

# Diabetes Scenario in a Backward Rural District Population of India and Need for Restructuring of Health Care Delivery Services

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## Abstract

Poor healthcare infrastructure and utilization complicated Indian diabetic epidemic especially in backward areas where many cases remain uncontrolled or even undiagnosed till complications develop. Dearth of information from eastern India regarding the burden and correlates of such uncontrolled and undiagnosed diabetes and consequent healthcare-seeking thus called for a detailed investigation in a poor-resource setting.

## Methods

A community-based cross-sectional study was conducted in Malda, an under-developed district in eastern India. Between October 2013 and July 2014, 18,028 consenting adults were randomly recruited, interviewed and tested for capillary blood sugar (fasting/post-prandial/random). Diabetics were defined by previous diagnoses or having fasting capillary blood sugar  $\geq 126$  mg/dl or post-prandial/random blood sugar  $\geq 200$  mg/dl. A previously diagnosed case was defined as uncontrolled if his/her measured blood sugar did fall in the diabetic level. On the other hand, previously undiagnosed persons, if found diabetic according to the test results, were termed as undiagnosed diabetic. Descriptive and regression analyses were conducted using SAS-9.3.2.

## Results

Six percent adult residents were suffering from diabetes in Malda, India. Unfortunately, more than two-third (approx. 63%) of these diabetics remained undiagnosed till this study while a little less than half (about 47%) of the diagnosed cases were uncontrolled. Furthermore, eight percent of the diagnosed diabetics sought treatment from non-qualified practitioners. Among diabetics, odds of remaining undiagnosed were relatively lower among older and richer diabetics of urban area while females were more likely to remain undiagnosed. Secondary-educated subjects had higher and divorced/separated/widowed/widowers had lower odds of having uncontrolled diabetes. Muslims and backward castes were less and educated, hard-working and richer diabetics were more likely to visit qualified private practitioners.

## Conclusions

Burden of uncontrolled and undiagnosed diabetes were high in Malda. Urgent interventions targeting young, female, married, less-educated and poor diabetics from rural area seemed necessary to ensure early detection and appropriate treatment.

**Keywords:** Diabetes Mellitus; Undiagnosed diabetes; Uncontrolled diabetes; Healthcare seeking

## Introduction

The global public health focus is gradually concentrating more on the non-communicable diseases (NCDs), owing to the progressively increasing trend in the burden of NCDs worldwide including the developing countries. Among these NCDs, the silent epidemic of diabetes currently has become one of the most worrisome public health concerns [1-3]. Diabetes mellitus is a heterogeneous metabolic syndrome characterized by variable degrees of insulin resistance and/or impaired insulin secretion resulting in abnormal metabolism of glucose leading to hyperglycemia [4]. Multi-factorial interplay between genetic, behavioral and environmental factors is responsible for abnormal glucose homeostasis in diabetics [4].

Globally an estimated number of 387 million people are currently diagnosed to have diabetes with an adult prevalence of 8.3% [1,2,5-7]. About 77% of these cases live in low and middle income countries and among them India and China are currently experiencing the most serious epidemic situation. In view of the fact that these two countries are the most populous countries in the world, the scenario seems alarming [1,2,5]. The current national diabetes prevalence is 8.6% in India, with more than 1 million annual diabetes-related deaths in the 20 to 79 age group [1,8].

Diabetes remains undiagnosed in many patients until the development of the symptoms of complications. Globally 46.3% diabetics remain unaware of their diabetic status and in India the estimated number is 35.5 million [1] and may be even higher due to lack of proper access and utilization of healthcare [2,9]. The solitary available evidence revealed that the prevalence of undiagnosed diabetes ranged between 3.1% to 9.4% in 10 states of India [10].

Uncontrolled diabetes among the diagnosed cases is another serious threat owing to its deleterious effects on body organs combined with the huge burden. Evidences suggest that in 70% of the diagnosed cases

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in India, diabetes remains uncontrolled [11]. To worsen the scenario, 90% of these uncontrolled diabetics consider their disease to be under control [12].

Burden of diabetes has shown a progressively increasing trend in India as evidenced by the upsurge of the diagnosed burden from approximately 62.4 million in 2011[13] to 66.8 million in 2014 [1,8]. Moreover the projected prevalence for the year 2030 was measured to be 79.4 million [4,8]. This increasing trend can well spell a disaster due to the silent destruction of the body organs and functions resulting from diabetes. While one person in every 12 has diagnosed diabetes in India [14]. these estimates are based on some regional observations and may only represent the tip of the iceberg keeping the undiagnosed and uncontrolled burden in mind. Thus, without immediate implementation of efficient intervention for risk reduction, early diagnosis and treatment, controlling the epidemic seems to be impossible. For proper diagnosis and treatment the patterns and predictors of healthcare-seeking are other important issues that need to be addressed appropriately [15].

Regarding risk reduction, in addition to the modifiable genetic factors, the rising burden of diabetes in this country [16] is often correlated with certain modifiable behaviors like lifestyle, eating habits, addictions (smoking and alcoholism), stress, and physical inactivity. Most of these evidences are based on hospital/clinic based purposively sampling from urban areas focusing on estimation of the local burden [12]. Handfuls of studies (mostly in western and southern India) have measured the association of these correlates with diabetes and almost none with uncontrolled and undiagnosed cases among residents of poor-resource settings in eastern India [17].

Dearth of information regarding the correlates of uncontrolled and undiagnosed diabetes among adult Indians living in poor-resource settings, thus called for a detailed investigation involving a representative adult population of Malda, one of the poorest districts located in the northern part of West Bengal state in eastern India.

## Materials and Methods

### Ethics Statement

The study protocol was reviewed and approved by the Ethics Committee of the National Institute of Cholera and Enteric Diseases (NICED), Kolkata. After explaining the study details in local language, written informed consent or left thumb impression (for illiterates, in presence of two impartial literate witnesses) was obtained from each adult resident, in favor of participation and providing sample for the blood sugar test.

### Study Design

Between October 2013 and July 2014, a community-based cross-sectional study was conducted with the objective of measuring the burden of diagnosed, undiagnosed and uncontrolled diabetes, identifying their socio-demographic correlates and understanding the patterns and predictors of the healthcare-seeking among diabetics in a poor-resource setting.

### Study site

The study was conducted involving a representative, consenting, adult (aged  $\geq 18$  years) population of Malda, one of the least developed districts in West Bengal state of India, having a population of 3.99 million with population density of 1,069/sq km and average literacy of 61.73% [18,19]. Sharing international border with Bangladesh and

interstate borders with Bihar and Jharkhand, rendered this district's health system exposed to unstable demographic pressure as high as 1,870 persons per available hospital bed [20].

Urban area of the district consists of 2 municipalities: Old Malda and English Bazar, each divided into several administrative units called wards (19 in Old Malda and 25 in English Bazar) while 3701 villages and 27 census towns constitute the rural part [18,21].

### Sample size estimation

In the absence of appropriate parameter values for the sample size estimation, to recruit maximum required sample, based on available highest regional estimates for West Bengal till date [22], using 6% as the expected value and an absolute precision of 1%, assuming  $\alpha=0.05$ , after finite population correction for 3.99 million, 17294 adults were required to be recruited. To account for an assumed 10% non-response, 19216 adults were invited.

### Recruitment

To recruit a representative sample of required size, maintaining proportional distribution, 16 municipal wards (4 in Old Malda and 12 in English Bazar) from urban and [23 villages/census towns from rural area were selected randomly using stratified random sampling with probability proportional to size (PPS). Exhaustive house-listing was next conducted in each of the selected wards/villages/census towns. Each municipal ward/village/census town was then categorized into several segments, each consisting of 125 households (defined based on sharing of cooking pot in a dwelling). Considering these segments as Primary Sampling Units (PSU), using stratified proportional random multistage sampling with probability proportional to size (PPS), 2 segments were selected randomly in each selected wards/villages/census towns and all households were surveyed there after collecting written informed consent from the residents. Thus from 4012 urban and 6095 rural households altogether 18028 consenting adults were recruited, interviewed and tested for diabetes.

### Interview

Using a structured, pre-tested, bi-lingual (English and local language: Bengali) questionnaire, all the individuals residing in the selected households were interviewed at home by trained interviewers. The instrument collected information on age (18-40/41-60/>60 years), gender (male/female), religion (Hindu/Muslim/Others), caste (backward (SC/ST/OBC)/others), marital status (currently married/never married/divorced, separated, widowed, widower) education (illiterate/primary/secondary/higher secondary/graduate and above), occupational type (sedentary work/moderate work/hard work) and residential area (urban/rural). Information on household assets was also collected and used to calculate an asset index which was log-transformed and categorized into lower/middle/upper tertile to determine lower/middle/upper socio-economic status (SES) based on percentile distribution. Participants were interviewed and their medical records (if available) were checked to identify the diagnosed diabetics and to understand their pattern of healthcare-seeking for diabetes (sought care from: nonqualified practitioners/qualified practitioners from Government sector/qualified practitioners from private sector).

### Laboratory testing

Capillary Blood sugar, fasting (fcg), post-prandial (ppcg) or random (rcg), was measured by on the spot finger prick and using SD Code Free TM Blood Glucose Monitoring System (manufactured by Standard Diagnostics, INC, Korea).[24], standardized and checked regularly.

## Outcome measures

According to the guidelines of American Diabetes Association, diabetic level of capillary blood sugar was defined as  $f_{cg} \geq 126$  mg/dL or  $ppcg/rcg \geq 200$  mg/dL [24,25]. Thus diabetics were defined as those having previously established diagnosis of diabetes or  $f_{cg} \geq 126$  mg/dL or  $ppcg/rcg \geq 200$  mg/dL [24-26]. Subjects who were previously diagnosed as diabetic were defined as uncontrolled diabetics if they had  $f_{cg} \geq 126$  mg/dL or  $ppcg/rcg \geq 200$  mg/dL [27]. Participants, who were never diagnosed as diabetic before, were termed as undiagnosed cases if they had  $f_{cg} \geq 126$  mg/dL or  $ppcg/rcg \geq 200$  mg/dL.

## Data analysis

Using SAS version 9.3.2 [28], overall and stratified distributions (frequency, proportions and corresponding 95% Confidence Intervals (95% CI)) of the study variables were determined followed by simple and multiple (including all socio-demographic factors in to the model) logistic regressions (including multinomial for dependent variables with >2 categories: healthcare-seeking) [29-31], to measure the strengths of associations (unadjusted (OR) from simple and adjusted (each for all other socio-demographic factors) Odds Ratios (OR) from multiple regressions with corresponding 95% CIs) of socio-demographic factors with diabetes (diagnosed, overall, undiagnosed and uncontrolled) and related care-seeking.

## Results

Altogether 18028 subjects were included in the analyses. Among participants, majority were aged  $\leq 40$  years ( $n=11191$ , 62.08%), female ( $n=11452$ , 63.52%), had Hindu religion ( $n=12774$ , 70.86%), belonged to backward castes ( $n=10374$ , 57.54%) and were currently married ( $n=13972$ , 77.55%). Higher proportions had secondary level of education ( $n=6891$ , 38.22%), were in jobs with moderate workload ( $n=9428$ , 52.30%), belonged to lower SES ( $n=7460$ , 41.38%) and resided in rural areas ( $n=10820$ , 60.02%) (Table 1).

Among participants, 404 (2.24%) subjects were diagnosed diabetics among whom 77.72% ( $n=314$ ) sought treatment from qualified physicians in private sector and 8.42% ( $n=34$ ) visited non-qualified practitioners. Overall burden of diabetes was 6.09% ( $n=1098$ ), 63.21% ( $n=694$ ) of which were undiagnosed so far while 47.38% ( $n=190$ ) of the previously diagnosed cases had uncontrolled diabetes (Table 1).

Prevalence of diabetes across the strata of socio-demographic factors is presented in (Table 2). Age stratified prevalence of diabetes (14.57%,  $n=237$ ) was highest among subjects aged >60 years. About 7.74% ( $n=509$ ) males and 5.14% ( $n=589$ ) females were suffering from diabetes. Divorced/separated/widowed/widower subgroup had higher prevalence of the disease compared to others (10.16%,  $n=195$ ). Burden was also high among subjects in sedentary work (8.57%,  $n=239$  for diabetes), upper SES (8.63%,  $n=333$  for diabetes) and urban residence (6.67%,  $n=481$  for diabetes) (Table 2).

Distribution of the uncontrolled and undiagnosed diabetes is presented in (Figure 1). While the proportion of cases, with uncontrolled diabetes did not vary much (except being much lower (12.5%,  $n=1$ ) among never married subjects compared to other marital status (50.31%,  $n=160$  among currently married and 38.67%,  $n=29$  among divorced/separated/widowed/widower)) across the strata of different socio-demographic factors, younger subjects (77.05%,  $n=272$  for 18-40 years age group), Muslims (76.38%,  $n=291$ ), those who were never married (80.95%,  $n=34$ ), less educated (78.57%,  $n=88$  for illiterates), hard-workers (76.67%,  $n=253$ ), subjects with lower SES (80.15%,

$n=319$ ) and rural residents (75.85%,  $n=468$ ) had higher proportion of undiagnosed cases (Figure 1).

Logistic regressions revealed that previously diagnosed cases were more likely to be relatively aged ( $aOR_{41-60\text{years}}=4.26(3.24-5.60)$  and  $aOR_{>60\text{years}}=5.88(4.16-8.32)$ ; reference=18-40 years), educated ( $aOR_{\text{Secondary}}=1.64(1.03-2.60)$ ,  $aOR_{\text{Higher Secondary}}=1.75(1.05-2.92)$  and  $aOR_{\geq\text{Graduate}}=2.57(1.58-4.19)$ ; reference=Illiterates), SES-wise better ( $aOR_{\text{Middle}}=1.45(1.06-1.98)$  and  $aOR_{\text{Upper}}=2.05(1.46-2.88)$ ; reference=Upper) and urban residents ( $aOR=1.68(1.31-2.16)$ ; reference=Rural). Female ( $aOR=0.55(0.43-0.71)$ ; reference=Male), never married ( $aOR=0.23(0.11-0.48)$ ; reference=Currently married) and hard-working subjects ( $aOR=0.59(0.41-0.83)$ ; reference=Sedentary work) were less likely to have a prior diagnosis of diabetes. Compared to the respective reference groups, subjects of higher age ( $aOR_{41-60\text{years}}=2.74(2.36-3.18)$  and  $aOR_{>60\text{years}}=3.79(3.06-4.68)$ ), Muslim religion ( $aOR=1.69(1.43-1.98)$ ; reference=Hindu), divorced/separated/widowed/widower marital status ( $aOR=1.25(1.03-1.52)$ ), better education ( $aOR_{\text{Primary}}=1.39(1.09-1.78)$ ,  $aOR_{\text{Secondary}}=1.41(1.13-1.78)$ ,  $aOR_{\text{Higher, secondary}}=1.90(1.46-2.48)$  and  $aOR_{\geq\text{Graduate}}=1.82(1.40-2.37)$ ) and upper SES ( $aOR=1.31(1.08-1.59)$ ) had higher odds of diabetes. On the other hand, females ( $aOR=0.62(0.53-0.72)$ ) and never married participants ( $aOR=0.39(0.28-0.55)$ ) were comparatively less likely to be diabetic (Table 3).

Subjects having higher age ( $aOR_{41-60\text{years}}=0.51(0.36-0.71)$  and  $aOR_{>60\text{years}}=0.44(0.29-0.69)$ ), better SES ( $aOR_{\text{Middle}}=0.62(0.42-0.92)$  and  $aOR_{\text{Upper}}=0.50(0.33-0.77)$ ) and urban residence ( $aOR=0.49(0.36-0.68)$ ) were less likely to have undiagnosed diabetes. Although the multiple regressions lacked sufficient power for the adjusted estimates, as per the unadjusted ORs it seemed that: among diabetics, educated subjects ( $OR_{\text{Secondary}}=0.53(0.32-0.86)$ ,  $OR_{\text{Higher secondary}}=0.55(0.32-0.95)$  and  $OR_{\geq\text{Graduate}}=0.19(0.11-0.32)$ ) were less likely and Muslims ( $OR=2.54(1.92-3.35)$ ), never married ( $OR=2.51(1.15-5.50)$ ) and moderate/hard-workers ( $OR_{\text{Moderate-worker}}=1.61(1.18-2.19)$ ,  $OR_{\text{Hard-worker}}=3.37(2.35-4.83)$ ) were more likely to remain undiagnosed (Table 3).

Among those who were previously diagnosed as a case of diabetes, divorced/separated/widowed/widowers had lower ( $aOR=0.49(0.26-0.95)$ ) and subjects with secondary level of familial education had higher ( $aOR=3.18(1.14-8.89)$ ) odds of having uncontrolled diabetes. According to the unadjusted model, likelihood of having uncontrolled diabetes seemed to be higher among Muslims also ( $OR=1.62(1.01-2.60)$ ) (Table 4).

Regarding healthcare-seeking, the odds of seeking healthcare from nonqualified practitioners were less for urban diabetics ( $aOR=0.28(0.09-0.87)$ ) compared to their rural counterparts. Diabetics of Muslim religion ( $aOR=0.41(0.17-0.95)$ ) and backward caste ( $aOR=0.50(0.26-0.98)$ ) were less likely while educated patients ( $aOR_{\text{Secondary}}=3.80(1.14-12.66)$  and  $aOR_{\geq\text{Graduate}}=8.42(2.17-32.74)$ ) and those in hard-working jobs ( $aOR=3.09(1.01-9.52)$ ) were more likely to visit qualified practitioner from private sector. Likelihood of visiting qualified physicians from private sector also seemed to be higher among cases belonging to upper SES ( $OR=2.35(1.08-5.09)$ ).

## Discussion

In this current study involving 18028 representative subjects from one of the poorest districts (Malda) of the West Bengal state of eastern India, the prevalence of diabetes was estimated to be 6.09% which was a bit lower than the adult prevalence of diabetes observed in other parts of India (10.4% in Tamil Nadu, 8.4% in Maharashtra and 13.6%

Variables	Categories	Frequency	Percentages (95% CI <sup>a</sup> )
Age group	18-40 years	11191	62.08 (61.37-62.78)
	41-60 years	5210	28.90 (28.24-29.56)
	>60 years	1627	9.02 (8.61-9.44)
Gender	Male	6576	36.48 (35.77-37.18)
	Female	11452	63.52 (62.82-64.23)
Religion	Hindu	12774	70.86 (70.19-71.52)
	Muslim	5190	28.79 (28.13-29.45)
	Others	64	0.36 (0.27-0.44)
Caste	Backward castes (SC/ST/OBC)	10374	57.54 (56.82-58.27)
	General castes	7654	42.46 (41.73-43.18)
Marital status	Currently married	13972	77.55 (76.94-78.16)
	Never married	2126	11.80 (11.33-12.27)
	Divorced/separated/widowed/widower	1919	10.65 (10.20-11.10)
Education	Illiterate	2558	14.19 (13.68-14.70)
	Primary	3379	18.74 (18.17-19.31)
	Secondary	6891	38.22 (37.51-38.93)
	Higher secondary	2269	12.59 (12.10-13.07)
	Graduate and above	2931	16.26 (15.72-16.80)
Occupational type	Sedentary work	2788	15.46 (14.94-15.99)
	Moderate work	9428	52.30 (51.57-53.03)
	Hard work	5812	32.24 (31.56-32.92)
Socio-economic strata	Upper	3858	21.40 (20.80-22.00)
	Middle	6710	37.22 (36.51-37.93)
	Lower	7460	41.38 (40.66-42.10)
Residential area	Rural	10820	60.02 (59.30-60.73)
	Urban	7208	39.98 (39.27-40.70)
Previously diagnosed with diabetes	No	17624	97.76 (97.54-97.98)
	Yes	404	2.24 (2.02-2.46)
Among diabetics: sought healthcare from	Non-qualified practitioners	34	8.42 (5.70-11.13)
	Qualified practitioners from private sector	314	77.72 (73.65-81.80)
	Qualified practitioners from Government sector	56	13.86 (10.48-17.25)
Fasting capillary blood sugar level	Non-diabetic	1549	80.68 (78.91-82.44)
	Diabetic	371	19.32 (17.56-21.09)
PP/Random capillary blood sugar level	Non-diabetic	15268	96.75 (96.47-97.03)
	Diabetic	513	3.25 (2.97-3.53)
Diabetes case status	Non-diabetic	16930	93.91 (93.56-94.26)
	Diabetic	1098	6.09 (5.74-6.44)
Diabetes diagnosis status	Diagnosed case	404	36.79 (33.94-39.65)
	Undiagnosed case	694	63.21 (60.35-66.06)
Diabetes control status	Controlled	211	52.62 (47.71-57.53)
	Uncontrolled	190	47.38 (42.47-52.29)

**Table 1:** Distribution of Socio-demographics, burden of diabetes (diagnosed/uncontrolled/undiagnosed) and related care-seeking among study subjects (Na=18028).

Variables	Labels	Diabetic	
		Frequency	Percentages (95% CI <sup>a</sup> )
Age group	18-40 years	353	3.15 (2.83-3.48)
	41-60 years	508	9.75 (8.94-10.56)
	>60 years	237	14.57 (12.85-16.28)
Gender	Male	509	7.74 (7.09-8.39)
	Female	589	5.14 (4.74-5.55)
Religion	Hindu	714	5.59 (5.19-5.99)
	Muslim	381	7.34 (6.63-8.05)
	Others	3	4.69 (0.00-10.01)
Caste	Backward castes	563	5.43 (4.99-5.86)
	General castes	535	6.99 (6.42-7.56)

Marital status	Currently married	861	6.16 (5.76-6.56)
	Never married	42	1.98 (1.38-2.57)
	Divorced/separated/widowed/widower	195	10.16 (8.81-11.51)
Education	Illiterate	112	4.38 (3.59-5.17)
	Primary	181	5.36 (4.60-6.12)
	Secondary	383	5.56 (5.02-6.10)
	Higher secondary	175	7.71 (6.61-8.81)
	Graduate and above	247	8.43 (7.42-9.43)
Occupational type	Sedentary work	239	8.57 (7.53-9.61)
	Moderate work	529	5.61 (5.15-6.08)
	Hard work	330	5.68 (5.08-6.27)
Socio-economic strata	Upper	333	8.63 (7.74-9.52)
	Middle	367	5.47 (4.93-6.01)
	Lower	398	5.34 (4.83-5.85)
Residential area	Rural	617	5.70 (5.27-6.14)
	Urban	481	6.67 (6.10-7.25)

**Table 2:** Distribution of diabetes across the socio-demographic strata among the study subjects, Malda, India, 2014 (Na=18028).

in Chandigarh in 2010) but slightly higher than the value reported from the neighboring state of Jharkhand (5.3%) and urban part of West Bengal (4.8%) [13]. The observed value was also lower than the global prevalence of diabetes among adults (9%) in 2014 [6], the prevalence reported from similar settings in Afghanistan (8.5%), Bangladesh (8.6%), China (8.0%), Indonesia (8.0%), Malaysia (10.2%), Thailand (8.9%), Nepal (8.8%), Pakistan (9.9%), Japan (7.3%), South Africa (11.8%) and Sri Lanka (8.3%), in 2010 [7].

Although this lower percentage could be interpreted as an improvement in the situation regarding diabetes epidemic in this poor-resource area, the actual picture might be quite reverse. Only 2.24% residents were previously diagnosed as diabetic, 47.38% of whom remained uncontrolled as they were found to be diabetic in our investigation also and 63.21% of the diabetics in the study area were undiagnosed so far. This burden of undiagnosed diabetes among adults seemed to be alarmingly high compared to the reported corresponding values from elsewhere (4.5% in Malaysia in 2006) [32] as well as other parts of India (10.5% in central and urban Kerala, 9.1% in Chennai, 40% in southern India as a whole and 4.25% in Kashmir) [33-36]. Compared to the global (46.3% in 2013) [2] and Indian (53.1%, 35.5 million undiagnosed among 66.8 million diabetics) [1] estimates for undiagnosed diabetes by IDF this value was also very high. But the results were not surprising keeping the respective observations of Ramachandran et al. and Graber et al. in mind who previously found that >70% diabetics in rural India [35] and 71% of diabetic patients admitted in a hospital in US [37] remained undiagnosed. The detected burden of uncontrolled cases also corroborated with previously observed level of poor glycemic control among Indian diabetics which ranged between 42-70% [3,11,34,38,39].

This high prevalence of uncontrolled and undiagnosed diabetics in Malda might have emphasized upon poor healthcare-seeking behavior of the study population as evident from the observation that among the diagnosed diabetics, 8.42% sought care from non-qualified practitioners. It was very likely that diagnosis of only those diabetics were possible who sought some healthcare services either for some symptoms related to diabetes or due to some other reasons (e.g.: routine checkup). Residents who got tested for diabetes could also be the more health-aware fraction of the population, having a relatively better healthcare-seeking and utilization. Owing to the largely asymptomatic nature of diabetes, especially in the early stages, it was also possible that only complicated cases were being diagnosed while being symptomatic and thus controlling the disease course among those late-diagnosed

cases probably were more difficult. Cumulatively it seemed that infrastructural development and behavioral modification programs were the need of the hour to ensure early diagnosis and appropriate treatment for minimizing the burden of diagnosed, undiagnosed and uncontrolled diabetes in this poor-resource setting.

Regarding the distribution of diabetes we observed that prevalence increased with age, being highest among subjects aged >60 years (14.57%) which corroborated with the global scenario [2,9,14,32]. Similar findings were also reported from studies conducted in Kashmir [36], urban slums of northern India [40] and the National Urban Survey in six major Indian cities [41]. Prevalence was higher among males (7.74 vs 5.14) compared to females alike other studies in India [35,40,42] and abroad [14]. Muslims (7.34%), general caste (6.99%), divorced/separated/widowed/widower (10.16%), more educated (8.43%), sedentary workers (8.57%) and those who were economically better-off (8.63) had higher diabetic prevalence among respective categories. The likelihood of being diabetic was more among urban residents (6.67%) than their rural counterparts, which also corroborated with previous observations from different parts of India [36,43].

Consistent with other studies in this country (both at the national level and in the southern parts), we found that odds of having diabetes increased among adults with advancing age [13,33,35,41] and females were less likely to be diabetic compared to males [13]. Muslims and general castes had higher odds of being diabetic compared to Hindus and backward castes respectively. Compared to currently married subjects, those who were never married had lower likelihood of being diabetic while those who were divorced/separated/widowed had higher odds of diabetes. With increase in educational level among adults in the households, odds of suffering from diabetes increased in the present study. Higher education was also found to be a significant correlate of diabetes among adults aged  $\geq 20$  years in Southern India [36]. Participants in hard-working jobs were less likely to have diabetes compared to those habituated to sedentary work, which corroborated with the National Urban Diabetic Survey and the Non-communicable Diseases Risk Factor Surveillance in India [41,44].

Similar to prior studies [13,41,43], subjects belonging to upper SES had higher risk of diabetes compared to poorer subjects in Malda district. With reference to rural, urban residents were more likely to be diabetic in our study. Similar findings were reported in other population-based studies among individuals aged 15 years or more in India [13,41,44].

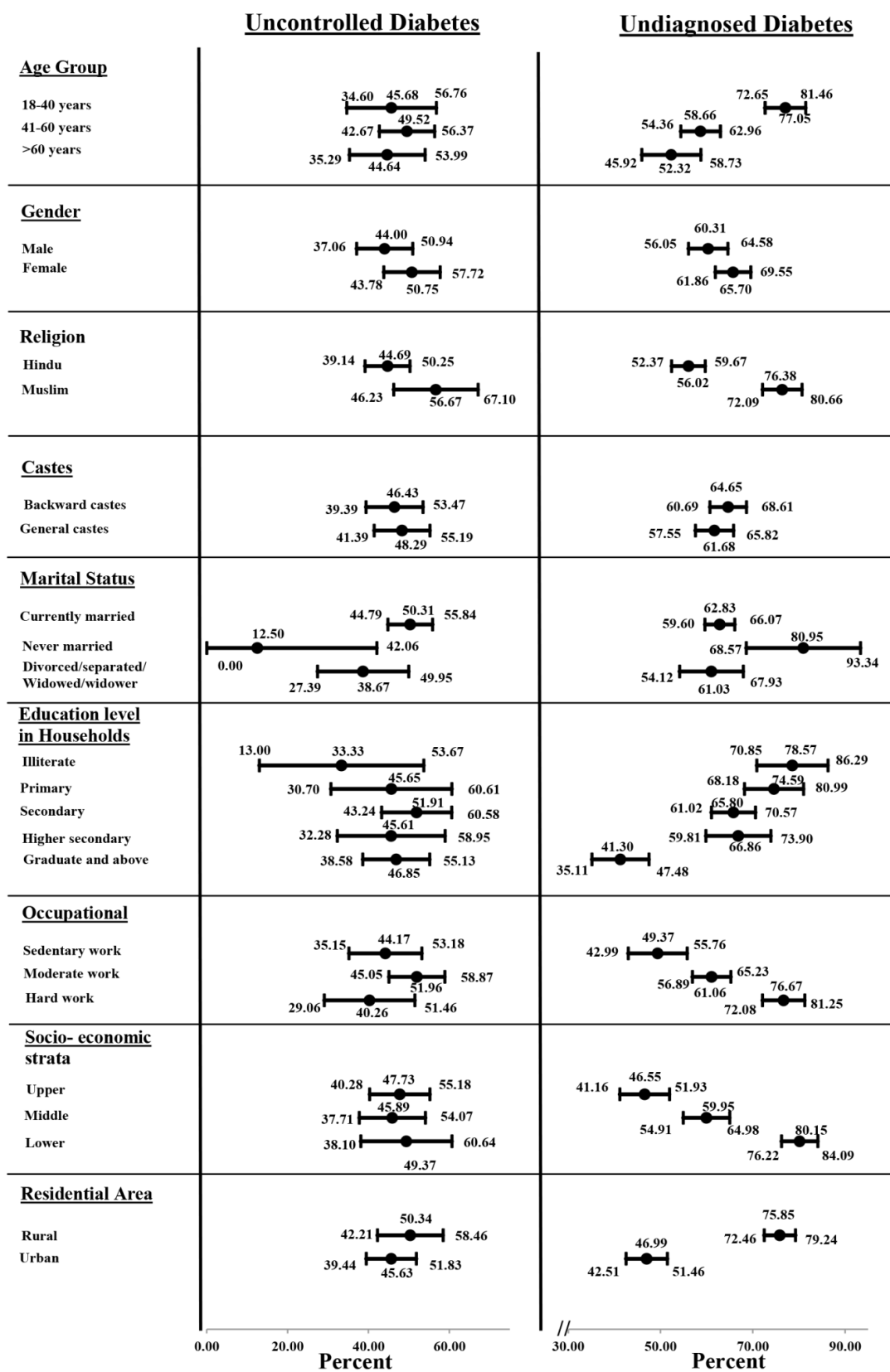


Figure 1: Distribution of undiagnosed and uncontrolled diabetics across the strata of socio-demographic factors.

Variables	Labels	Type	Previously diagnosed with diabetes		Diabetic (ref=non-diabetic)		Undiagnosed diabetic (ref=diagnosed)		Uncontrolled diabetic (ref=controlled)	
			OR <sup>c</sup> (95% CI <sup>d</sup> )	p value	OR <sup>c</sup> (95% CI <sup>d</sup> )	p value	OR <sup>c</sup> (95% CI <sup>d</sup> )	p value	OR <sup>c</sup> (95% CI <sup>d</sup> )	p value
Age group (ref=18-40 years)	41-60 years	Unadjusted	5.76 (4.45-7.46)	<0.0001	3.32 (2.88-3.82)	<0.0001	0.42 (0.31-0.57)	<0.0001	1.17 (0.70-1.95)	0.5576
		Adjusted	4.26 (3.24-5.60)	<0.0001	2.74 (2.36-3.18)	<0.0001	0.51 (0.36-0.71)	<0.0001	1.22 (0.70-2.13)	0.4741
	>60 years	Unadjusted	10.24 (7.66-13.69)	<0.0001	5.24 (4.40-6.23)	<0.0001	0.33 (0.23-0.47)	<0.0001	0.96 (0.54-1.70)	0.8865
		Adjusted	5.88 (4.16-8.32)	<0.0001	3.79 (3.06-4.68)	<0.0001	0.44 (0.29-0.69)	0.0003	1.16 (0.59-2.28)	0.6623
Gender (ref=male)	Female	Unadjusted	0.57 (0.47-0.69)	<0.0001	0.65 (0.57-0.73)	<0.0001	1.26 (0.99-1.61)	0.0649	1.31 (0.89-1.94)	0.1765
		Adjusted	0.55 (0.43-0.71)	<0.0001	0.62 (0.53-0.72)	<0.0001	1.22 (0.87-1.70)	0.2521	1.50 (0.90-2.50)	0.1214
Religion (ref=Hindu)	Muslim	Unadjusted	0.70 (0.55-0.89)	0.0032	1.34 (1.18-1.52)	<0.0001	2.54 (1.92-3.35)	<0.0001	1.62 (1.01-2.60)	0.0462
		Adjusted	1.28 (0.97-1.71)	0.084	1.69 (1.43-1.98)	<0.0001	1.26 (0.87-1.83)	0.231	1.72 (0.96-3.09)	0.068
	Others	Unadjusted	-	-	0.83 (0.26-2.65)	0.7548	-	-	-	-
		Adjusted	-	-	1.18 (0.36-3.83)	0.7883	-	-	-	-
Caste (ref= General castes)	Backward castes	Unadjusted	0.71 (0.58-0.87)	0.0007	0.76 (0.68-0.86)	<0.0001	1.14 (0.89-1.45)	0.3076	0.93 (0.63-1.37)	0.7087
		Adjusted	0.88 (0.71-1.10)	0.2535	0.95 (0.83-1.09)	0.4609	1.22 (0.91-1.64)	0.1926	1.00 (0.65-1.53)	0.9974
Marital status (ref=Currently married)	Never married	Unadjusted	0.16 (0.08-0.33)	<0.0001	0.31 (0.22-0.42)	<0.0001	2.51 (1.15-5.50)	0.0209	0.14 (0.02-1.16)	0.0685
		Adjusted	0.23 (0.11-0.48)	<0.0001	0.39 (0.28-0.55)	<0.0001	1.96 (0.83-4.63)	0.1273	0.14 (0.02-1.25)	0.0785
	Divorced/separated/widowed/widower	Unadjusted	1.76 (1.36-2.27)	<0.0001	1.72 (1.46-2.03)	<0.0001	0.93 (0.67-1.28)	0.6377	0.62 (0.37-1.04)	0.0708
		Adjusted	1.08 (0.80-1.47)	0.613	1.25 (1.03-1.52)	0.0255	1.20 (0.79-1.82)	0.4037	0.49 (0.26-0.95)	0.0335
Education (ref=Illiterate)	Primary	Unadjusted	1.46 (0.89-2.39)	0.137	1.24 (0.97-1.57)	0.0854	0.80 (0.46-1.40)	0.4373	1.68 (0.60-4.70)	0.3227
		Adjusted	1.52 (0.92-2.51)	0.1031	1.39 (1.09-1.78)	0.0083	0.89 (0.49-1.60)	0.6956	2.06 (0.69-6.14)	0.1932
	Secondary	Unadjusted	2.05 (1.32-3.17)	0.0013	1.29 (1.04-1.60)	0.0225	0.53 (0.32-0.86)	0.0112	2.16 (0.86-5.39)	0.0994
		Adjusted	1.64 (1.03-2.60)	0.0355	1.41 (1.13-1.78)	0.0029	0.89 (0.52-1.53)	0.6717	3.18 (1.14-8.89)	0.0275
	Higher secondary	Unadjusted	2.77 (1.72-4.47)	<0.0001	1.83 (1.43-2.33)	<0.0001	0.55 (0.32-0.95)	0.0333	1.68 (0.62-4.54)	0.3088
		Adjusted	1.75 (1.05-2.92)	0.0326	1.90 (1.46-2.48)	<0.0001	1.05 (0.57-1.94)	0.8804	2.37 (0.77-7.31)	0.1336
	Graduate and above	Unadjusted	5.50 (3.56-8.49)	<0.0001	2.01 (1.60-2.53)	<0.0001	0.19 (0.11-0.32)	<0.0001	1.76 (0.71-4.38)	0.222
		Adjusted	2.57 (1.58-4.19)	0.0001	1.82 (1.40-2.37)	<0.0001	0.55 (0.30-1.01)	0.0546	2.35 (0.80-6.89)	0.1186
Occupational type (ref=Sedentary work)	Moderate work	Unadjusted	0.49 (0.39-0.62)	<0.0001	0.63 (0.54-0.74)	<0.0001	1.61 (1.18-2.19)	0.0025	1.37 (0.87-2.15)	0.1759
		Adjusted	0.87 (0.66-1.16)	0.3567	0.96 (0.79-1.17)	0.6678	1.18 (0.78-1.78)	0.4261	1.01 (0.57-1.80)	0.9686
	Hard work	Unadjusted	0.30 (0.22-0.40)	<0.0001	0.64 (0.54-0.76)	<0.0001	3.37 (2.35-4.83)	<0.0001	0.85 (0.48-1.52)	0.5886
		Adjusted	0.59 (0.41-0.83)	0.0025	0.83 (0.67-1.03)	0.0905	1.57 (0.99-2.47)	0.0555	0.61 (0.30-1.24)	0.1744
Socio-economic strata (ref=Lower)	Upper	Unadjusted	4.52 (3.46-5.91)	<0.0001	1.68 (1.44-1.95)	<0.0001	0.22 (0.16-0.30)	<0.0001	0.94 (0.55-1.59)	0.8082
		Adjusted	2.05 (1.46-2.88)	<0.0001	1.31 (1.08-1.59)	0.0068	0.50 (0.33-0.77)	0.0016	0.80 (0.38-1.65)	0.5383
	Middle	Unadjusted	2.09 (1.59-2.76)	<0.0001	1.03 (0.89-1.19)	0.7239	0.37 (0.27-0.51)	<0.0001	0.87 (0.50-1.51)	0.6181
		Adjusted	1.45 (1.06-1.98)	0.0207	1.00 (0.84-1.18)	0.9729	0.62 (0.42-0.92)	0.0161	0.68 (0.34-1.34)	0.2589
Residential area (ref=rural)	Urban	Unadjusted	2.63 (2.14-3.22)	<0.0001	1.18 (1.05-1.34)	0.0076	0.28 (0.22-0.37)	<0.0001	0.83 (0.55-1.24)	0.3625
		Adjusted	1.68 (1.31-2.16)	<0.0001	1.12 (0.96-1.31)	0.1534	0.49 (0.36-0.68)	<0.0001	0.94 (0.56-1.55)	0.7955

Table 3: Associations of socio-behavioral correlates with diagnosed, undiagnosed and uncontrolled diabetes among study subjects (Nb=18028).

In a previous study in Indonesia, age was found to be an important predictor for undiagnosed diabetes [45]. In the current study it was observed that compared to younger, older subjects were less likely to have undiagnosed diabetes. Higher scope and requirement for testing of sugar levels (routinely or due to other co-morbidities) probability increased the chance of diagnosis of diabetes with advancing age.

Female diabetics were more likely to remain undiagnosed compared to their male counterparts in Malda. Keeping the social position of

women in a poor-resource Indian setting it seemed that comparatively higher self-neglect, poorer awareness and inappropriate perception of own health might be among the potential explanations.

Subjects belonging to relatively higher SES had lower odds of having undiagnosed diabetes compared to poorer subjects. Similar observation was reported from Bangladesh by Islam et al. [46]. Better awareness, affordability and healthcare-seeking among diabetics in higher SES probably resulted in increased probability of being tested

Variables	Categories	Type of analyses	Among diabetics: sought healthcare from (ref=Qualified physician from Governmental sector)			
			Non-qualified practitioner		Qualified practitioner from private sector	
			OR <sup>c</sup> (95% CI <sup>d</sup> )	p value	OR <sup>c</sup> (95% CI <sup>d</sup> )	p value
Age group (ref=18-40 years)	41-60 years	Unadjusted	0.47 (0.16-1.36)	0.1626	0.95 (0.44-2.08)	0.9055
		Adjusted	0.40 (0.13-1.29)	0.1247	0.69 (0.30-1.62)	0.3969
	>60 years	Unadjusted	0.43 (0.13-1.42)	0.1654	0.86 (0.37-2.01)	0.7327
		Adjusted	0.27 (0.06-1.16)	0.0775	0.56 (0.20-1.56)	0.2679
Gender (ref=male)	Female	Unadjusted	1.21 (0.52-2.84)	0.6638	1.07 (0.61-1.90)	0.8055
		Adjusted	1.51 (0.49-4.65)	0.4713	1.48 (0.68-3.19)	0.3221
Religion (ref=Hindu)	Muslim	Unadjusted	1.10 (0.44-2.75)	0.8428	0.56 (0.30-1.06)	0.0769
		Adjusted	0.50 (0.15-1.66)	0.2585	0.41 (0.17-0.95)	0.0381
Caste (ref= General castes)	Backward castes	Unadjusted	0.84 (0.36-1.99)	0.6975	0.68 (0.38-1.20)	0.1831
		Adjusted	0.64 (0.24-1.70)	0.3706	0.50 (0.26-0.98)	0.0434
Marital status (ref=Currently married)	Never married	Unadjusted	-	-	-	-
		Adjusted	-	-	-	-
	Divorced/separated/ widowed/widower	Unadjusted	2.35 (0.80-6.87)	0.1194	1.42 (0.64-3.17)	0.389
		Adjusted	2.73 (0.65-11.39)	0.1693	1.71 (0.60-4.83)	0.3126
Education (ref=Illiterate)	Primary	Unadjusted	2.23 (0.36-13.96)	0.3924	1.19 (0.38-3.70)	0.7664
		Adjusted	3.93 (0.54-28.42)	0.1757	1.47 (0.42-5.12)	0.5434
	Secondary	Unadjusted	2.33 (0.41-13.20)	0.3379	2.62 (0.94-7.32)	0.0664
		Adjusted	5.83 (0.85-40.21)	0.0736	3.80 (1.14-12.66)	0.0298
	Higher secondary	Unadjusted	2.72 (0.43-17.42)	0.2903	2.18 (0.69-6.88)	0.1848
		Adjusted	8.05 (0.98-66.35)	0.0528	3.19 (0.82-12.47)	0.0955
	Graduate and above	Unadjusted	1.91 (0.30-12.26)	0.4955	5.43 (1.83-16.12)	0.0023
		Adjusted	7.45 (0.84-66.46)	0.0722	8.42 (2.17-32.74)	0.0021
Occupational type (ref=Sedentary work)	Moderate work	Unadjusted	0.63 (0.23-1.70)	0.3594	0.92 (0.48-1.75)	0.798
		Adjusted	0.48 (0.13-1.83)	0.284	0.97 (0.41-2.33)	0.9499
	Hard work	Unadjusted	2.21 (0.65-7.54)	0.2062	1.57 (0.61-4.00)	0.3482
		Adjusted	1.90 (0.41-8.73)	0.4093	3.09 (1.01-9.52)	0.0491
Socio-economic strata (ref=Lower)	Upper	Unadjusted	0.69 (0.23-2.06)	0.5013	2.35 (1.08-5.09)	0.0307
		Adjusted	0.91 (0.21-4.04)	0.9035	1.46 (0.51-4.17)	0.4834
	Middle	Unadjusted	0.56 (0.20-1.57)	0.2715	1.16 (0.56-2.42)	0.6871
		Adjusted	0.68 (0.19-2.49)	0.5628	0.88 (0.35-2.24)	0.7952
Residential area (ref=rural=1)	Urban	Unadjusted	0.41 (0.17-0.97)	0.043	0.94 (0.52-1.71)	0.8373
		Adjusted	0.28 (0.09-0.87)	0.0271	0.51 (0.22-1.15)	0.1045

**Table 4:** Associations of socio-behavioral correlates with health-seeking pattern among diabetics (Nb=18028).

and thus being diagnosed.

Being consistent with the prior findings from another Indian study, we also found that urban subjects were less likely to have undiagnosed diabetes with reference to the rural residents [47]. Potential explanations might include relatively better awareness, availability of testing facilities, healthcare access and utilization in urban areas compared to rural.

In the current study it was observed that subjects with secondary level (compared to illiterate) of education were more likely while divorced/

separated/widowed/widowers (compared to currently married) were less likely to have uncontrolled diabetes. For most of the other variables we did not have sufficient power to infer. Higher education seemed to instill improved awareness and thus better glycemic control among diabetics, as was observed previously [3]. Muslim diabetics also seemed more likely to have poorer control on their disease status probably due to different food habits and lifestyle. Awareness and healthcare-seeking could also be considered as other issues.



Data on healthcare-seeking behavior among patients diagnosed with diabetes is limited, more so in developing countries. With increase in educational level, chances of seeking healthcare from qualified private practitioner increased among diabetics of Malda. An evaluation of healthcare-seeking among diabetics in Malaysia revealed an independent association of higher education with treatment-seeking [48]. Education was also associated with healthcare-seeking behavior and compliance among diabetic patients in rural areas of South India [49]. Probably higher education resulted in better knowledge, attitude and practice regarding healthcare-seeking among diabetics in general. Urban diabetics had lower odds of seeking care from non-qualified practitioners while Muslims and backward castes were less likely to seek care from qualified private practitioners. On the other hand diabetics who were hard working had higher odds of seeking care from qualified private practitioner.

This study had certain limitations. Like any other cross-sectional study, causal interpretation of the observed associations is not recommended. Results of our study should also be extrapolated beyond the study sample with caution. Due to the potential vulnerability to temporal ambiguity by design, some of our observations might have suffered from reverse causation. Residual confounding due to variables not included in our analyses could also be an issue. Information bias due to misclassification of self-reported information should always be kept in mind, especially due to the potential for differential recall. Relatively higher participation of the female members during the household survey could also be considered as a limitation.

Despite the aforementioned limitation, it seemed that by virtue of a large, representative population-based sampling and robust analyses our study could generate important insight regarding the burden and correlates of uncontrolled and undiagnosed diabetics in a poor resource setting of our country. Policy makers are likely to be able to design appropriately targeted intervention based on the findings of our result.

Burden of undiagnosed and uncontrolled diabetes was alarmingly high in Malda. Urgent intervention to improve detection, control and prevention of diabetes, targeting young adults, females, rural residents, Muslims, married subjects and those having lower SES seemed to be the need of the hour. Effective utilization of services for early detection of diabetes & initiation of treatment could be achieved through successful awareness generation followed by community participation. Nonqualified practitioners should be adequately trained to motivate and mobilize the individuals and the community to ensure early diagnosis of diabetics, their appropriate treatment and referral. Qualified physicians should also be trained suitably and provided with necessary logistics to motivate individuals regarding healthy lifestyle, appropriate testing, compliance to treatment and regular follow up to ensure prevention of the disease, early diagnosis and appropriate treatment. Extensive community awareness involving community leaders would help in minimizing the burden of Diabetes in these poor-resource settings.

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#### Conflict of interests

None to declare.

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