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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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3 **1 Prevalence of Diabetes Mellitus and Associated Risk Factors in Nepal: Findings from A**
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6 **2 Nationwide Population-Based Survey**
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14 ABSTRACT

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

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

26 **Primary outcome measures** Prevalence of DM

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

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3 34 (≥ 150 mg/dl) (AOR: 2.1, 95% CI: 1.8-2.6) also had twice higher odds of DM compared to those
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6 35 with normal BP, an average body mass index (BMI) and normal triglyceride level respectively.
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9 36 **Conclusions** Targeted interventions to higher risk groups as well as prevention and control of
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11 37 other associated biological risk factors might help to reduce the prevalence of DM in Nepal.
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17 39 **Strengths and limitations of the study**

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21 40 • This study provided first nationally representative prevalence of DM in people aged 20
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23 41 years and above measured through fasting and post-prandial blood sample.
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26 42 • In addition, the factors that were found to influence prevalence of DM in adult population
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28 43 were also determined.
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31 44 • Although this study includes information on various risk factors for DM, we do not have
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33 45 information on the physical activity and dietary habits of participants, which are known
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36 46 to be important predictors of DM.
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48 INTRODUCTION

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

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

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3 69 2 diabetes in Nepal(9). This warrants a large scale study that is representative of the whole
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6 70 population, which provides a national (including subnational) prevalence of type 2 diabetes using
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8 71 standard criteria and identifies its predictors.
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11 72 This study reports the first nationally representative population-based prevalence of DM
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13 73 measured through both fasting and postprandial (PP) blood sample including that in different
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16 74 sub-groups and factors associated with occurrence of DM in Nepal.
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18 19 75 **METHODS**

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22 76 A population based cross sectional study was conducted covering all seven provinces of Nepal
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25 77 from 2016 to 2018. The sample size was calculated by considering the prevalence of raised blood
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27 78 glucose ($p=4\%$) from the 2013 non-communicable diseases (NCD) risk factors STEPS survey,
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30 79 Nepal(13). Ethical approval was sought from the Ethical Review Board(ERB) of the Nepal Health
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32 80 Research Council (NHRC) with registration number 110/2016. Written informed consent was
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35 81 taken separately from the participants for physical measurements and laboratory tests. The study
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37 82 was carried out among 13,200 participants aged 20 years and above using multistage cluster
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40 83 sampling technique. Men and women not providing consent to participate in either or both
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42 84 stages of the study (questionnaire and physical measurements, or biochemical measurements)
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45 85 were excluded from that particular stage or both the stages depending upon the consent
46
47 86 received. Detail methodology for this study has been explained elsewhere(14).
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50 87 **Data collection**

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53 88 Data collection was done in two steps: first as face-to-face interview with a questionnaire and as
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56 89 second step physical measurements and collection of blood sample of the same participant with
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3 90 the prior appointments. Additional details on data collection such as orientation of field team has
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5
6 91 been explained previously(14). REMO-Research and Monitoring Software, was used to
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8 92 programme the questionnaires into the mobile phones. This software was developed by Rooster
9
10 93 Logic, an Information and Communication Technology (ICT) company led by local engineers with
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12
13 94 focus on database creation and management, research, and monitoring. This software has been
14
15 95 extensively used for digital data collection in Nepal and allows small to large scale research
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18 96 projects to be conducted with ease and enables real-time monitoring of data. This software has
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20 97 been used by the NHRC in various previous surveys(15, 16).

23 98 **Socio-demographic and behavioural information**

26 99 Information on socio-demographic and behavioural risk factors was collected through face-to-
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29 100 face interviews using an interviewer-administered questionnaire. Information was collected on
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31 101 age, sex, ethnicity, educational status, marital status, occupation type, history of raised blood
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34 102 pressure and DM, alcohol consumption, and smoking habits. The commonly used classification
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36 103 for ethnicity in Nepal has six categories: 1) Dalit (marginalized group of people, with relatively
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39 104 lower socio-economic and education status); 2) Disadvantaged Janajatis (disadvantaged group of
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41 105 people and also indigenous, with relatively lower socio-economic and education status); 3)
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44 106 Disadvantaged non Dalit Terai Caste Groups (disadvantaged group of people from the Terai, the
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46 107 lowlands, with relatively lower socio-economic and education status but not the dalit groups); 4)
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49 108 Religious Minorities (Muslim, Christian, etc.); 5) Relatively advantaged Janajatis (indigenous
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51 109 group of people with relatively higher socio-economic status, such as Newar, Thakali, and
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53
54 110 Gurung); and 6) Upper Caste Groups (population with relatively higher socio-economic and
55
56 111 education status, mostly Brahmins, Chhetris, and Thakuri)(17).

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3 112 Data on part of physical measurements, blood pressure measurement, and biochemical
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6 113 measurement was done using respective equipment and procedures, and the detail including the
7
8 114 information on quality control has been explained elsewhere(14). Participants were defined as
9
10 115 having DM if they had raised fasting glucose (≥ 126 mg) or raised PP blood glucose level (≥ 200 mg),
11
12
13 116 or if the participants were on anti-diabetic medication at the time of the study(18, 19) whereas
14
15 117 the key definition of the terms raised blood pressure, body mass index, tobacco use, and alcohol
16
17
18 118 consumption has been explained in the report published previously (14).
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21 119 **Data management and analysis**

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24 120 Data was extracted by the core team involved in data management, from the server where the
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27 121 collected data was stored. Data cleaning was performed using IBM SPSS® Statistics software
28
29 122 version 20.0 (IBM, U.S.A.). The cleaned data was then exported to Stata® version 13.0 for analysis
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31
32 123 (Stata Corp, U.S.A.). Descriptive results were produced for each of the outcome variables using
33
34 124 complex sample analysis considering the PSUs, strata and weight. Bivariate and multivariate
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37 125 analyses were used to assess the association between explanatory variables and the outcome
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39 126 variable. All explanatory variables with p -value of < 0.05 in the bivariate analysis were inserted in
40
41 127 the multivariate binary logistic regression model to see the independent effect of each variable
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44 128 on the occurrence of DM. The magnitude of the association was measured using the adjusted
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47 129 odds ratio (AOR) and 95% confidence interval (CI). A p -value < 0.05 was considered as statistically
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49 130 significant(20).
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131 **Patient and public involvement statement**

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

136 **RESULTS**

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

140 **Socio-demographic characteristics**

141 Out of the 13,200 targeted participants, 12,557(95.3%) participated in the interview with a
142 questionnaire (step 1), and 12,148 (92%) participated for the physical measurements and
143 laboratory investigations (step 2). Socio-demographic characteristics of the participants are
144 presented in Table 1. Among total of 12,557 participants, the majority of participants (76.8%)
145 were in the age group 20-59 years. More than half of the participants (57.9%) were female. More
146 people belonged to the upper caste groups (32.7%), followed by disadvantaged janajatis (20.7%).
147 More than half (53.1%) were illiterate or never had formal schooling. Geographically, about one-
148 fourth of the participants were from Bagmati province (24.7%), as it contained the capital city
149 with dense population with the lowest proportion from Karnali Province (4.8%). More than half
150 (51.5%) of the participants were urban dwellers.

151 **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
	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

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153 Behavioural and biological characteristics

154 About one third of the participants (31.9%) said that they were smokers. Nearly one fourth of the
 155 participants (24.6%) reported that they were current alcohol drinkers. Raised blood pressure was
 156 prevalent among 36.9% of the participants. The proportion of participants who were either
 157 overweight or obese was 30.7%. More than one-third (35.7%) of participants had raised
 158 triglycerides. Behavioural and biological characteristics of the participants are presented in Table
 159 2.

160 **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)

161

162 **Factors associated with diabetes mellitus**

163 The overall prevalence of DM was 8.5% (95%CI:7.8-9.3). The following two tables (Table 3 and 4)
164 show the results on factors associated with DM, along with prevalence of DM among the different
165 subgroups examined. Table 3, above, shows the prevalence of DM across subgroups by different
166 background characteristics, and the factors associated with occurrence of DM through
167 multivariate analysis in terms of AOR. The prevalence of DM is seen to have increased with age.
168 Participants in the age group of 60 years and above had about 5 times higher odds of having DM
169 (AOR: 4.7, 95%CI:3.3-6.6) compared to those in the age group of 20 to 39 years. Similarly, male
170 participants had higher odds of having DM (AOR: 1.3, 95%CI:1.1-1.6) compared to female
171 participants. Urban residents had about 2 times higher odds of having DM (AOR: 1.7, 95%CI:1.4-
172 2.2) compared to those residing in rural area. Table 4 above shows the prevalence of DM across
173 subgroups by different behavioural and biological characteristics and the factors associated with
174 occurrence of DM through multivariate analysis in terms of AOR. Participants with raised blood
175 pressure had about 2 times higher odds of having DM compared to those whose blood pressure
176 was normal (AOR: 2.2, 95% CI: 1.8-2.7). Regarding body mass index, participants who were
177 overweight and obese had two times higher odds of having DM than those with normal body
178 mass index (AOR: 2.0, 95% CI: 1.6-2.4). Participants who had high triglyceride level (≥ 150 mg/dl)
179 had about 2 times higher odds of having DM than their counterparts (AOR: 2.1, 95% CI: 1.8-2.6).

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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)***

184 1 Reference category, *p value≤0.05 **p value≤0.01 ***p value≤0.0001

185 **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)***

186 1 Reference category, *p value≤0.05 **p value≤0.01*** p value≤0.0001

187 DISCUSSION

188 The first nationally representative study identified high prevalence of DM among the
189 participants, which is higher than the figure reported by a recent non-communicable disease risk
190 factors survey (5.8%)(21) and IDF's estimate for Nepal i.e 4% in 2017(22). However, the
191 prevalence of DM is similar to the findings observed in a systematic review (pooled prevalence-
192 -8.4%, 95% CI: 6.2-10.5%), which summarised the prevalence of type 2 diabetes in Nepal for a
193 period of 14 years (8). Similar figure (8.5%, 95% CI: 6.9-10.4%) was reported in another systematic
194 review conducted in Nepal(21). Our finding is also in line with the WHO estimates for DM in Nepal
195 which reported a prevalence of 9.1% in 2016(23). The latest estimates from the global burden of
196 disease study, however, show a national prevalence of 4.4% of diabetes type 2(24). Likewise,
197 WHO global report on DM also estimated a regional prevalence of 8.6% in South East Asia (SEA)
198 in 2014, which is consistent with the findings from our study(4). The finding from our study is
199 similar to estimates of DM prevalence from different studies in the neighbouring countries,
200 including India (8.7%)(25), China (10.9%)(26), Sri Lanka (8.4%), Bhutan (7.7%), Maldives (7.5%)
201 and Bangladesh (6.8%)(22). The prevalence of DM in our study may be attributed to a
202 combination of factors including rapid urbanisation, changing lifestyles, unhealthy diets, tobacco
203 use, and increasing life expectancy. Adding to this, several challenges prevailing around diabetes
204 management such as high treatment cost, availability of limited health facilities, lack of awareness
205 about the disease and particularly no specific guideline available for the prevention and
206 treatment of the disease in Nepal might have exacerbated the burden of this disease(10).

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3 207 Our study reports that age was significantly associated with DM, with older aged people (60 years
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6 208 and above) having higher odds of having DM. Older age as an important predictor for DM is
7
8 209 consistent with the findings of studies from different contexts(8, 9, 27-30). The life expectancy of
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10 210 Nepalese people has increased from 58 years in 1990 to 71 years in 2019(24) and the proportion
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12
13 211 of the older population is growing (31), which further tends to increase in future(32). With aging,
14
15 212 skeletal muscle insulin sensitivity might be impaired which in turn increase the risk of insulin
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18 213 resistance and type 2 diabetes(33). The findings of the study and these factors underscore the
19
20 214 need of tailored interventions for management and control of DM among population with higher
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23 215 age. Further to this our study showed that, male had higher odds of having DM than females.
24
25 216 This finding is supported by an another study conducted in Nepal, which identified being female
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27
28 217 as significant protective factor for DM (AOR: 0.4, 95% CI: 0.3-0.7)(9). A systematic review
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30 218 conducted in South Asia also supported the findings from our study, indicating being male as a
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32
33 219 significant risk factor for DM(34). However, this is in contrast to the findings reported in a
34
35 220 different systematic review suggesting that females were at higher risk of DM in Nepal (OR:1.6,
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37
38 221 95% CI: 1.3-1.9)(8). Higher prevalence of DM among men has been associated with large amount
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40 222 of visceral fat in men(35). Besides, lower tendency of women to develop visceral adiposity may
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43 223 explain that women are protected from DM in comparison to men(36).
44
45 224 Our study reported that urban residents were more likely to have DM compared to those residing
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48 225 in rural areas. Nepal has been experiencing an increasing rate in urbanization(37). Increasing
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50 226 urbanization leading to change in dietary pattern, sedentary lifestyle, reduction in physical
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53 227 activity might have contributed to the higher burden of DM. Complementing this result, findings
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55 228 from NCDs STEPS survey 2019 suggests inadequate intake of fruits and vegetables and lower
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3 229 participation in physical activity among urban population compared to their rural
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6 230 counterparts(38). All these factors might have some contributing role towards higher prevalence
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8 231 of DM among urban population. Similar to the findings from this study, an epidemiological survey
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10 232 conducted by the Nepal Diabetes Association found higher prevalence (14.6%) of DM in urban
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13 233 area in comparison to rural area (2.5%) (39, 40). Consistent with the findings from our study, a
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15 234 systematic review also found the pooled prevalence of DM to be higher (8.1%, 95% CI: 7.3-
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17 235 8.9%)in urban areas compared to rural areas in Nepal (1.03%, 95% CI: 0.7-1.3%)(8). A study from
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20 236 Myanmar also presented similar findings of higher prevalence in urban areas compared to rural
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23 237 areas (12.1% vs 7.1%)(41). Studies have reported between two to five times higher odds of having
24
25 238 DM and pre-DM in association with urban residence(42, 43).

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27
28 239 Our study showed that participants with raised blood pressure had about two times higher odds
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31 240 of having DM compared to those whose blood pressure was normal. This result is consistent with
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33 241 findings from South Asia(34), Ethiopia(44) and Nepal(8). The prevalence of hypertension and DM
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35 242 has been increasing in Nepal, however, the progress towards its effective prevention, treatment
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38 243 and control is found to be low(9, 45). With the coexisting conditions of hypertension and DM, the
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41 244 importance of secondary prevention (screening, timely diagnosis and treatment) of both these
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43 245 conditions is of paramount importance.

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45
46 246 Overweight and obesity are important risk factors for DM (5, 44, 46). Our study showed that
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48 247 participants who were overweight and obese had about 2 times higher odds of having DM than
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50
51 248 those with a normal BMI. Consistent with the findings from our study, a meta-analysis performed
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53 249 among Indian adults showed a statistically significant association between obesity and type 2 DM
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55 250 (OR = 1.14, 95%CI: 1.0-1.2)(47). Similar findings were observed in different studies conducted in

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2
3 251 South Asia(34), US(48), Ethiopia(44) and Nepal(49). Overweight and obesity has been increasing
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5
6 252 in Nepal particularly among women(50). Obesity being a strong predictor for DM, there is a need
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8 253 to take preventive actions to control obesity which might in turn provide some level of control of
9
10 254 growing DM prevalence in the country.

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12
13 255 The other variable that showed significant association with the prevalence of DM was triglyceride
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15 256 level. Participants with a high triglyceride level ($\geq 150\text{mg/dl}$) had about 2 times higher odds of
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17 257 having DM than their counterparts. This is in line with findings from studies conducted elsewhere,
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19 258 including in Ethiopia(44), Bangladesh(51) and China(52). Similar findings have been reported by
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21 259 different previous studies from Nepal(53-55). This also highlights the need of interventions for
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23 260 prevention and control of several of these metabolic risk factors such as dyslipidemia so as to
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25 261 achieve DM control in Nepal.

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28 262 Besides the factors explained above, the provincial differences in prevalence of DM (though not
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30 263 seen as statistically significant after multivariate analysis) also highlights the importance of
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32 264 tailoring interventions to the provinces with higher prevalence such as Province 1, 2, 5 and
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34 265 Bagmati Province.

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37 266 Our study has several strengths and limitations. Major strengths include: a large sample size,
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39 267 coverage of rural and urban residences; all three ecological belts of the country (the Terai, hills
40
41 268 and mountains); and all provinces of Nepal. This approach provided nationally representative
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43 269 data and increased its generalizability among the Nepalese population. The study also provided
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45 270 detailed information on the possible association with a wide range of risk factors for DM.
46
47 271 However, the cross-sectional nature of the study did not allow for a causal relationship to be
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49 272 established between these risk factors and the prevalence of DM. In addition, no information

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3 273 was collected on the physical activity and dietary habits of participants, which have been
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6 274 established as important predictors of DM in other studies (56-59).
7

8 9 275 **CONCLUSIONS**

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12 276 Our study showed DM to be more prevalent among individuals aged 20 years and above. Older
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14 277 age, male gender, residing in urban areas, high BMI, raised blood pressure, and raised triglyceride
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16 278 level independently predicted the occurrence of DM in this study. Findings suggest that targeted
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18 279 DM prevention and control interventions, especially to those population groups with higher
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20 280 chances of DM occurrence, in addition to prevention and control of the biological risk factors
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22 281 associated with DM through appropriate measures, would help curb the prevalence of DM in
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24 282 Nepal.
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43

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45
46 289 entry and management. KKA and NS was involved in conducting data analysis. NS, KKA, AP and
47
48 290 NKM wrote the manuscript. PG and AKJ supported in monitoring overall data quality. All authors
49
50 291 reviewed the manuscript. NS and KBK contributed equally.
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296 **Data sharing statement** Data will be made available on request.

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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.

BMJ Open

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

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3 **1 Prevalence of Diabetes Mellitus and Associated Risk Factors in Nepal: Findings from A**
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6 **2 Nationwide Population-Based Survey**
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12 #Equal contributions

14 ABSTRACT

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

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

26 **Primary outcome measures** Prevalence of DM

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

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3 34 (≥ 150 mg/dl) (AOR: 2.1, 95% CI: 1.8-2.6) also had twice higher odds of DM compared to those
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6 35 with normal BP, an average body mass index (BMI) and normal triglyceride level respectively.
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9 36 **Conclusions** Targeted interventions to higher risk groups as well as prevention and control of
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11 37 other associated biological risk factors might help to reduce the prevalence of DM in Nepal.
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17 39 **Strengths and limitations of the study**

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21 40 • The study included a large sample spread across 400 clusters (wards-lowest
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23 41 administrative units) covering 72 districts out of 77 districts in Nepal.
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26 42 • Blood glucose was measured through both fasting and post-prandial blood sample.
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29 43 • The study used digital data collection and feedback was given on a regular basis after data
30
31 44 were uploaded on a real time basis.
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34 45 • Data quality was ensured through standard training processes and quality assurance
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37 46 procedures.
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40 47 • The study does not have information on the physical activity and dietary habits of
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42 48 participants, which are known to be important predictors of DM.
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50 INTRODUCTION

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

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

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3 71 2 diabetes in Nepal(9). This warrants a large scale study that is representative of the whole
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6 72 population, which provides a national (including subnational) prevalence of type 2 diabetes using
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8 73 standard criteria and identifies its predictors.
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11 74 This study reports the first nationally representative population-based prevalence of DM
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13 75 measured through both fasting and postprandial (PP) blood sample including that in different
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16 76 sub-groups and factors associated with occurrence of DM in Nepal.
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18 19 77 **METHODS**

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22 78 A population based cross sectional study was conducted covering all seven provinces of Nepal
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25 79 from 2016 to 2018. The sample size was calculated by considering the prevalence of raised blood
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28 80 glucose ($p=4\%$) from the 2013 non-communicable diseases (NCD) risk factors STEPS survey,
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30 81 Nepal(13). Ethical approval was sought from the Ethical Review Board(ERB) of the Nepal Health
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32 82 Research Council (NHRC) with registration number 110/2016. Written informed consent was
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35 83 taken separately from the participants for physical measurements and laboratory tests. The study
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37 84 was carried out among 13,200 participants aged 20 years and above using multistage cluster
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40 85 sampling technique. Men and women not providing consent to participate in either or both
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42 86 stages of the study (questionnaire and physical measurements, or biochemical measurements)
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45 87 were excluded from that particular stage or both the stages depending upon the consent
46
47 88 received. Detail methodology for this study has been explained elsewhere(14).
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50 89 **Data collection**

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53 90 Data collection was done in two steps: first as face-to-face interview with a questionnaire and as
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56 91 second step physical measurements and collection of blood sample of the same participant with
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3 92 the prior appointments. Additional details on data collection such as orientation of field team has
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5
6 93 been explained previously(14). REMO-Research and Monitoring Software, was used to
7
8 94 programme the questionnaires into the mobile phones. This software was developed by Rooster
9
10 95 Logic, an Information and Communication Technology (ICT) company led by local engineers with
11
12
13 96 focus on database creation and management, research, and monitoring. This software has been
14
15 97 extensively used for digital data collection in Nepal and allows small to large scale research
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18 98 projects to be conducted with ease and enables real-time monitoring of data. This software has
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20 99 been used by the NHRC in various previous surveys(15, 16).
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23 100 **Socio-demographic and behavioural information**

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26 101 Information on socio-demographic and behavioural risk factors was collected through face-to-
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29 102 face interviews using an interviewer-administered questionnaire. Information was collected on
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31 103 age, sex, ethnicity, educational status, marital status, occupation type, history of raised blood
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34 104 pressure and DM, alcohol consumption, and smoking habits. The commonly used classification
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36 105 for ethnicity in Nepal has six categories: 1) Dalit (marginalized group of people, with relatively
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39 106 lower socio-economic and education status); 2) Disadvantaged Janajatis (disadvantaged group of
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41 107 people and also indigenous, with relatively lower socio-economic and education status); 3)
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44 108 Disadvantaged non Dalit Terai Caste Groups (disadvantaged group of people from the Terai, the
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46 109 lowlands, with relatively lower socio-economic and education status but not the dalit groups); 4)
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49 110 Religious Minorities (Muslim, Christian, etc.); 5) Relatively advantaged Janajatis (indigenous
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51 111 group of people with relatively higher socio-economic status, such as Newar, Thakali, and
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53
54 112 Gurung); and 6) Upper Caste Groups (population with relatively higher socio-economic and
55
56 113 education status, mostly Brahmins, Chhetris, and Thakuri)(17).
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3 114 Data on part of physical measurements, blood pressure measurement, and biochemical
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6 115 measurement was done using respective equipment and procedures, and the detail including the
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8 116 information on quality control has been explained elsewhere(14). Participants were defined as
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10
11 117 having DM if they had raised fasting glucose (≥ 126 mg) or raised PP blood glucose level (≥ 200 mg),
12
13 118 or if the participants were on anti-diabetic medication at the time of the study(18, 19) whereas
14
15 119 the key definition of the terms raised blood pressure, body mass index, tobacco use, and alcohol
16
17
18 120 consumption has been explained in the report published previously (14).
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21 121 **Data management and analysis**

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24 122 Data was extracted by the core team involved in data management, from the server where the
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27 123 collected data was stored. Data cleaning was performed using IBM SPSS® Statistics software
28
29
30 124 version 20.0 (IBM, U.S.A.). The cleaned data was then exported to Stata® version 13.0 for analysis
31
32 125 (Stata Corp, U.S.A.). Descriptive results were produced for each of the outcome variables using
33
34 126 complex sample analysis considering the PSUs, strata and weight. Bivariate and multivariate
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37 127 analyses were used to assess the association between explanatory variables and the outcome
38
39 128 variable. All explanatory variables with p -value of < 0.05 in the bivariate analysis were inserted in
40
41 129 the multivariate binary logistic regression model to see the independent effect of each variable
42
43
44 130 on the occurrence of DM. The magnitude of the association was measured using the adjusted
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46
47 131 odds ratio (AOR) and 95% confidence interval (CI). A p -value < 0.05 was considered as statistically
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49 132 significant(20).
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133 **Patient and public involvement statement**

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

138 **RESULTS**

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

142 **Socio-demographic characteristics**

143 Out of the 13,200 targeted participants, 12,557(95.3%) participated in the interview with a
144 questionnaire (step 1), and 12,148 (92%) participated for the physical measurements and
145 laboratory investigations (step 2). Socio-demographic characteristics of the participants are
146 presented in Table 1. Among total of 12,557 participants, the majority of participants (76.8%)
147 were in the age group 20-59 years. More than half of the participants (57.9%) were female. More
148 people belonged to the upper caste groups (32.7%), followed by disadvantaged janajatis (20.7%).
149 More than half (53.1%) were illiterate or never had formal schooling. Geographically, about one-
150 fourth of the participants were from Bagmati province (24.7%), as it contained the capital city
151 with dense population with the lowest proportion from Karnali Province (4.8%). More than half
152 (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
	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

154

155 Behavioural and biological characteristics

156 About one third of the participants (31.9%) said that they were smokers. Nearly one fourth of the
 157 participants (24.6%) reported that they were current alcohol drinkers. Raised blood pressure was
 158 prevalent among 36.9% of the participants. The proportion of participants who were either
 159 overweight or obese was 30.7%. More than one-third (35.7%) of participants had raised
 160 triglycerides. Behavioural and biological characteristics of the participants are presented in Table
 161 2.

162 **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)

163

164 **Factors associated with diabetes mellitus**

165 The overall prevalence of DM was 8.5% (95%CI:7.8-9.3). The following two tables (Table 3 and 4)
166 show the results on factors associated with DM, along with prevalence of DM among the different
167 subgroups examined. Table 3, above, shows the prevalence of DM across subgroups by different
168 background characteristics, and the factors associated with occurrence of DM through
169 multivariate analysis in terms of AOR. The prevalence of DM is seen to have increased with age.
170 Participants in the age group of 60 years and above had about 5 times higher odds of having DM
171 (AOR: 4.7, 95%CI:3.3-6.6) compared to those in the age group of 20 to 39 years. Similarly, male
172 participants had higher odds of having DM (AOR: 1.3, 95%CI:1.1-1.6) compared to female
173 participants. Urban residents had about 2 times higher odds of having DM (AOR: 1.7, 95%CI:1.4-
174 2.2) compared to those residing in rural area. Table 4 above shows the prevalence of DM across
175 subgroups by different behavioural and biological characteristics and the factors associated with
176 occurrence of DM through multivariate analysis in terms of AOR. Participants with raised blood
177 pressure had about 2 times higher odds of having DM compared to those whose blood pressure
178 was normal (AOR: 2.2, 95% CI: 1.8-2.7). Regarding body mass index, participants who were
179 overweight and obese had two times higher odds of having DM than those with normal body
180 mass index (AOR: 2.0, 95% CI: 1.6-2.4). Participants who had high triglyceride level (≥ 150 mg/dl)
181 had about 2 times higher odds of having DM than their counterparts (AOR: 2.1, 95% CI: 1.8-2.6).

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185 **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)***

186 1 Reference category, *p value≤0.05 **p value≤0.01 ***p value≤0.0001

187 **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)***

188 1 Reference category, *p value≤0.05 **p value≤0.01*** p value≤0.0001

189 DISCUSSION

190 The first nationally representative study identified high prevalence of DM among the
191 participants, which is higher than the IDF's estimate for Nepal i.e 4% in 2017(21). However, the
192 prevalence of DM is similar to the findings observed in a systematic review (pooled prevalence-
193 -8.4%, 95% CI: 6.2-10.5%), which summarised the prevalence of type 2 diabetes in Nepal for a
194 period of 14 years (8). Similar figure (8.5%, 95% CI: 6.9-10.4%) was reported in another systematic
195 review conducted in Nepal(22). Our finding is also in line with the WHO estimates for DM in Nepal
196 which reported a prevalence of 9.1% in 2016(23). The latest estimates from the global burden of
197 disease study, however, show a national prevalence of 4.4% of diabetes type 2(24). Likewise,
198 WHO global report on DM also estimated a regional prevalence of 8.6% in South East Asia (SEA)
199 in 2014, which is consistent with the findings from our study(4). The finding from our study is
200 similar to estimates of DM prevalence from different studies in the neighbouring countries,
201 including India (8.7%)(25), China (10.9%)(26), Sri Lanka (8.4%), Bhutan (7.7%), Maldives (7.5%)
202 and Bangladesh (6.8%)(21). The prevalence of DM in our study may be attributed to a
203 combination of factors including rapid urbanisation, changing lifestyles, unhealthy diets, tobacco
204 use, and increasing life expectancy. Adding to this, several challenges prevailing around diabetes
205 management such as high treatment cost, availability of limited health facilities, lack of awareness
206 about the disease and particularly no specific guideline available for the prevention and
207 treatment of the disease in Nepal might have exacerbated the burden of this disease(10).

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

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3 210 consistent with the findings of studies from different contexts(8, 9, 27-30). The life expectancy of
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6 211 Nepalese people has increased from 58 years in 1990 to 71 years in 2019(24) and the proportion
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8 212 of the older population is growing (31), which further tends to increase in future(32). With aging,
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10 213 skeletal muscle insulin sensitivity might be impaired which in turn increase the risk of insulin
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13 214 resistance and type 2 diabetes(33). The findings of the study and these factors underscore the
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15 215 need of tailored interventions for management and control of DM among population with higher
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18 216 age. Further to this our study showed that, male had higher odds of having DM than females.
19
20 217 This finding is supported by an another study conducted in Nepal, which identified being female
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23 218 as significant protective factor for DM (AOR: 0.4, 95% CI: 0.3-0.7)(9). A systematic review
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25 219 conducted in South Asia also supported the findings from our study, indicating being male as a
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27
28 220 significant risk factor for DM(34). However, this is in contrast to the findings reported in a
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30 221 different systematic review suggesting that females were at higher risk of DM in Nepal (OR:1.6,
31
32 222 95% CI: 1.3-1.9)(8). Higher prevalence of DM among men has been associated with large amount
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35 223 of visceral fat in men(35). Besides, lower tendency of women to develop visceral adiposity may
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38 224 explain that women are protected from DM in comparison to men(36).
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40 225 Our study reported that urban residents were more likely to have DM compared to those residing
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43 226 in rural areas. Nepal has been experiencing an increasing rate in urbanization(37). Increasing
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45 227 urbanization leading to change in dietary pattern, sedentary lifestyle, reduction in physical
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48 228 activity might have contributed to the higher burden of DM. Complementing this result, findings
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50 229 from NCDs STEPS survey 2019 suggests inadequate intake of fruits and vegetables and lower
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53 230 participation in physical activity among urban population compared to their rural
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55 231 counterparts(38). All these factors might have some contributing role towards higher prevalence

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3 232 of DM among urban population. Similar to the findings from this study, an epidemiological survey
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6 233 conducted by the Nepal Diabetes Association found higher prevalence (14.6%) of DM in urban
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8 234 area in comparison to rural area (2.5%) (39, 40). Consistent with the findings from our study, a
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11 235 systematic review also found the pooled prevalence of DM to be higher (8.1%, 95% CI: 7.3-
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13 236 8.9%) in urban areas compared to rural areas in Nepal (1.03%, 95% CI: 0.7-1.3%)(8). A study from
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15 237 Myanmar also presented similar findings of higher prevalence in urban areas compared to rural
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18 238 areas (12.1% vs 7.1%)(41). Studies have reported between two to five times higher odds of having
19
20 239 DM and pre-DM in association with urban residence(42, 43).

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23 240 Our study showed that participants with raised blood pressure had about two times higher odds
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26 241 of having DM compared to those whose blood pressure was normal. This result is consistent with
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28 242 findings from South Asia(34), Ethiopia(44) and Nepal(8). The prevalence of hypertension and DM
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31 243 has been increasing in Nepal, however, the progress towards its effective prevention, treatment
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33 244 and control is found to be low(9, 45). With the coexisting conditions of hypertension and DM, the
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35 245 importance of secondary prevention (screening, timely diagnosis and treatment) of both these
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38 246 conditions is of paramount importance.

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41 247 Overweight and obesity are important risk factors for DM (5, 44, 46). Our study showed that
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44 248 participants who were overweight and obese had about 2 times higher odds of having DM than
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46 249 those with a normal BMI. Consistent with the findings from our study, a meta-analysis performed
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48 250 among Indian adults showed a statistically significant association between obesity and type 2 DM
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51 251 (OR = 1.14, 95%CI: 1.0-1.2)(47). Similar findings were observed in different studies conducted in
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53 252 South Asia(34), US(48), Ethiopia(44) and Nepal(49). Overweight and obesity has been increasing
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56 253 in Nepal particularly among women(50). Obesity being a strong predictor for DM, there is a need

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

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

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

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

276 CONCLUSIONS

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

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

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297 **Data sharing statement** Data will be made available on request.

298 **Word count** 3486

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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.