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Prevalence of Diabetes Mellitus and Associated Risk Factors in Nepal: Findings from A Nationwide Population-Based Survey

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ABSTRACT

Objectives The burden of diabetes mellitus (DM) has increased globally, particularly in low-and middle-income countries, including Nepal. Population-based nationally representative data on the prevalence of DM is limited. This paper presents the prevalence of DM and its associated risk factors in Nepal.

Research designs and methods This population-based study sampled 13,200 participants aged 20 years and above in 400 clusters of 72 districts of Nepal. The study used a standardised questionnaire adapted from the World Health Organization STEPwise approach to non-communicable disease risk factor surveillance instrument and digitalised in Android-compatible mobile phones. Fasting and two hours postprandial blood samples were taken to test various biochemical parameters. Descriptive followed by multivariate analyses were done to assess the association between explanatory variables and the outcome variable.

Primary outcome measures Prevalence of DM

Results The prevalence of DM was found to be 8.5% (95%CI:7.8-9.3). The odds of DM occurrence was higher in the upper age groups [40-59 years at adjusted odds ratio (AOR) 3.1(95%CI:2.3-4.2) and 60+ years at AOR 4.7(95%CI3.3-6.6)], compared to the group aged 20-39 years. Men were found to have higher odds of DM (AOR:1.3, 95%CI:1.1-1.6) compared to women. Urban residents had almost twice higher odds of DM (AOR:1.7, 95%CI:1.4-2.2) compared to rural residents. Participants with raised blood pressure (BP) (AOR: 2.2, 95% CI:1.8-2.7), those who were overweight and obese (AOR: 2.0, 95%CI:1.6-2.4) and those who had high triglycride level

(≥150mg/dl) (AOR: 2.1, 95% CI: 1.8-2.6) also had twice higher odds of DM compared to those with normal BP, an average body mass index (BMI) and normal triglyceride level respectively.

Conclusions Targeted interventions to higher risk groups as well as prevention and control of other associated biological risk factors might help to reduce the prevalence of DM in Nepal.

Strengths and limitations of the study

- This study provided first nationally representative prevalence of DM in people aged 20 years and above measured through fasting and post-prandial blood sample.
- In addition, the factors that were found to influence prevalence of DM in adult population were also determined.
- Although this study includes information on various risk factors for DM, we do not have information on the physical activity and dietary habits of participants, which are known to be important predictors of DM.

INTRODUCTION

The burden of diabetes mellitus (DM) has increased globally. In 2019, approximately 463 million adults aged 20-79 years were living with diabetes worldwide(1), causing an estimated 1.5 miliion deaths(2). This number is expected to rise to 700 million by 2045(1) DM contributes to at least USD 727 billion in health expenses, with 12% of total spending on adults(3). The burden of DM in terms of prevalence and number has risen dramatically, particularly in low- and middle-income countries (LMICs)(4).

The prevalence of DM and related risk factors, including overweight and obesity, have increased across South Asia in recent decades(5). According to the International Diabetes Federation (IDF), an estimated 82 million adults aged 20-79 years were living with DM in the South East Asia Region (SEAR) in 2017, representing a regional prevalence of 8.5%(6). Factors like decline in nutrition quality, reduction in physical activity, and increase in sedentary behaviours are reflected in the increasing prevalence of type 2 diabetes and related risk factors in the region(5).The IDF reported the national prevalence of DM among people 20-79 years in Nepal to be 4% in 2017, which is expected to rise to 6.1% by 2045. In the same age group, 11.7% of total deaths were attributed to DM in Nepal(7). A systematic review carried out in 2014 showed a pooled prevalence of DM as 8.4%, with the variation in prevalence ranging from 1.4% to 19.0% in Nepal(8). Even though, there are several national estimates available on the prevalence of DM in Nepal(9-12), those studies were limited to small sample size or geographic location that would not be representative of the whole population in Nepal. In addition, criteria used for defining the prevalence of DM varied across studies. Furthermore, there is a lack of research identifying the predictors of type

2 diabetes in Nepal(9). This warrants a large scale study that is representative of the whole population, which provides a national (including subnational) prevalence of type 2 diabetes using standard criteria and identifies its predictors.

This study reports the first nationally representative population-based prevalence of DM measured through both fasting and postprandial (PP) blood sample including that in different sub-groups and factors associated with occurrence of DM in Nepal.

METHODS

A population based cross sectional study was conducted covering all seven provinces of Nepal from 2016 to 2018. The sample size was calculated by considering the prevalence of raised blood glucose (p=4%) from the 2013 non-communicable diseases (NCD) risk factors STEPS survey, Nepal(13). Ethical approval was sought from the Ethical Review Board(ERB) of the Nepal Health Research Council (NHRC) with registration number 110/2016. Written informed consent was taken separately from the participants for physical measurements and laboratory tests. The study was carried out among 13,200 participants aged 20 years and above using mutlisatge cluster sampling technique. Men and women not providing consent to participate in either or both stages of the study (questionnaire and physical measurements, or biochemical measurements) were excluded from that particular stage or both the stages depending upon the consent received. Detail methodology for this study has been explained elsewhere(14).

Data collection

Data collection was done in two steps: first as face-to-face interview with a questionnaire and as second step physical measurements and collection of blood sample of the same participant with

the prior appointments. Additional details on data collection such as orientation of field team has been explained previously(14). REMO-Research and Monitoring Software, was used to programme the questionnaires into the mobile phones. This software was developed by Rooster Logic, an Information and Communication Technology (ICT) company led by local engineers with focus on database creation and management, research, and monitoring. This software has been extensively used for digital data collection in Nepal and allows small to large scale research projects to be conducted with ease and enables real-time monitoring of data. This software has been used by the NHRC in various previous surveys(15, 16).

Socio-demographic and behavioural information

Information on socio-demographic and behavioural risk factors was collected through face-to-face interviews using an interviewer-administered questionnaire. Information was collected on age, sex, ethnicity, educational status, marital status, occupation type, history of raised blood pressure and DM, alcohol consumption, and smoking habits. The commonly used classification for ethnicity in Nepal has six categories: 1) Dalit (marginalized group of people, with relatively lower socio-economic and education status); 2) Disadvantaged Janajatis (disadvantaged group of people and also indigenous, with relatively lower socio-economic and education status); 3) Disadvantaged non Dalit Terai Caste Groups (disadvantaged group of people from the Terai, the lowlands, with relatively lower socio-economic and education status but not the dalit groups); 4) Religious Minorities (Muslim, Christian, etc.); 5) Relatively advantaged Janajatis (indigenous group of people with relatively higher socio-economic status, such as Newar, Thakali, and Gurung); and6) Upper Caste Groups (population with relatively higher socio-economic and education status, mostly Brahmins, Chhetris, and Thakuri)(17).

Data on part of physical measurements, blood pressure measurement, and biochemical measurement was done using respective equipment and procedures, and the detail including the information on quality control has been explained elsewhere(14). Participants were defined as having DM if they had raised fasting glucose (≥126mg) or raised PP blood glucose level ((≥200mg), or if the participants were on anti-diabetic medication at the time of the study(18, 19) whereas the key definition of the terms raised blood pressure, body mass index, tobacco use, and alcohol consumption has been explained in the report published previously (14).

Data management and analysis

Data was extracted by the core team involved in data management, from the server where the collected data was stored. Data cleaning was performed using IBM SPSS® Statistics software version 20.0 (IBM, U.S.A.). The cleaned data was then exported to Stata® version 13.0 for analysis (Stata Corp, U.S.A.). Descriptive results were produced for each of the outcome variables using complex sample analysis considering the PSUs, strata and weight. Bivariate and multivariate analyses were used to assess the association between explanatory variables and the outcome variable. All explanatory variables with *p*-value of <0.05 in the bivariate analysis were inserted in the multivariate binary logistic regression model to see the independent effect of each variable on the occurrence of DM. The magnitude of the association was measured using the adjusted odds ratio (AOR) and 95% confidence interval (CI). A *p*-value <0.05 was considered as statistically significant(20).

Patient and public involvement statement

There was no involvement of patient in the study conception or design. However, experts in the relevant field were involved from the beginning and regular consultation was done with them. The findings from the study was disseminated to the general public and concerned stakeholders through a dissemination program.

RESULTS

The following section describes the results. It is divided into a descriptive picture of socio-demographic, behavioural and biological characteristics, and followed by the factors associated with the occurrence of DM.

Socio-demographic characteristics

Out of the 13,200 targeted participants, 12,557(95.3%) participated in the interview with a questionnaire (step 1), and 12,148 (92%) participated for the physical measurements and laboratory investigations (step 2). Socio-demographic characteristics of the participants are presented in Table 1. Among total of 12,557 participants, the majority of participants (76.8%) were in the age group 20-59 years. More than half of the participants (57.9%) were female. More people belonged to the upper caste groups (32.7%), followed by disadvantaged janajatis (20.7%). More than half (53.1%) were illiterate or never had formal schooling. Geographically, about one-fourth of the participants were from Bagmati province (24.7%), as it contained the capital city with dense population with the lowest proportion from Karnali Province (4.8%). More than half (51.5%) of the participants were urban dwellers.

Table 1: Socio-demographic characteristics of the participants

Variables	Characteristics (N=12557)	N	%
Age	20-39	4,562	35.5
	40-59	5,186	41.3
	60 years and above	2,809	23.3
Sex	Male	4,908	42.2
	Female	7,649	57.9
Ethnicity	Upper caste groups	4,263	32.7
	Disadvantaged janajatis	2,656	20.7
	Relatively advantaged janajatis	2,077	17.0
	Disadvantaged non-dalit terai caste groups	1,900	17.0
	Dalits	1,298	9.6
	Religious minorities	363	2.9
Education	Illiterate/No formal schooling	6,820	53.1
	Below secondary (<10 years)	2,839	22.3
	Secondary and above (≥10 years)	2,898	24.6
Province	Province 1	2,185	17.6
	Province 2	2,083	18.4
	Bagmati Province	3,223	24.7

	Gandaki Province	1,337	9.6
	Province 5	2,070	15.9
	Karnali Province	601	4.8
	Sudurpaschim Province	1,058	9.1
Place of residence	Rural	6,300	48.5
	Urban	6,257	51.5

Behavioural and biological characteristics

About one third of the participants (31.9%) said that they were smokers. Nearly one fourth of the participants (24.6%) reported that they were current alcohol drinkers. Raised blood pressure was prevalent among 36.9% of the participants. The proportion of participants who were either overweight or obese was 30.7%. More than one-third (35.7%) of participants had raised triglycerides. Behavioural and biological characteristics of the participants are presented in Table 2.

Table 2: Behavioural and biological characteristics of the participants

Variables	Characteristics (N=12557)	N	% (95% CI)
Smoking habit	Smokers	3,955	31.9(30.3-33.5)
	Non-smoker	8,602	68.1(66.5-69.7)
Users of smokeless tobacco	Users	3,087	25.4(24.1-26.8)

products	Non-users	9,470	74.6(73.3-75.9)
Users of either smoke or smokeless tobacco products	Users	1,609	13.1(12.2-14.1)
	Non-users	10,948	86.9(86.0-87.8)
Alcohol consumption	Yes	3,115	24.6(22.98-26.3)
	No	9,442	75.4(73.7-77.02)
Blood pressure	Raised	4,504	36.9(35.4-38.5)
	Normal	8,053	63.1(61.6-64.6)
Body mass index (N=12,556)	Underweight	1,534	12.3(11.3-13.4)
	Normal	7,156	57.0(55.6-58.5)
	Overweight and obese	3,866	30.7(28.9-32.5)
Increased Waist Hip ratio (N=11,997)	Increased	6,896	55.3(53.9-56.7)
	Normal	5,101	44.7(43.4-46.1)
Total cholesterol (N=10,861)	Raised	3,120	28.8(27.3-30.4)
	Normal	7,741	71.2(69.6-72.7)
Triglyceride (N=10,986)	Raised	3,862	35.7(34.2-37.2)
	Normal	7,124	64.3(62.8- 65.9)

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Factors associated with diabetes mellitus

The overall prevalence of DM was 8.5% (95%CI:7.8-9.3). The following two tables (Table 3 and 4) show the results on factors associated with DM, along with prevalence of DM among the different subgroups examined. Table 3, above, shows the prevalence of DM across subgroups by different background characteristics, and the factors associated with occurrence of DM through multivariate analysis in terms of AOR. The prevalence of DM is seen to have increased with age. Participants in the age group of 60 years and above had about 5 times higher odds of having DM (AOR: 4.7, 95%CI:3.3-6.6) compared to those in the age group of 20 to 39 years. Similarly, male participants had higher odds of having DM (AOR: 1.3, 95%CI:1.1-1.6) compared to female participants. Urban residents had about 2 times higher odds of having DM (AOR: 1.7, 95%CI:1.4-2.2) compared to those residing in rural area. Table 4 above shows the prevalence of DM across subgroups by different behavioural and biological characteristics and the factors associated with occurrence of DM through multivariate analysis in terms of AOR. Participants with raised blood pressure had about 2 times higher odds of having DM compared to those whose blood pressure was normal (AOR: 2.2, 95% CI: 1.8-2.7). Regarding body mass index, participants who were overweight and obese had two times higher odds of having DM than those with normal body mass index (AOR: 2.0, 95% CI: 1.6-2.4). Participants who had high triglyceride level (≥150mg/dl) had about 2 times higher odds of having DM than their counterparts (AOR: 2.1, 95% CI: 1.8-2.6).

183 **Table 3: Association of socio-demographic factors with diabetes mellitus**

Variables and characteristics	Number of Participants	Proportion with DM (%)	Odds of having DM	
			COR (95% CI)	AOR (95% CI)
Age				
20-39	4,046	115 (3.0)	1	1
40-59	4,723	469(10.4)	3.7(2.9-4.9)***	3.1(2.3-4.2)***
60 years and above	2,508	300(13.3)	4.9 (3.7-6.5)***	4.7(3.3-6.6)***
Sex				
Female	6,952	436(6.7)	1	1
Male	4,325	448(11.0)	1.7(1.5-2.0)***	1.3(1.1- 1.6)**
Ethnicity				
Disadvantaged janajatis	1,130	68(6.6)	1	1
Dalits	2,369	151(6.7)	1.0(0.7-1.4)	1.3(0.8-1.9)
Disadvantaged non-dalit terai caste groups	1,690	127(8.4)	1.3(1.0-1.7)	1.5(1.1-2.1)*
Religious minorities	285	38(17.5)	2.9(1.7-5.0)***	2.4(1.2-4.7)*
Relatively advantaged janajatis	1,884	210(11.9)	1.9(1.4-2.5)***	1.2(0.9-1.6)
Upper caste groups	3,919	290(7.8)	1.2(0.9-1.5)	1.0(0.7-1.3)

Education				
Illiterate/No formal schooling	6,128	535(8.4)	1	1
Below secondary (<10 years)	2,548	196(7.9)	1.0(0.8-1.2)	1.1(0.8-1.4)
Secondary and above (≥10 years)	2,601	274(10.1)	1.3(1.1-1.6)**	1.4(1.1-1.8)*
Province				
Karnali Province	565	16(3.2)	1	1
Province 1	1,909	134(7.7)	2.5(1.2-5.2)*	2.2(1.1-4.4)*
Province 2	1,845	138(8.5)	2.8(1.3-5.8)**	1.8(0.9-3.7)
Bagmati Province	2,820	298(11.5)	3.9(1.9-8.0)***	1.8(0.9-3.5)
Gandaki Province	1,249	79(6.7)	2.2(1.0-4.6)*	1.1(0.6-2.3)
Lumbini	1,905	170(9.6)	3.2(1.5-6.6)**	1.9(0.9-3.8)
Sudurpaschim Province	984	49(5.2)	1.6(0.7-3.8)	1.5(0.7-3.5)
Place of residence				
Rural	5,663	277(5.5)	1	1
Urban	5,614	607(11.3)	2.2(1.8-2.7)***	1.7(1.4-2.2)***

*1 Reference category,*p value≤0.05 **p value≤0.01***p value≤0.0001*

Table 4: Association of behavioural and biological factors with diabetes mellitus

Characteristics	Number of Participants	Proportion with DM n (%)	Odds of having DM	
			COR (95% CI)	AOR (95% CI)
Smoking habit				
Non smoker	7,789	581(8.0)	1	1
Smokers	3,488	303(9.5)	1.2(1.0-1.4)*	1.0(0.9-1.3)
Users of smokeless tobacco products				
Nonusers	8,544	642(8.1)	1	-
Users	2,733	242(9.7)	1.2(1.0-1.5)*	-
Users of either smoke or smokeless tobacco products				
Nonusers	9,857	751(8.3)	1	-
Users	1,420	133(10.1)	1.2(1.0-1.5)	-
Alcohol consumption				
No	8,538	657(8.4)	1	-
Yes	2,739	227(8.7)	1.0(0.9-1.2)	-
Blood pressure				
Normal	7,197	311 (4.6)	1	1

Raised	4,080	573 (15.1)	3.7 (3.1-4.4) ***	2.2(1.8-2.7)***
Body mass index (N=12,556)				
Normal	6,378	355 (6.1)	1	1
Underweight	1,365	51 (4.0)	0.6(0.4-0.9) *	0.8(0.5-1.1)
Overweight and obese	3,534	478 (14.6)	2.6(2.2-3.1) ***	2.0(1.6-2.4)***
Increased Waist Hip ratio (N=11,158)				
No	4,683	347 (8.0)	1	-
Yes	6,475	527 (8.9)	1.1(0.9-1.4)	-
Total cholesterol (N=10,837)				
Normal	7,722	478 (7.0)	1	1
Raised	3,115	357 (11.8)	1.8(1.5-2.1) ***	1.0(0.8-1.2)
Triglyceride (N=10,960)				
Normal	7,103	334 (5.0)	1	1
Raised	3,857	479 (13.4)	2.9 (2.5-3.5) ***	2.1(1.8-2.6)***

*1 Reference category, *p value≤0.05 **p value≤0.01*** p value≤0.0001*

DISCUSSION

The first nationally representative study identified high prevalence of DM among the participants, which is higher than the figure reported by a recent non-communicable disease risk factors survey (5.8%)(21) and IDF's estimate for Nepal i.e 4% in 2017(22). However, the prevalence of DM is similar to the findings observed in a systematic review (pooled prevalence-–8.4%, 95% CI: 6.2-10.5%), which summarised the prevalence of type 2 diabetes in Nepal for a period of 14 years (8). Similar figure (8.5%, 95% CI: 6.9-10.4%) was reported in another systematic review conducted in Nepal(21). Our finding is also in line with the WHO estimates for DM in Nepal which reported a prevalence of 9.1% in 2016(23). The latest estimates from the global burden of disease study, however, show a national prevalence of 4.4% of diabetes type 2(24). Likewise, WHO global report on DM also estimated a regional prevalence of 8.6% in South East Asia (SEA) in 2014, which is consistent with the findings from our study(4). The finding from our study is similar to estimates of DM prevalence from different studies in the neighbouring countries, including India (8.7%)(25), China (10.9%)(26), Sri Lanka (8.4%), Bhutan (7.7%), Maldives (7.5%) and Bangladesh (6.8%)(22). The prevalence of DM in our study may be attributed to a combination of factors including rapid urbanisation, changing lifestyles, unhealthy diets, tobacco use, and increasing life expectancy. Adding to this, several challenges prevailing around diabetes management such as high treament cost, availability of limited health facilities, lack of awareness about the disease and particularly no specific guideline available for the prevention and treatment of the disease in Nepal might have exacerberated the burden of this disease(10).

Our study reports that age was significantly associated with DM, with older aged people (60 years and above) having higher odds of having DM. Older age as an important predictor for DM is consistent with the findings of studies from different contexts(8, 9, 27-30). The life expectancy of Nepalese people has increased from 58 years in 1990 to 71 years in 2019(24) and the proportion of the older poulation is growing (31), which further tends to increase in future(32). With aging, skeletal muscle insulin sensitivity might be impaired which in turn increase the risk of insulin resistance and type 2 diabetes(33). The findings of the study and these factors underscore the need of tailored interventions for management and control of DM among population with higher age. Further to this our study showed that, male had higher odds of having DM than females. This finding is supported by an another study conducted in Nepal, which identified being female as significant protective factor for DM (AOR: 0.4, 95% CI: 0.3-0.7)(9). A systematic review conducted in South Asia also supported the findings from our study, indicating being male as a significant risk factor for DM(34). However, this is in contrast to the findings reported in a different systematic review suggesting that females were at higher risk of DM in Nepal (OR:1.6, 95% CI: 1.3-1.9)(8). Higher prevalence of DM among men has been associated with large amount of visceral fat in men(35). Besides, lower tendency of women to develop visceral adiposity may explain that women are protected from DM in comparison to men(36).

Our study reported that urban residents were more likely to have DM compared to those residing in rural areas. Nepal has been experiencing an increasing rate in urbanization(37). Increasing urbanization leading to change in dietary pattern, sedentary lifestyle, reduction in physical activity might have contributed to the higher burden of DM. Complementing this result, findings from NCDs STEPS survey 2019 suggests inadequate intake of fruits and vegetables and lower

participation in physical activity among urban population campared to their rural counterparts(38). All these factors might have some contributing role towards higher prevalence of DM among urban population. Similar to the findings from this study, an epidemological survey conducted by the Nepal Diabetes Association found higher prevalence (14.6%) of DM in urban area in comparison to rural area (2.5%) (39, 40). Consistent with the findings from our study, a systematic review also found the pooled prevalence of DM to be higher (8.1%, 95% CI: 7.3-8.9%)in urban areas compared to rural areas in Nepal (1.03%, 95% CI: 0.7-1.3%)(8). A study from Myanmar also presented similar findings of higher prevalence in urban areas compared to rural areas (12.1% vs 7.1%)(41). Studies have reported between two to five times higher odds of having DM and pre-DM in association with urban residence(42, 43).

Our study showed that participants with raised blood pressure had about two times higher odds of having DM compared to those whose blood pressure was normal. This result is consistent with findings from South Asia(34), Ethiopia(44) and Nepal(8). The prevalence of hypertension and DM has been increasing in Nepal, however, the progress towards its effective prevention, treatment and control is found to be low(9, 45). With the coexisting conditions of hypertension and DM, the importance of secondary prevention (screening, timely diagnosis and treatment) of both these conditions is of paramount importance.

Overweight and obesity are important risk factors for DM (5, 44, 46). Our study showed that participants who were overweight and obese had about 2 times higher odds of having DM than those with a normal BMI. Consistent with the findings from our study, a meta-analysis performed among Indian adults showed a statistically significant association between obesity and type 2 DM (OR = 1.14, 95%CI: 1.0-1.2)(47). Similar findings were observed in different studies conducted in

South Asia(34), US(48), Ethiopia(44) and Nepal(49). Overweight and obesity has been increasing in Nepal particularly among women(50). Obesity being a strong predictor for DM, there is a need to take preventive actions to control obesity which might in turn provide some level of control of growing DM prevalence in the country.

The other variable that showed significant association with the prevalence of DM was triglyceride level. Participants with a high triglyceride level (≥150mg/dl) had about 2 times higher odds of having DM than their counterparts. This is in line with findings from studies conducted elsewhere, including in Ethiopia(44), Bangladesh(51) and China(52). Similar findings have been reported by different previous studies from Nepal(53-55). This also highlights the need of interventions for prevention and control of several of these metabolic risk factors such as dyslipidemia so as to achieve DM control in Nepal.

Besides the factors explained above, the provinical differences in prevalence of DM (though not seen as statistically signficant after multivariate analysis) also highlights the importance of tailoring interventions to the provinces with higher prevalence such as Province 1, 2, 5 and Bagmati Province.

Our study has several strengths and limitations. Major strengths include: a large sample size, coverage of rural and urban residences; all three ecological belts of the country (the Terai, hills and mountains); and all provinces of Nepal. This approach provided nationally representative data and increased its generalizability among the Nepalese population. The study also provided detailed information on the possible association with a wide range of risk factors for DM. However, the cross-sectional nature of the study did not allow for a causal relationship to be established between these risk factors and the prevalence of DM. In addition, no information

was collected on the physical activity and dietary habits of participants, which have been established as important predictors of DM in other studies (56-59).

CONCLUSIONS

Our study showed DM to be more prevalent among individuals aged 20 years and above. Older age, male gender, residing in urban areas, high BMI, raised blood pressure, and raised triglyceride level independently predicted the occurrence of DM in this study. Findings suggest that targeted DM prevention and control interventions, especially to those population groups with higher chances of DM occurrence, in addition to prevention and control of the biological risk factors associated with DM through appropriate measures, would help curb the prevalence of DM in Nepal.

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Author's contributions KBK, KKA and MD conceived the study. NG and DKC helped in data entry and management. KKA and NS was involved in conducting data analysis. NS, KKA, AP and NKM wrote the manuscript. PG and AKJ supported in monitoring overall data quality. All authors reviewed the manuscript. NS and KBK contributed equally.

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STROBE Statement—Checklist of items that should be included in reports of ***cross-sectional studies***

	Item No	Recommendation	Page No
Title and abstract	1	(*a*) Indicate the study's design with a commonly used term in the title or the abstract	2
		(*b*) Provide in the abstract an informative and balanced summary of what was done and what was found	2,3
Introduction			
Background/rationale	2	Explain the scientific background and rationale for the investigation being reported	4,5
Objectives	3	State specific objectives, including any prespecified hypotheses	5
Methods			
Study design	4	Present key elements of study design early in the paper	5
Setting	5	Describe the setting, locations, and relevant dates, including periods of recruitment, exposure, follow-up, and data collection	5
Participants	6	(*a*) Give the eligibility criteria, and the sources and methods of selection of participants	5
Variables	7	Clearly define all outcomes, exposures, predictors, potential confounders, and effect modifiers. Give diagnostic criteria, if applicable	6, 7
Data sources/ measurement	8*	For each variable of interest, give sources of data and details of methods of assessment (measurement). Describe comparability of assessment methods if there is more than one group	7
Bias	9	Describe any efforts to address potential sources of bias	N/A
Study size	10	Explain how the study size was arrived at	5
Quantitative variables	11	Explain how quantitative variables were handled in the analyses. If applicable, describe which groupings were chosen and why	6, 7
Statistical methods	12	(*a*) Describe all statistical methods, including those used to control for confounding	7
		(*b*) Describe any methods used to examine subgroups and interactions	7
		(*c*) Explain how missing data were addressed	7
		(*d*) If applicable, describe analytical methods taking account of sampling strategy	7
		(*e*) Describe any sensitivity analyses	N/A
Results			
Participants	13*	(a) Report numbers of individuals at each stage of study—eg numbers potentially eligible, examined for eligibility, confirmed eligible, included in the study, completing follow-up, and analysed	5
		(b) Give reasons for non-participation at each stage	N/A
		(c) Consider use of a flow diagram	N/A
Descriptive data	14*	(a) Give characteristics of study participants (eg demographic, clinical, social) and information on exposures and potential confounders	8 to 10
		(b) Indicate number of participants with missing data for each variable of interest	11
Outcome data	15*	Report numbers of outcome events or summary measures	12
Main results	16	(*a*) Give unadjusted estimates and, if applicable, confounder-adjusted estimates and their precision (eg, 95% confidence interval). Make clear which confounders were adjusted for and why they were included	12 to 16

		(*b*) Report category boundaries when continuous variables were categorized	N/A
		(*c*) If relevant, consider translating estimates of relative risk into absolute risk for a meaningful time period	N/A
Other analyses	17	Report other analyses done—eg analyses of subgroups and interactions, and sensitivity analyses	N/A
Discussion			
Key results	18	Summarise key results with reference to study objectives	8 to 16
Limitations	19	Discuss limitations of the study, taking into account sources of potential bias or imprecision. Discuss both direction and magnitude of any potential bias	20
Interpretation	20	Give a cautious overall interpretation of results considering objectives, limitations, multiplicity of analyses, results from similar studies, and other relevant evidence	16 to 20
Generalisability	21	Discuss the generalisability (external validity) of the study results	20
Other information			
Funding	22	Give the source of funding and the role of the funders for the present study and, if applicable, for the original study on which the present article is based	22

*Give information separately for exposed and unexposed groups.

Note: An Explanation and Elaboration article discusses each checklist item and gives methodological background and published examples of transparent reporting. The STROBE checklist is best used in conjunction with this article (freely available on the Web sites of PLoS Medicine at http://www.plosmedicine.org/, Annals of Internal Medicine at http://www.annals.org/, and Epidemiology at http://www.epidem.com/). Information on the STROBE Initiative is available at www.strobe-statement.org.

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Prevalence of Diabetes Mellitus and Associated Risk Factors in Nepal: Findings from A Nationwide Population-Based Survey

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ABSTRACT

Objectives The burden of diabetes mellitus (DM) has increased globally, particularly in low-and middle-income countries, including Nepal. Population-based nationally representative data on the prevalence of DM is limited. This paper presents the prevalence of DM and its associated risk factors in Nepal.

Research designs and methods This population-based study sampled 13,200 participants aged 20 years and above in 400 clusters of 72 districts of Nepal. The study used a standardised questionnaire adapted from the World Health Organization STEPwise approach to non-communicable disease risk factor surveillance instrument and digitalised in Android-compatible mobile phones. Fasting and two hours postprandial blood samples were taken to test various biochemical parameters. Descriptive followed by multivariate analyses were done to assess the association between explanatory variables and the outcome variable.

Primary outcome measures Prevalence of DM

Results The prevalence of DM was found to be 8.5% (95%CI:7.8-9.3). The odds of DM occurrence was higher in the upper age groups [40-59 years at adjusted odds ratio (AOR) 3.1(95%CI:2.3-4.2) and 60+ years at AOR 4.7(95%CI3.3-6.6)], compared to the group aged 20-39 years. Men were found to have higher odds of DM (AOR:1.3, 95%CI:1.1-1.6) compared to women. Urban residents had almost twice higher odds of DM (AOR:1.7, 95%CI:1.4-2.2) compared to rural residents. Participants with raised blood pressure (BP) (AOR: 2.2, 95% CI:1.8-2.7), those who were overweight and obese (AOR: 2.0, 95%CI:1.6-2.4) and those who had high triglycride level

(≥150mg/dl) (AOR: 2.1, 95% CI: 1.8-2.6) also had twice higher odds of DM compared to those with normal BP, an average body mass index (BMI) and normal triglyceride level respectively.

Conclusions Targeted interventions to higher risk groups as well as prevention and control of other associated biological risk factors might help to reduce the prevalence of DM in Nepal.

Strengths and limitations of the study

- The study included a large sample spread across 400 clusters (wards-lowest administrative units) covering 72 districts out of 77 districts in Nepal.
- Blood glucose was measured through both fasting and post-prandial blood sample.
- The study used digital data collection and feedback was given on a regular basis after data were uploaded on a real time basis.
- Data quality was ensured through standard training processes and quality assurance procedures.
- The study does not have information on the physical activity and dietary habits of participants, which are known to be important predictors of DM.

INTRODUCTION

The burden of diabetes mellitus (DM) has increased globally. In 2019, approximately 463 million adults aged 20-79 years were living with diabetes worldwide(1), causing an estimated 1.5 miliion deaths(2). This number is expected to rise to 700 million by 2045(1) DM contributes to at least USD 727 billion in health expenses, with 12% of total spending on adults(3). The burden of DM in terms of prevalence and number has risen dramatically, particularly in low- and middle-income countries (LMICs)(4).

The prevalence of DM and related risk factors, including overweight and obesity, have increased across South Asia in recent decades(5). According to the International Diabetes Federation (IDF), an estimated 82 million adults aged 20-79 years were living with DM in the South East Asia Region (SEAR) in 2017, representing a regional prevalence of 8.5%(6). Factors like decline in nutrition quality, reduction in physical activity, and increase in sedentary behaviours are reflected in the increasing prevalence of type 2 diabetes and related risk factors in the region(5).The IDF reported the national prevalence of DM among people 20-79 years in Nepal to be 4% in 2017, which is expected to rise to 6.1% by 2045. In the same age group, 11.7% of total deaths were attributed to DM in Nepal(7). A systematic review carried out in 2014 showed a pooled prevalence of DM as 8.4%, with the variation in prevalence ranging from 1.4% to 19.0% in Nepal(8). Even though, there are several national estimates available on the prevalence of DM in Nepal(9-12), those studies were limited to small sample size or geographic location that would not be representative of the whole population in Nepal. In addition, criteria used for defining the prevalence of DM varied across studies. Furthermore, there is a lack of research identifying the predictors of type

2 diabetes in Nepal(9). This warrants a large scale study that is representative of the whole population, which provides a national (including subnational) prevalence of type 2 diabetes using standard criteria and identifies its predictors.

This study reports the first nationally representative population-based prevalence of DM measured through both fasting and postprandial (PP) blood sample including that in different sub-groups and factors associated with occurrence of DM in Nepal.

METHODS

A population based cross sectional study was conducted covering all seven provinces of Nepal from 2016 to 2018. The sample size was calculated by considering the prevalence of raised blood glucose (p=4%) from the 2013 non-communicable diseases (NCD) risk factors STEPS survey, Nepal(13). Ethical approval was sought from the Ethical Review Board(ERB) of the Nepal Health Research Council (NHRC) with registration number 110/2016. Written informed consent was taken separately from the participants for physical measurements and laboratory tests. The study was carried out among 13,200 participants aged 20 years and above using mutlisatge cluster sampling technique. Men and women not providing consent to participate in either or both stages of the study (questionnaire and physical measurements, or biochemical measurements) were excluded from that particular stage or both the stages depending upon the consent received. Detail methodology for this study has been explained elsewhere(14).

Data collection

Data collection was done in two steps: first as face-to-face interview with a questionnaire and as second step physical measurements and collection of blood sample of the same participant with

the prior appointments. Additional details on data collection such as orientation of field team has been explained previously(14). REMO-Research and Monitoring Software, was used to programme the questionnaires into the mobile phones. This software was developed by Rooster Logic, an Information and Communication Technology (ICT) company led by local engineers with focus on database creation and management, research, and monitoring. This software has been extensively used for digital data collection in Nepal and allows small to large scale research projects to be conducted with ease and enables real-time monitoring of data. This software has been used by the NHRC in various previous surveys(15, 16).

Socio-demographic and behavioural information

Information on socio-demographic and behavioural risk factors was collected through face-to-face interviews using an interviewer-administered questionnaire. Information was collected on age, sex, ethnicity, educational status, marital status, occupation type, history of raised blood pressure and DM, alcohol consumption, and smoking habits. The commonly used classification for ethnicity in Nepal has six categories: 1) Dalit (marginalized group of people, with relatively lower socio-economic and education status); 2) Disadvantaged Janajatis (disadvantaged group of people and also indigenous, with relatively lower socio-economic and education status); 3) Disadvantaged non Dalit Terai Caste Groups (disadvantaged group of people from the Terai, the lowlands, with relatively lower socio-economic and education status but not the dalit groups); 4) Religious Minorities (Muslim, Christian, etc.); 5) Relatively advantaged Janajatis (indigenous group of people with relatively higher socio-economic status, such as Newar, Thakali, and Gurung); and6) Upper Caste Groups (population with relatively higher socio-economic and education status, mostly Brahmins, Chhetris, and Thakuri)(17).

Data on part of physical measurements, blood pressure measurement, and biochemical measurement was done using respective equipment and procedures, and the detail including the information on quality control has been explained elsewhere(14). Participants were defined as having DM if they had raised fasting glucose (≥126mg) or raised PP blood glucose level ((≥200mg), or if the participants were on anti-diabetic medication at the time of the study(18, 19) whereas the key definition of the terms raised blood pressure, body mass index, tobacco use, and alcohol consumption has been explained in the report published previously (14).

Data management and analysis

Data was extracted by the core team involved in data management, from the server where the collected data was stored. Data cleaning was performed using IBM SPSS® Statistics software version 20.0 (IBM, U.S.A.). The cleaned data was then exported to Stata® version 13.0 for analysis (Stata Corp, U.S.A.). Descriptive results were produced for each of the outcome variables using complex sample analysis considering the PSUs, strata and weight. Bivariate and multivariate analyses were used to assess the association between explanatory variables and the outcome variable. All explanatory variables with *p*-value of <0.05 in the bivariate analysis were inserted in the multivariate binary logistic regression model to see the independent effect of each variable on the occurrence of DM. The magnitude of the association was measured using the adjusted odds ratio (AOR) and 95% confidence interval (CI). A *p*-value <0.05 was considered as statistically significant(20).

Patient and public involvement statement

There was no involvement of patient in the study conception or design. However, experts in the relevant field were involved from the beginning and regular consultation was done with them. The findings from the study was disseminated to the general public and concerned stakeholders through a dissemination program.

RESULTS

The following section describes the results. It is divided into a descriptive picture of socio-demographic, behavioural and biological characteristics, and followed by the factors associated with the occurrence of DM.

Socio-demographic characteristics

Out of the 13,200 targeted participants, 12,557(95.3%) participated in the interview with a questionnaire (step 1), and 12,148 (92%) participated for the physical measurements and laboratory investigations (step 2). Socio-demographic characteristics of the participants are presented in Table 1. Among total of 12,557 participants, the majority of participants (76.8%) were in the age group 20-59 years. More than half of the participants (57.9%) were female. More people belonged to the upper caste groups (32.7%), followed by disadvantaged janajatis (20.7%). More than half (53.1%) were illiterate or never had formal schooling. Geographically, about one-fourth of the participants were from Bagmati province (24.7%), as it contained the capital city with dense population with the lowest proportion from Karnali Province (4.8%). More than half (51.5%) of the participants were urban dwellers.

153 **Table 1: Socio-demographic characteristics of the participants**

Variables	Characteristics (N=12557)	N	%
Age	20-39	4,562	35.5
	40-59	5,186	41.3
	60 years and above	2,809	23.3
Sex	Male	4,908	42.2
	Female	7,649	57.9
Ethnicity	Upper caste groups	4,263	32.7
	Disadvantaged janajatis	2,656	20.7
	Relatively advantaged janajatis	2,077	17.0
	Disadvantaged non-dalit terai caste groups	1,900	17.0
	Dalits	1,298	9.6
	Religious minorities	363	2.9
Education	Illiterate/No formal schooling	6,820	53.1
	Below secondary (<10 years)	2,839	22.3
	Secondary and above (≥10 years)	2,898	24.6
Province	Province 1	2,185	17.6
	Province 2	2,083	18.4
	Bagmati Province	3,223	24.7

	Gandaki Province	1,337	9.6
	Province 5	2,070	15.9
	Karnali Province	601	4.8
	Sudurpaschim Province	1,058	9.1
Place of residence	Rural	6,300	48.5
	Urban	6,257	51.5

Behavioural and biological characteristics

About one third of the participants (31.9%) said that they were smokers. Nearly one fourth of the participants (24.6%) reported that they were current alcohol drinkers. Raised blood pressure was prevalent among 36.9% of the participants. The proportion of participants who were either overweight or obese was 30.7%. More than one-third (35.7%) of participants had raised triglycerides. Behavioural and biological characteristics of the participants are presented in Table 2.

Table 2: Behavioural and biological characteristics of the participants

Variables	Characteristics (N=12557)	N	% (95% CI)
Smoking habit	Smokers	3,955	31.9(30.3-33.5)
	Non-smoker	8,602	68.1(66.5-69.7)
Users of smokeless tobacco	Users	3,087	25.4(24.1-26.8)

products	Non-users	9,470	74.6(73.3-75.9)
Users of either smoke or smokeless tobacco products	Users	1,609	13.1(12.2-14.1)
	Non-users	10,948	86.9(86.0-87.8)
Alcohol consumption	Yes	3,115	24.6(22.98-26.3)
	No	9,442	75.4(73.7-77.02)
Blood pressure	Raised	4,504	36.9(35.4-38.5)
	Normal	8,053	63.1(61.6-64.6)
Body mass index (N=12,556)	Underweight	1,534	12.3(11.3-13.4)
	Normal	7,156	57.0(55.6-58.5)
	Overweight and obese	3,866	30.7(28.9-32.5)
Increased Waist Hip ratio (N=11,997)	Increased	6,896	55.3(53.9-56.7)
	Normal	5,101	44.7(43.4-46.1)
Total cholesterol (N=10,861)	Raised	3,120	28.8(27.3-30.4)
	Normal	7,741	71.2(69.6-72.7)
Triglyceride (N=10,986)	Raised	3,862	35.7(34.2-37.2)
	Normal	7,124	64.3(62.8- 65.9)

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Factors associated with diabetes mellitus

The overall prevalence of DM was 8.5% (95%CI:7.8-9.3). The following two tables (Table 3 and 4) show the results on factors associated with DM, along with prevalence of DM among the different subgroups examined. Table 3, above, shows the prevalence of DM across subgroups by different background characteristics, and the factors associated with occurrence of DM through multivariate analysis in terms of AOR. The prevalence of DM is seen to have increased with age. Participants in the age group of 60 years and above had about 5 times higher odds of having DM (AOR: 4.7, 95%CI:3.3-6.6) compared to those in the age group of 20 to 39 years. Similarly, male participants had higher odds of having DM (AOR: 1.3, 95%CI:1.1-1.6) compared to female participants. Urban residents had about 2 times higher odds of having DM (AOR: 1.7, 95%CI:1.4-2.2) compared to those residing in rural area. Table 4 above shows the prevalence of DM across subgroups by different behavioural and biological characteristics and the factors associated with occurrence of DM through multivariate analysis in terms of AOR. Participants with raised blood pressure had about 2 times higher odds of having DM compared to those whose blood pressure was normal (AOR: 2.2, 95% CI: 1.8-2.7). Regarding body mass index, participants who were overweight and obese had two times higher odds of having DM than those with normal body mass index (AOR: 2.0, 95% CI: 1.6-2.4). Participants who had high triglyceride level (≥150mg/dl) had about 2 times higher odds of having DM than their counterparts (AOR: 2.1, 95% CI: 1.8-2.6).

Table 3: Association of socio-demographic factors with diabetes mellitus

Variables and characteristics	Number of Participants	Proportion with DM (%)	Odds of having DM	
			COR (95% CI)	AOR (95% CI)
Age				
20-39	4,046	115 (3.0)	1	1
40-59	4,723	469(10.4)	3.7(2.9-4.9)***	3.1(2.3-4.2)***
60 years and above	2,508	300(13.3)	4.9 (3.7-6.5)***	4.7(3.3-6.6)***
Sex				
Female	6,952	436(6.7)	1	1
Male	4,325	448(11.0)	1.7(1.5-2.0)***	1.3(1.1- 1.6)**
Ethnicity				
Disadvantaged janajatis	1,130	68(6.6)	1	1
Dalits	2,369	151(6.7)	1.0(0.7-1.4)	1.3(0.8-1.9)
Disadvantaged non-dalit terai caste groups	1,690	127(8.4)	1.3(1.0-1.7)	1.5(1.1-2.1)*
Religious minorities	285	38(17.5)	2.9(1.7-5.0)***	2.4(1.2-4.7)*
Relatively advantaged janajatis	1,884	210(11.9)	1.9(1.4-2.5)***	1.2(0.9-1.6)
Upper caste groups	3,919	290(7.8)	1.2(0.9-1.5)	1.0(0.7-1.3)

Education				
Illiterate/No formal schooling	6,128	535(8.4)	1	1
Below secondary (<10 years)	2,548	196(7.9)	1.0(0.8-1.2)	1.1(0.8-1.4)
Secondary and above (≥10 years)	2,601	274(10.1)	1.3(1.1-1.6)**	1.4(1.1-1.8)*
Province				
Karnali Province	565	16(3.2)	1	1
Province 1	1,909	134(7.7)	2.5(1.2-5.2)*	2.2(1.1-4.4)*
Province 2	1,845	138(8.5)	2.8(1.3-5.8)**	1.8(0.9-3.7)
Bagmati Province	2,820	298(11.5)	3.9(1.9-8.0)***	1.8(0.9-3.5)
Gandaki Province	1,249	79(6.7)	2.2(1.0-4.6)*	1.1(0.6-2.3)
Lumbini	1,905	170(9.6)	3.2(1.5-6.6)**	1.9(0.9-3.8)
Sudurpaschim Province	984	49(5.2)	1.6(0.7-3.8)	1.5(0.7-3.5)
Place of residence				
Rural	5,663	277(5.5)	1	1
Urban	5,614	607(11.3)	2.2(1.8-2.7)***	1.7(1.4-2.2)***

*1 Reference category,*p value≤0.05 **p value≤0.01***p value≤0.0001*

Table 4: Association of behavioural and biological factors with diabetes mellitus

Characteristics	Number of Participants	Proportion with DM n (%)	Odds of having DM	
			COR (95% CI)	AOR (95% CI)
Smoking habit				
Non smoker	7,789	581(8.0)	1	1
Smokers	3,488	303(9.5)	1.2(1.0-1.4)*	1.0(0.9-1.3)
Users of smokeless tobacco products				
Nonusers	8,544	642(8.1)	1	-
Users	2,733	242(9.7)	1.2(1.0-1.5)*	-
Users of either smoke or smokeless tobacco products				
Nonusers	9,857	751(8.3)	1	-
Users	1,420	133(10.1)	1.2(1.0-1.5)	-
Alcohol consumption				
No	8,538	657(8.4)	1	-
Yes	2,739	227(8.7)	1.0(0.9-1.2)	-
Blood pressure				
Normal	7,197	311 (4.6)	1	1

Raised	4,080	573 (15.1)	3.7 (3.1-4.4) ***	2.2(1.8-2.7)***
Body mass index (N=12,556)				
Normal	6,378	355 (6.1)	1	1
Underweight	1,365	51 (4.0)	0.6(0.4-0.9) *	0.8(0.5-1.1)
Overweight and obese	3,534	478 (14.6)	2.6(2.2-3.1) ***	2.0(1.6-2.4)***
Increased Waist Hip ratio (N=11,158)				
No	4,683	347 (8.0)	1	-
Yes	6,475	527 (8.9)	1.1(0.9-1.4)	-
Total cholesterol (N=10,837)				
Normal	7,722	478 (7.0)	1	1
Raised	3,115	357 (11.8)	1.8(1.5-2.1) ***	1.0(0.8-1.2)
Triglyceride (N=10,960)				
Normal	7,103	334 (5.0)	1	1
Raised	3,857	479 (13.4)	2.9 (2.5-3.5) ***	2.1(1.8-2.6)***

*1 Reference category, *p value≤0.05 **p value≤0.01*** p value≤0.0001*

DISCUSSION

The first nationally representative study identified high prevalence of DM among the participants, which is higher than the IDF's estimate for Nepal i.e 4% in 2017(21). However, the prevalence of DM is similar to the findings observed in a systematic review (pooled prevalence--8.4%, 95% CI: 6.2-10.5%), which summarised the prevalence of type 2 diabetes in Nepal for a period of 14 years (8). Similar figure (8.5%, 95% CI: 6.9-10.4%) was reported in another systematic review conducted in Nepal(22). Our finding is also in line with the WHO estimates for DM in Nepal which reported a prevalence of 9.1% in 2016(23). The latest estimates from the global burden of disease study, however, show a national prevalence of 4.4% of diabetes type 2(24). Likewise, WHO global report on DM also estimated a regional prevalence of 8.6% in South East Asia (SEA) in 2014, which is consistent with the findings from our study(4). The finding from our study is similar to estimates of DM prevalence from different studies in the neighbouring countries, including India (8.7%)(25), China (10.9%)(26), Sri Lanka (8.4%), Bhutan (7.7%), Maldives (7.5%) and Bangladesh (6.8%)(21). The prevalence of DM in our study may be attributed to a combination of factors including rapid urbanisation, changing lifestyles, unhealthy diets, tobacco use, and increasing life expectancy. Adding to this, several challenges prevailing around diabetes management such as high treament cost, availability of limited health facilities, lack of awareness about the disease and particularly no specific guideline available for the prevention and treatment of the disease in Nepal might have exacerberated the burden of this disease(10).

Our study reports that age was significantly associated with DM, with older aged people (60 years and above) having higher odds of having DM. Older age as an important predictor for DM is

consistent with the findings of studies from different contexts(8, 9, 27-30). The life expectancy of Nepalese people has increased from 58 years in 1990 to 71 years in 2019(24) and the proportion of the older poulation is growing (31), which further tends to increase in future(32). With aging, skeletal muscle insulin sensitivity might be impaired which in turn increase the risk of insulin resistance and type 2 diabetes(33). The findings of the study and these factors underscore the need of tailored interventions for management and control of DM among population with higher age. Further to this our study showed that, male had higher odds of having DM than females. This finding is supported by an another study conducted in Nepal, which identified being female as significant protective factor for DM (AOR: 0.4, 95% CI: 0.3-0.7)(9). A systematic review conducted in South Asia also supported the findings from our study, indicating being male as a significant risk factor for DM(34). However, this is in contrast to the findings reported in a different systematic review suggesting that females were at higher risk of DM in Nepal (OR:1.6, 95% CI: 1.3-1.9)(8). Higher prevalence of DM among men has been associated with large amount of visceral fat in men(35). Besides, lower tendency of women to develop visceral adiposity may explain that women are protected from DM in comparison to men(36).

Our study reported that urban residents were more likely to have DM compared to those residing in rural areas. Nepal has been experiencing an increasing rate in urbanization(37). Increasing urbanization leading to change in dietary pattern, sedentary lifestyle, reduction in physical activity might have contributed to the higher burden of DM. Complementing this result, findings from NCDs STEPS survey 2019 suggests inadequate intake of fruits and vegetables and lower participation in physical activity among urban population campared to their rural counterparts(38). All these factors might have some contributing role towards higher prevalence

of DM among urban population. Similar to the findings from this study, an epidemological survey conducted by the Nepal Diabetes Association found higher prevalence (14.6%) of DM in urban area in comparison to rural area (2.5%) (39, 40). Consistent with the findings from our study, a systematic review also found the pooled prevalence of DM to be higher (8.1%, 95% CI: 7.3-8.9%)in urban areas compared to rural areas in Nepal (1.03%, 95% CI: 0.7-1.3%)(8). A study from Myanmar also presented similar findings of higher prevalence in urban areas compared to rural areas (12.1% vs 7.1%)(41). Studies have reported between two to five times higher odds of having DM and pre-DM in association with urban residence(42, 43).

Our study showed that participants with raised blood pressure had about two times higher odds of having DM compared to those whose blood pressure was normal. This result is consistent with findings from South Asia(34), Ethiopia(44) and Nepal(8). The prevalence of hypertension and DM has been increasing in Nepal, however, the progress towards its effective prevention, treatment and control is found to be low(9, 45). With the coexisting conditions of hypertension and DM, the importance of secondary prevention (screening, timely diagnosis and treatment) of both these conditions is of paramount importance.

Overweight and obesity are important risk factors for DM (5, 44, 46). Our study showed that participants who were overweight and obese had about 2 times higher odds of having DM than those with a normal BMI. Consistent with the findings from our study, a meta-analysis performed among Indian adults showed a statistically significant association between obesity and type 2 DM (OR = 1.14, 95%CI: 1.0-1.2)(47). Similar findings were observed in different studies conducted in South Asia(34), US(48), Ethiopia(44) and Nepal(49). Overweight and obesity has been increasing in Nepal particularly among women(50). Obesity being a strong predictor for DM, there is a need

to take preventive actions to control obesity which might in turn provide some level of control of growing DM prevalence in the country.

The other variable that showed significant association with the prevalence of DM was triglyceride level. Participants with a high triglyceride level (≥150mg/dl) had about 2 times higher odds of having DM than their counterparts. This is in line with findings from studies conducted elsewhere, including in Ethiopia(44), Bangladesh(51) and China(52). Similar findings have been reported by different previous studies from Nepal(53-55). This also highlights the need of interventions for prevention and control of several of these metabolic risk factors such as dyslipidemia so as to achieve DM control in Nepal.

Besides the factors explained above, the provinical differences in prevalence of DM (though not seen as statistically signficant after multivariate analysis) also highlights the importance of tailoring interventions to the provinces with higher prevalence such as Province 1, 2, 5 and Bagmati Province.

Our study has several strengths and limitations. Major strengths include: a large sample size, coverage of rural and urban residences; all three ecological belts of the country (the Terai, hills and mountains); and all provinces of Nepal. This approach provided nationally representative data and increased its generalizability among the Nepalese population. The study also provided detailed information on the possible association with a wide range of risk factors for DM. However, the cross-sectional nature of the study did not allow for a causal relationship to be established between these risk factors and the prevalence of DM. In addition, no information was collected on the physical activity and dietary habits of participants, which have been established as important predictors of DM in other studies (56-59).

CONCLUSIONS

Our study showed DM to be more prevalent among individuals aged 20 years and above. Older age, male gender, residing in urban areas, high BMI, raised blood pressure, and raised triglyceride level independently predicted the occurrence of DM in this study. Findings suggest that targeted DM prevention and control interventions, especially to those population groups with higher chances of DM occurrence, in addition to prevention and control of the biological risk factors associated with DM through appropriate measures, would help curb the prevalence of DM in Nepal.

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STROBE Statement—Checklist of items that should be included in reports of ***cross-sectional studies***

	Item No	Recommendation	Page No
Title and abstract	1	(*a*) Indicate the study's design with a commonly used term in the title or the abstract	2
		(*b*) Provide in the abstract an informative and balanced summary of what was done and what was found	2,3
Introduction			
Background/rationale	2	Explain the scientific background and rationale for the investigation being reported	4,5
Objectives	3	State specific objectives, including any prespecified hypotheses	5
Methods			
Study design	4	Present key elements of study design early in the paper	5
Setting	5	Describe the setting, locations, and relevant dates, including periods of recruitment, exposure, follow-up, and data collection	5
Participants	6	(*a*) Give the eligibility criteria, and the sources and methods of selection of participants	5
Variables	7	Clearly define all outcomes, exposures, predictors, potential confounders, and effect modifiers. Give diagnostic criteria, if applicable	6, 7
Data sources/ measurement	8*	For each variable of interest, give sources of data and details of methods of assessment (measurement). Describe comparability of assessment methods if there is more than one group	7
Bias	9	Describe any efforts to address potential sources of bias	N/A
Study size	10	Explain how the study size was arrived at	5
Quantitative variables	11	Explain how quantitative variables were handled in the analyses. If applicable, describe which groupings were chosen and why	6, 7
Statistical methods	12	(*a*) Describe all statistical methods, including those used to control for confounding	7
		(*b*) Describe any methods used to examine subgroups and interactions	7
		(*c*) Explain how missing data were addressed	7
		(*d*) If applicable, describe analytical methods taking account of sampling strategy	7
		(*e*) Describe any sensitivity analyses	N/A
Results			
Participants	13*	(a) Report numbers of individuals at each stage of study—eg numbers potentially eligible, examined for eligibility, confirmed eligible, included in the study, completing follow-up, and analysed	5
		(b) Give reasons for non-participation at each stage	N/A
		(c) Consider use of a flow diagram	N/A
Descriptive data	14*	(a) Give characteristics of study participants (eg demographic, clinical, social) and information on exposures and potential confounders	8 to 10
		(b) Indicate number of participants with missing data for each variable of interest	11
Outcome data	15*	Report numbers of outcome events or summary measures	12
Main results	16	(*a*) Give unadjusted estimates and, if applicable, confounder-adjusted estimates and their precision (eg, 95% confidence interval). Make clear which confounders were adjusted for and why they were included	12 to 16

		(*b*) Report category boundaries when continuous variables were categorized	N/A
		(*c*) If relevant, consider translating estimates of relative risk into absolute risk for a meaningful time period	N/A
Other analyses	17	Report other analyses done—eg analyses of subgroups and interactions, and sensitivity analyses	N/A
Discussion			
Key results	18	Summarise key results with reference to study objectives	8 to 16
Limitations	19	Discuss limitations of the study, taking into account sources of potential bias or imprecision. Discuss both direction and magnitude of any potential bias	20
Interpretation	20	Give a cautious overall interpretation of results considering objectives, limitations, multiplicity of analyses, results from similar studies, and other relevant evidence	16 to 20
Generalisability	21	Discuss the generalisability (external validity) of the study results	20
Other information			
Funding	22	Give the source of funding and the role of the funders for the present study and, if applicable, for the original study on which the present article is based	22

*Give information separately for exposed and unexposed groups.

Note: An Explanation and Elaboration article discusses each checklist item and gives methodological background and published examples of transparent reporting. The STROBE checklist is best used in conjunction with this article (freely available on the Web sites of PLoS Medicine at http://www.plosmedicine.org/, Annals of Internal Medicine at http://www.annals.org/, and Epidemiology at http://www.epidem.com/). Information on the STROBE Initiative is available at www.strobe-statement.org.