalence of diagnosed diabetes (7%) compared to women (6%). In comparison, the prevalence of undiagnosed diabetes (2%) was similar in males and females.

The diabetes mellitus prevalence was quite similar to the prevalence in other countries like Ethiopia (6.5%) [23], and Canada (7.5%) [24]. Studies from Nepal (42.85%) [25], China (15.8%) [26], South Africa (15.28%) [27], Iran (14.4%) [28], Pakistan (13.7%) [29], Iraq (8.7%) [30], US (9.7%) [31] showed a high prevalence of diabetes mellitus, and France (4.0%) [32] showed a low prevalence. Additionally, the prevalence of undetected diabetes mellitus in Australia (1%) [33] was lower than the prevalence in our country, where our study was comparable to those of research conducted in Ethiopia (2.3%) [34]. Furthermore, studies found a higher prevalence of undiagnosed diabetes Mellitus in Iran (4.8%) [28], Thailand (8.11%) [35], and Iraq (11%) [30]. Employment status did not

Table 4 Associate factors of Diagnosed and Undiagnosed DM among Females: Multinomial Regression Analysis

Variables	Female					
	Diagnosed Diabetes mellitus vs. normal			Undiagnosed Diabetes mellitus vs. normal		
	RRR	95%CI		RRR	95%CI	
Age in years (ref: <30)						
30-39	2.11	**1.55**	**2.87**	2.49	**1.42**	**4.36**
40-49	2.62	**1.9**	**3.63**	3.46	**1.93**	**6.2**
50-59	3.72	**2.64**	**5.26**	5	**2.68**	**9.31**
60-69	2.67	**1.79**	**4**	2.96	**1.39**	**6.34**
≥70	1.98	**1.19**	**3.29**	3.61	**1.55**	**8.4**
Currently working (ref: No)						
Yes	**1.28**	**1.02**	**1.6**	**1.52**	**1.01**	**2.31**
Wealth Status (ref: Middle)						
Poorest	0.72	0.5	1.03	0.55	0.24	1.28
Poorer	0.87	0.62	1.24	0.69	0.31	1.57
Richer	1.15	0.84	1.58	1.52	0.84	2.78
Richest	1.42	**1.05**	**1.93**	2.63	**1.53**	**4.53**
Hypertension (ref: No)						
Yes	1.69	**1.35**	**2.11**	1.4	**0.96**	**2.04**
BMI (ref: Normal)						
Underweight	0.9	**0.64**	**1.26**	0.28	**0.08**	**0.9**
Overweight	1.47	**1.16**	**1.86**	2.13	**1.42**	**3.21**
Obese	1.22	0.82	1.82	2.97	1.76	5.01
Division (ref: Sylhet)						
Barisal	1.04	0.69	1.58	1.38	0.6	3.16
Chittagong	0.97	0.66	1.43	1.78	0.87	3.63
Dhaka	1.48	**1.02**	**2.16**	2.08	**1.01**	**4.26**
Khulna	0.72	0.48	1.09	1.21	0.56	2.6
Mymensingh	1.11	0.73	1.68	1.12	0.45	2.77
Rajshahi	0.79	0.52	1.2	1.28	0.57	2.85
Rangpur	0.65	0.41	1.02	1.23	0.53	2.88

*Bold faces are statistically significant with a *p*-value<0.05

influence diabetes risk among males, whereas females who were not employed had a higher likelihood of developing both diagnosed and undiagnosed diabetes. The nature of one's occupation can impact the likelihood of developing diabetes, influenced by factors like behavior, metabolic regulation, earnings, and physical activity. Two studies, attributed to indicated that a significant proportion of Saudi women exhibited high levels of inactivity, falling short of international recommendations for minimal physical activity [36]. Additionally, another study found that female nurses working fewer than 20 h per week had a reduced risk of diabetes compared to those working 21 to 40 h per week, while those working overtime (41 h or more per week) faced an increased risk [37].

In our study, we found prevalence of diabetes and undiagnosed diabetes increased with extended age for both males and females' group. This suggests that as life expectancy rises in Bangladesh (presently standing at 72.3 years), the growing elderly population will lead to a greater prevalence and burden of diabetes [38]. Our research did not uncover a notable correlation between diabetes and place of residence; however, we did observe a greater incidence of diabetes in rural areas. This observation aligns with the understanding that rural areas often have insufficiently trained personnel and limited healthcare resources [39]. Our study revealed that affluent individuals, both men and women, faced a notable risk of both diagnosed and undiagnosed diabetes. Numerous studies conducted in Bangladesh and other nations have similarly demonstrated a significant association between wealth status and the prevalence of diagnosed and undiagnosed diabetes mellitus [38, 39]. We noted a considerably greater occurrence of diabetes in the top wealth quintile compared to the lowest. This could be attributed to individuals in the highest wealth quintile within developing

economies using their disposable income to acquire Western, high-calorie foods and opting out of physically strenuous activities as indicators of social status [40]. The hypertensive females had more chance of developing diagnosed and undiagnosed diabetes compared to males. The proportion of diabetes observed among participants was 4.1 times as high as the proportion of diabetes found in the general US adult population [41].

Being underweight serves as a protective factor against diagnosed DM in males, while it offers protection against both diagnosed and undiagnosed DM in females.

Our findings have important policy implications, suggesting that early detection and screening are essential for reducing the prevalence of undiagnosed diabetes among females in Bangladesh. Second, the prevention of undetected diabetes in Bangladesh depends critically emphasis on how we can motivate females for jobs because additional research discovered a lower prevalence of diabetes mellitus as occupational activity increased among both genders [25]. With a strong correlation between age and undetected diabetes because research has shown that advancing age is associated with reduced daily physical activity, as older individuals tend to engage in insufficient physical activity, spend more time inactive, and have lower overall levels of physical activity [42]. One potential reason for the elevated prevalence of both diagnosed and undiagnosed diabetes could intensify its efforts to enact measures for diabetes prevention. This might necessitate healthcare system reforms that prioritize the prevention of non-communicable diseases. Another implication drawn from our analysis is that diabetes prevention efforts should concentrate on decreasing obesity and hypertension, while also improving employment opportunities, especially for women.

Limitations

A key limitation of using Bangladesh Demographic and Health Survey (BDHS) data for assessing sex disparities in the prevalence of diagnosed and undiagnosed diabetes mellitus is the reliance on cross-sectional data. This design limits the ability to establish causal relationships between risk factors and diabetes outcomes. Additionally, self-reported data on diagnosed diabetes may introduce recall bias, while undiagnosed cases are identified only through blood glucose measurements at a single point in time, which may not capture fluctuating glucose levels or account for seasonal variations. Furthermore, BDHS data may not include detailed clinical information, such as family history or lifestyle factors (e.g., diet and physical activity), which are important for a comprehensive assessment of diabetes risk.

Conclusion

This study offers nuanced insights into sex-specific disparities in diabetes prevalence, highlighting the influence of sociodemographic and health factors. Women in Dhaka and those unemployed are at higher risk of both diagnosed and undiagnosed diabetes compared to men. The findings emphasize the need for targeted interventions that address common risk factors—such as age, wealth, and regional differences—while focusing particularly on unemployed women in Dhaka. Diabetes prevalence, both diagnosed and undiagnosed, increases with age and is higher among individuals with hypertension, those who are overweight, and elderly residents in Dhaka. Policymakers must prioritize these key factors for both sexes to curb the growing diabetes burden in Bangladesh.

Acknowledgements

The authors thank MEASURE DHS (Demography and Health Surveys) for granting access to the BDHS 2017–2018 data.

Clinical trial number

Not applicable.

Authors' contributions

SAS involved in planning the study as well as the data analysis. NA revised the text and reorganized the data. SI participated in data cleansing, article amendment, and analysis. NRD and MA assisted with modifications. It was AH supervised the study and rewrote the manuscript. Every writer reviewed and approved the final product.

Funding

The author(s) received no specific funding for this work.

Data availability

Since this analysis utilized data extracted from the BDHS 2017-18, most of the data and study materials are publicly accessible. For additional inquiries or discussions, interested individuals are encouraged to reach out to the corresponding author.

Declarations

Ethics approval and consent to participate

Health and Demographic Survey the Institutional Review Boards of the Bangladesh Medical Research Council in Dhaka, Bangladesh, and ICF International in Rockville, Maryland, USA, gave their approval to the data gathering methods for the 2017–18 BDHS. Before any questions were asked or before biomarker and anthropometric measurements were taken, informed consent was sought from each survey participant. The current study's analysis did not include respondents who did not give their consent.

Consent for publication

Not applicable.

Competing interests

The authors declare no competing interests.

Author details

[1]Sylhet MAG Osmani Medical College and Hospital, Sylhet, Bangladesh. [2]Jaintapur Upazila Health Complex, Sylhet, Bangladesh. [3]Sylhet Women's Medical College, Sylhet, Bangladesh. [4]Parkview Nursing College, Sylhet, Bangladesh. [5]Gowainghat Upazila Health Complex, Sylhet, Bangladesh. [6]College of Health Sciences, University of Sharjah, Sharjah, United Arab Emirates.

Received: 11 March 2024 Accepted: 14 November 2024
Published online: 18 December 2024

References

1. Zozulinska D, Wierusz-Wysocka B. Type 2 diabetes mellitus as inflammatory disease. Diabetes Res Clin Pract. 2006Nov;74(2):S12–6.
2. Ozdemir M, Buyukbese MA, Cetinkaya A, Ozdemir G. Risk factors for ocular surface disorders in patients with diabetes mellitus. Diabetes Res Clin Pract. 2003Mar;59(3):195–9.
3. Afroz A, Hird TR, Zomer E, Owen A, Chen L, Ademi Z, et al. The impact of diabetes on the productivity and economy of Bangladesh. BMJ Glob Health. 2020Jun;5(6): e002420.
4. Akter S, Rahman MM, Abe SK, Sultana P. Prevalence of diabetes and prediabetes and their risk factors among Bangladeshi adults: a nationwide survey. Bull World Health Organ. 2014Mar 1;92(3):204–213A.
5. Alam DS, Talukder SH, Chowdhury MAH, Siddiquee AT, Ahmed S, Pervin S, et al. Overweight and abdominal obesity as determinants of undiagnosed diabetes and pre-diabetes in Bangladesh. BMC Obese. 2016Dec;3(1):19.
6. Hasan Md M, Tasnim F, Tariqujjaman MD, Ahmed S. Socioeconomic Inequalities of Undiagnosed Diabetes in a Resource-Poor Setting: Insights from the Cross-Sectional Bangladesh Demographic and Health Survey 2011. IJERPH. 2019;16(1):115.
7. Saeedi P, Petersohn I, Salpea P, Malanda B, Karuranga S, Unwin N, et al. Global and regional diabetes prevalence estimates for 2019 and projections for 2030 and 2045: Results from the International Diabetes Federation Diabetes Atlas, 9th edition. Diabetes Res Clin Pract. 2019;157:107843 DM, Lammert M, Parving HH, Pedersen.
8. Gaede P, Valentine WJ, Palmer AJ, Tucker O. Cost-effectiveness of intensified versus conventional multifactorial intervention in type 2 diabetes: results and projections from the Steno-2 study. Diabetes Care. 2008;31:1510–5.
9. Li R, Zhang P, Barker LE, Chowdhury FM, Zhang X. Cost-effectiveness of interventions to prevent and control diabetes mellitus: a systematic review. Diabetes Care. 2010;33:1872–94.
10. Hossain A, Suhel SA, Chowdhury SR, Islam S, Akther N, Dhor NR, Hossain MZ, Hossain MA, Rahman SA. Hypertension and undiagnosed hypertension among Bangladeshi adults: Identifying prevalence and associated factors using a nationwide survey. Front Public Health. 2022Dec;6(10):1066449. https://doi.org/10.3389/fpubh.2022.1066449.
11. Chowdhury SR, Chandra Das D, Sunna TC, Beyene J, Hossain A. Global and regional prevalence of multimorbidity in the adult population in community settings: a systematic review and meta-analysis. E Clinical Medicine. 2023Feb;16(57): 101860. https://doi.org/10.1016/j.eclinm.2023.101860.
12. Shi L, Shu XO, Li H, Cai H, Liu Q, Zheng W, et al. Physical Activity, Smoking, and Alcohol Consumption in Association with Incidence of Type 2 Diabetes among Middle-Aged and Elderly Chinese Men Laks J, editor. PLoS ONE. 2013;8(11):e77919.
13. Hossain A, Baten RBA, Saadi A, Rana J, Rahman T, Reza HM, Alameddine M. Chronic Illness and Quality of Life 5 Years After Displacement Among Rohingya Refugees in Bangladesh. JAMA Netw Open. 2024Sep 3;7(9): e2433809. https://doi.org/10.1001/jamanetworkopen.2024.33809.PMID:39287945;PMCID:PMC11409150.
14. Hossain A, Mithila O. Sleep duration and treatment compliance: a population-based cross-sectional study of hypertensive patients in Bangladesh. BMC Res Notes. 2016May;13(9):271. https://doi.org/10.1186/s13104-016-2075-6.
15. Hossain A, Ahsan GU, Hossain MZ, Hossain MA, Sultana ZZ, Arefin A, Jahan SMS, Sutra dhar P. A prospective longitudinal study with treated hypertensive patients in Northern Bangladesh (PREDIcT-HTN) to understand uncontrolled hypertension and adverse clinical events: A protocol for 5-years follow-up. PLoS One. 2022 May 31;17(5):e0269240. https://doi.org/10.1371/journal.pone.0269240.
16. Saquib N, Saquib J, Ahmed T, Khanam MA, Cullen MR. Cardiovascular diseases and Type 2 Diabetes in Bangladesh: A systematic review and meta-analysis of studies between 1995 and 2010. BMC Public Health. 2012Dec;12(1):434.
17. Nguyen VD, Vien QM, Do TH, Phan CD, Nguyen HC, Nguyen VT, et al. Prevalence of undiagnosed diabetes and pre-diabetes and its associated risk factors in Vietnam. J Glob Health Sci. 2019;1: e7.
18. Shahjalal M, Chakma SK, Ahmed T, Yasmin I, Mahumud RA, Hossain A. Prevalence and determinants of using complementary and alternative medicine for the treatment of chronic illnesses: A multicenter study in Bangladesh. PLoS ONE. 2022Jan 5;17(1): e0262221. https://doi.org/10.1371/journal.pone.0262221.PMID:34986159;PMCID:PMC8730415.
19. Hodis JD, Gottesman RF, Windham BG, Knopman DS, Lutsey PL, Walker KA, et al. Association of hypertension according to new american college of cardiology/ american heart association blood pressure guidelines with incident dementia in the aric study cohort. J Am Heart Assoc. 2020;9: e017546. https://doi.org/10.1161/JAHA.120.017546.
20. Hossain A, Ahmed B, Rahman T, Sammonds P, Zaman S, Benzadid S, Jakariya M. Household food insecurity, income loss, and symptoms of psychological distress among adults following the Cyclone Amphan in coastal Bangladesh. PLoS ONE. 2021;16(11): e0259098. https://doi.org/10.1371/journal.pone.0259098.
21. Islam M, Sultana ZZ, Iqbal A, Ali M, Hossain A. Effect of in-house crowding on childhood hospital admissions for acute respiratory infection: A matched case-control study in Bangladesh. International journal of infectious diseases : IJID : official publication of the International Society for Infectious Diseases. 2021;105:639–45. https://doi.org/10.1016/j.ijid.2021.03.002.
22. Camey SA, Torman VB, Hirakata VN, Cortes RX, Vigo A. Bias of using odds ratio estimates in multinomial logistic regressions to estimate relative risk or prevalence ratio and alternatives. Cad Saude Publica. 2014;30:21–9. https://doi.org/10.1590/0102-311x00077313.
23. Zeru MA, Tesfa E, Mitiku AA, et al. Prevalence and risk factors of type-2 diabetes mellitus in Ethiopia: systematic review and meta-analysis. Sci Rep. 2021;11:21733. https://doi.org/10.1038/s41598-021-01256-9.
24. Hosseini, Z., Whiting, S. J., & Vatanparast, H. (2019). Type 2 diabetes prevalence among Canadian adults - dietary habits and sociodemographic risk factors. Applied physiology, nutrition, and metabolism = Physiologie appliquee, nutrition et metabolisme, 44(10), 1099–1104. https://doi.org/10.1139/apnm-2018-0567.
25. Ranabhat K, Mishra SR, Dhimal M, Shrestha B, Khanal V. Type 2 Diabetes and Its correlates: A Cross Sectional Study in a Tertiary Hospital of Nepal. J Community Health. 2017Apr;42(2):228–34. https://doi.org/10.1007/s10900-016-0247-x.
26. Yan Y, Wu T, Zhang M, et al. Prevalence, awareness and control of type 2 diabetes mellitus and risk factors in Chinese elderly population. BMC Public Health. 2022;22:1382. https://doi.org/10.1186/s12889-022-13759-9.
27. Pheiffer C, Pillay-van Wyk V, Turawa E, Levitt N, Kengne AP, Bradshaw D. Prevalence of Type 2 Diabetes in South Africa: A Systematic Review and Meta-Analysis. Int J Environ Res Public Health. 2021May 30;18(11):5868. https://doi.org/10.3390/ijerph18115868.
28. Mirzaei M, Rahmaninan M, Mirzaei M, et al. Epidemiology of diabetes mellitus, pre-diabetes, undiagnosed and uncontrolled diabetes in Central Iran: results from Yazd health study. BMC Public Health. 2020;20:166. https://doi.org/10.1186/s12889-020-8267-y.
29. Adnan M, Aasim M. Prevalence of Type 2 Diabetes Mellitus in Adult Population of Pakistan: A Meta-Analysis of Prospective Cross-Sectional Surveys. Ann Glob Health. 2020Jan 31;86(1):7. https://doi.org/10.5334/aogh.2679.PMID:32025503;PMCID:PMC6993597.
30. Mansour AA, Al-Maliky AA, Kasem B, Jabar A, Mosbeh KA. Prevalence of diagnosed and undiagnosed diabetes mellitus in adults aged 19 years and older in Basrah. Iraq Diabetes MetabSyndrObes. 2014May;2(7):139–44. https://doi.org/10.2147/DMSO.S59652.
31. Xu G, Liu B, Sun Y, Du Y, Snetselaar LG, Hu FB, Bao W. Prevalence of diagnosed type 1 and type 2 diabetes among US adults in 2016 and 2017: population based study. BMJ (Clinical research ed). 2018;362: k1497. https://doi.org/10.1136/bmj.k1497.
32. Jin, C., Lai, Y., Li, Y., Teng, D., Yang, W., Teng, W., Shan, Z., & China National Diabetes and Metabolic Disorders Study Group and the Thyroid Disorders, Iodine Status and Diabetes Epidemiological Survey Group. Changes in the prevalence of diabetes and control of risk factors for diabetes among Chinese adults from 2007 to 2017: An analysis of repeated national cross-sectional surveys. J Diabetes. 2024;16(2): e13492. https://doi.org/10.1111/1753-0407.13492.

33. Zheng M, Bernardo CO, Stocks N, Gonzalez-Chica D. Diabetes Mellitus Diagnosis and Screening in Australian General Practice: A National Study. J Diabetes Res. 2022Mar;23(2022):1566408. https://doi.org/10.1155/2022/1566408.
34. Bantie GM, Wondaye AA, Arike EB, Melaku MT, Ejigu ST, Lule A, Lingerew WM, Tamirat KS. Prevalence of undiagnosed diabetes mellitus and associated factors among adult residents of Bahir Dar city, northwest Ethiopia: a community-based cross-sectional study. BMJ Open. 2019Oct 31;9(10):e030158. https://doi.org/10.1136/bmjopen-2019-030158.
35. Suwannaphant K, Laohasiriwong W, Puttanapong N, Saengsuwan J, Phajan T. Association between Socioeconomic Status and Diabetes Mellitus: The National Socioeconomics Survey, 2010 and 2012. J Clin Diagn Res. 2017 Jul;11(7):LC18-LC22. https://doi.org/10.7860/JCDR/2017/28221.10286. Epub 2017 Jul 1.
36. Einas SA and Al-Sobayel HI. Physical activity andhealth beliefs among Saudi women. Journal of Nutrition and Metabolism. 2012; Article ID 642187:6 6. https://doi.org/10.1155/2012/642187.
37. Kroenke CH, Spiegelman D, Manson J, Schernhammer ES, Colditz GA, Kawachi I. Work characteristics and incidence of type 2 diabetes in women. Am J Epidemiol. 2007Jan 15;165(2):175–83. https://doi.org/10.1093/aje/kwj355.
38. Suh D-C, Kim C-M, Choi I-S, Plauschinat CA, Barone JA. Trends in blood pressure control and treatment among type 2 diabetes with comorbid hypertension in the UnitedStates: 1988–2004. J Hypertens. 2009;27:1908–16.
39. Animaw W, Seyoum Y. Increasing prevalence of diabetes mellitus in a developing country and its related factors. PLoS ONE. 2017Nov 7;12(11):e0187670. https://doi.org/10.1371/journal.pone.0187670.PMID:29112962;PMCID:PMC5675402.
40. Pampel FC, Denney JT, Krueger PM. Obesity, SES, and Economic Development: A Test of the Reversal Hypothesis. Soc Sci Med. 2012;74:1073–81.
41. McElfish PA, Scott AJ, Chatrathi HE, Rowland B, Long CR, Nagarsheth N, Calcagni M, Patolia J, Haggard-Duff LK, Selig JP. Undiagnosed Hypertension and Undiagnosed Type 2 Diabetes among Overweight and Obese Marshallese Participants in a Diabetes Prevention Program. Yale J Biol Med. 2021Mar 31;94(1):5–12.
42. Harris TJ, Owen CG, Victor CR, Adams R, Cook DG. What factors are associated with physical activity in older people, assessed objectively by accelerometry? Br J Sport Med. 2009;43(6):442e50.

Publisher's Note