COMORBID DIABETES AND HYPERTENSION: GENDER DIFFERENCES IN PREVALENCE AND RISK FACTORS AMONG ADULTS (≥18 YEARS) IN AN URBAN COMMUNITY IN KATHMANDU DISTRICT IN NEPAL

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ABSTRACT

Chronic diseases such as diabetes and hypertension are often influenced by biological, behavioural, environmental and social factors in women and men. This study aimed to identify the gender differences in prevalence and risk factors of comorbid diabetes and hypertension (CM) among adults aged 18 years and above in an urban community in Kathmandu, Nepal. A community-based cross-sectional analytical study was carried out in Gokarneshwor Ward 1, 2 and 3 among adults aged 18 years and above from September 2020- May 2023. Diabetes (DM) was defined as persons previously diagnosed by a physician and/or on anti-diabetic medication. Hypertension (HTN) was defined as a systolic blood pressure (SBP) of ≥140 mm Hg or a diastolic blood pressure (DBP) of ≥90 mm Hg or those who were diagnosed by a physician and/or receiving antihypertensive medication. Comorbidity (CM) was defined as persons with diabetes and hypertension. Information regarding socio-demographic data, behavioural and biological risk factors, anthropometric assessment and morbidity were obtained from adults aged 18 years and above using a Family study proforma. Multinomial logistic regression analyses with the referent category being persons with no diabetes or hypertension (NDH) were performed for three categories HTN vs NDH, DM vs NDH and CM vs NDH. Among 1538 adults with 776 women, overall prevalence of comorbidity was 5.3% (95% CI: 4.3 – 6.5); among men 6.1% and 5.5% among women. After adjusting for age, for both women and men, being currently married, alcohol use, family history of diabetes and generalized obesity were associated with comorbidity. However, these associations were more robust for men. Moreover, measures of central obesity were associated with comorbidity for men alone. Though alcohol use was higher among men, the association with comorbidity was more robust for women. Paradoxically, lower educational status among women and higher education among men were associated with higher odds of comorbidity. In conclusion, prevalence of comorbid diabetes and hypertension may differ marginally among men and women. Though comorbidity rates appear to be lower in Nepal in comparison to other countries in South Asia, the rising burden emphasizes the need for tailored public health interventions that address modifiable risk factors among men and women. Further research may help to elucidate the role of gender on cardiovascular risk and hard outcomes such as cardiovascular events and mortality among persons with comorbid diabetes and hypertension.

KEYWORDS

Comorbid diabetes and hypertension, gender, prevalence, risk factors, Nepal

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INTRODUCTION

Chronic diseases such as diabetes and hypertension are often influenced by biological, behavioural as well as environmental and social factors in women and men.[1] Gender can be defined as a social construct influenced by behaviour, environment and cultural identity. Sex (biological) and gender differences can play an important role in the pathogenesis, awareness, access to treatment and the sequelae of diabetes and hypertension.[2,3] Consequently, women may experience the same health conditions differently than men.[4,5]

Global estimates suggest that the prevalence of diabetes is marginally higher among men as compared to women (10.8% vs 10.2%). This trend is also seen in the South Asian region.[6,7] Prevalence of diabetes is reportedly higher among males of SA ethnicity while prediabetes is more prevalent among the females. However, SA women may be at a higher risk of diabetes due to their lower socio-economic status.[8]

The association between diabetes and hypertension has been well documented in literature. Persons with diabetes (PWDs) appear to have a two-fold higher risk of hypertension in comparison to those without diabetes. With the increasing rise in the number of persons with diabetes, it is estimated that more than half of them will have hypertension. Comorbid diabetes and hypertension may accelerate the onset of complications such as cardio-vascular disease, stroke and renal disease.[9-11]

This study aimed to identify the gender differences in prevalence and risk factors of co-morbid diabetes and hypertension among adults aged 18 years and above in an urban community in Kathmandu, Nepal.

MATERIALS AND METHODS

A community-based observational cross-sectional analytical study was carried out in Gokarneshwor Ward 1, 2 and 3 among adults aged 18 years and above from September 2020-May 2023. Ethical approval was obtained from NMC-IRC (Ref. No. 033-077/078) for the study. Assuming a baseline prevalence of diabetes of 8.4%, a 2% margin of error, a 10% non-response rate, the minimum sample size was calculated to be 745 adults. As gender was the primary variable under consideration, a minimum of 745 women and 745 men were required for the study.

During the study period, 626 households were randomly allotted to undergraduate medical students for family study during their sixth semester posting in the Department of Community Medicine. The family study proforma was used to collect socio-demographic data including education status, ethnicity, marital status, occupational status, monthly family income and household socioeconomic status and behavioural and biological risk factors such as smoking, alcohol use, family history of diabetes, physical activity levels from family members aged 18 years and above (adults) who were present in the household after obtaining due consent. Among persons with diabetes or hypertension information on age at onset and treatment seeking were also elicited. Anthropometric assessment was carried out as follows:

- *Weight*: Measured with a weighing scale that was placed on a flat surface without slippers and reported in kilograms (kg).
- *Height*: Measured by placing the person against a wall and marking the height by a ruler. The height was then measured using a non-stretchable measuring tape on the rigid wall surface and reported in centimetres (cm).[12]
- Waist circumference was measured midway between the lower most margin of the ribs and the top of the iliac crest.
- Hip circumference was measured at the maximum circumference of the buttocks, with the subject standing and the feet placed together.[13]

The following definitions were used for the categorization of study participants: Diabetes was defined as persons previously diagnosed by a physician and/or on anti-diabetic medication.[14] Hypertension was defined as a systolic blood pressure (SBP) of ≥140 mm Hg or a diastolic blood pressure (DBP) of ≥90 mm Hg or those who were diagnosed by a physician and/or receiving antihypertensive medication.[15] Generalized obesity was defined as BMI ≥25 kg/m2 as per Asia-Pacific guidelines. Overweight was defined as BMI ≥23 kg/m^2 as per Asia-Pacific guidelines. Central obesity was defined as waist circumference ≥90 cm in males and ≥80 cm in females and waist to height ratio (WtHtR) ≥0.5.[16] A family history of DM was deemed to be present when either one or both parents were known to have diabetes mellitus. The level of physical activity was assessed as vigorous, moderate, mild physical based on occupation and classified as insufficiently active and sufficiently active categories. Those who have ever consumed alcohol during their lifetime were classified as ever alcohol users while those who have smoked in their lifetime were classified as ever smokers. For multinomial logistic regression, ethnicity was

recategorized as *Brahmin* and *Chhetris* (0) and others (1). Marital status was recoded as married (2) or single (1). The latter category included unmarried, divorced and widowed persons. By occupation, the participants were grouped as employed outside home or studying (0), and those at home including homemakers, retired or unemployed (1).

Statistical analysis: The collected data was entered in MS Excel spreadsheet and licensed Stata 15 software was used for analysis. The significance level (α) was set at 5% for all statistical analyses. Bivariate analysis was used to assess differences among men and women in relation to socio-demographic, biological and behavioural risk factors. Chi-square test was used to examine significant differences. Overall and gender specific prevalence rates of hypertension, diabetes and comorbidity were reported within 95% confidence limits.

For further analyses, the study population was divided into four groups: the normal group without either diabetes or hypertension (NDH), the hypertension group with hypertension alone and no diabetes (HTN), diabetes group with diabetes alone and no hypertension (DM), and the comorbidity group with both diabetes and hypertension (CM).

Independent associations between morbidity groups (NDH, HTN, DM, CM) and socio-demographic, behavioural and biological risk factors was assessed by multinomial logistic regression analyses with the NDH group being the referent category. Crude and age-adjusted Odds Ratios for HTN vs NDH, DM vs NDH and CM vs NDH with 95% confidence intervals were calculated. An OR >1 indicated that the odds of the outcome falling in the comparison group relative to the odds of the outcome falling in the referent group was increased. An OR <1 indicated that the odds of the outcome falling in the comparison group relative to the odds of the outcome falling in the referent group was decreased.

Using the post-estimation command in STATA, marginal effects plots were generated to depict the probability (adjusted predictions) of hypertension, diabetes and comorbidity outcomes at different values of age among men and women.

RESULTS

Altogether, 1538 adults were included in the study, amongst whom 776 (50.5%) were women. Looking at socio-demographic characteristics, women had lower educational status (primary

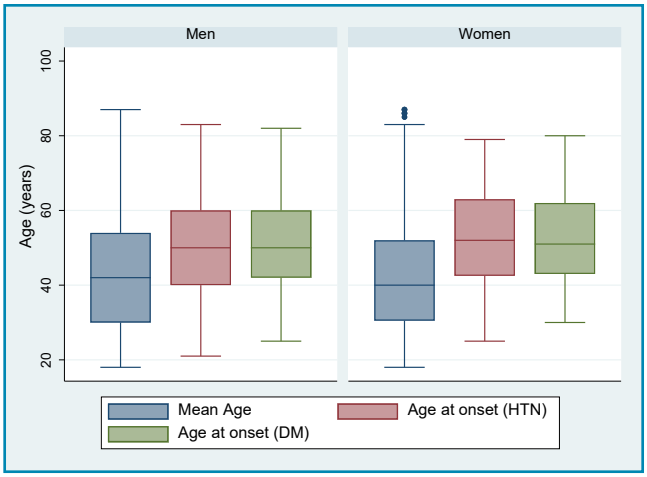

Fig. 1: Boxplot depicting age distribution and age at onset of hypertension and diabetes among men (n=762) and women (n=776)

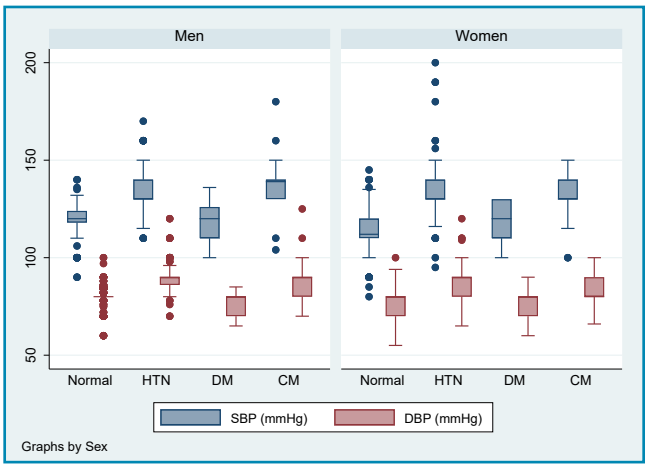

Fig. 2: Boxplot depicting systolic and diastolic blood pressure distribution in relation to morbidity outcomes among men (n=762) and women (n=776)

level and lower) and physical activity levels in comparison to men. Moreover, rates of generalized (BMI ≥ 25 kg/m2) and central obesity (increased waist circumference and WtHtR) were higher among women. Behavioural risk factors such as smoking and alcohol use was higher among men (Table 1).

Median age was 42 years (IQR 30-54 years) among men and 40 years (IQR 30.5-52 years) among women (P=0.36). Likewise, there was no significant difference in median age at onset for hypertension (50 years vs 52 years, P=0.07) and diabetes (50 years vs 51 years, P=0.50) between the sexes (Fig. 1). The distribution of systolic and diastolic blood pressure (mmHg) across morbidity outcomes is shown by the boxplot in Fig. 2.

Within 95% confidence limits, the overall prevalence of hypertension ranged from 21.9% to 26.3% and diabetes ranged

Table 1: Gender differences in socio-demographic, biological and behavioural risk factors among study participants (n=1538)

Variable	Men n (%)	Women n (%)	Overall n (%)	P value*
Number	762 (49.5)	776 (50.5)	1,538	
Age (years)				
18-29	179 (23.5)	167 (21.5)	346 (22.5)	0.07
30-49	316 (41.5)	367 (47.3)	683 (44.4)	
≥ 50	267 (35.0)	242 (31.2)	509 (33.1)	
Marital status				
Single/Widowed	154 (20.2)	154 (20.0)	308 (20.1)	0.92
Currently married	608 (79.8)	615 (80.0)	1,223 (79.9)	
Ethnicity				
Bahun and *Chhetri*	399	392	791	0.97
Adibasi-Janajati and others	377	369	746	
Educational attainment				
Secondary and above	438 (57.6)	308 (39.7)	746 (48.5)	<0.0001***
Primary and lower	323 (42.4)	468 (60.3)	791 (51.5)	
Occupational status				
Working outside home	541	207	748	<0.0001***
Student	74	46	120	
Homemaker/Retired/ Unemployed	147	522	669	
SES				
Upper & Middle	608 (79.8)	621 (80.0)	1,229 (79.9)	0.90
Lower	154 (20.2)	155 (20.0)	309 (20.1)	
Smoking status				
Never smoker	597 (78.4)	730 (94.1)	1,327 (86.3)	<0.0001***
Ever smoker	165 (21.6)	46 (5.9)	211 (13.7)	
Alcohol use				
Never user	494 (64.8)	664 (85.7)	1,158 (75.3)	<0.0001***
Ever user	268 (35.2)	111 (14.3)	379 (24.7)	
BMI status (kg/m2)				
Normal weight (18.5-22.9)	251 (32.9)	217 (27.9)	468 (30.4)	0.002**
Overweight (23-24.9)	175 (23.0)	148 (19.1)	323 (21.0)	
Obese (≥ 25)	336 (44.1)	411 (52.9)	747 (48.6)	
Family h/o diabetes				
No	728 (95.5)	741 (95.5)	1469	0.96
Yes	34 (4.5)	35 (4.5)	69	
Physical activity level				
Sufficiently active	118 (15.5)	52 (6.7)	170 (11.1)	<0.0001***
Insufficiently active	644 (84.5)	724 (93.3)	1,368 (88.9)	
Central obesity measures				
WC (cm)				
Normal	301 (47.6)	147 (22.5)	448 (34.8)	<0.0001***
Increased (M ≥ 90/ F ≥ 80)	332 (52.4)	507 (77.52)	839 (65.2)	
Waist to height ratio				
Normal	167 (21.9)	110 (14.2)	277 (18.0)	<0.0001***
Increased (> 0.5)	(8.1)	666 (5.8)	1,261 (82.0)	

**Chi-square test*

Table 2: Overall and gender-specific prevalence of hypertension, diabetes and comorbidity among the study population (n=1,538)

Morbidity status	Overall n (%)	95% CL	Men n (%)	Women n (%)	Chi-square P value
Number	1,538		762	776	
Hypertension					0.035
No	1,168 (75.9)	73.7 -78.1	561 (73.6)	607 (78.2)	
Yes	370 (24.1)	21.9 -26.3	201 (26.4)	169 (21.8)	
Diabetes					0.53
No	1,376 (89.5)	87.8 – 90.9	678 (88.9)	698 (89.9)	
Yes	162 (10.5)	9.1 -12.2	84 (11.1)	78 (10.1)	
Comorbidity					0.18
No	1,457 (94.7)	93.5 – 95.7	716 (93.9)	741 (95.5)	
Yes	81 (5.3)	4.3 – 6.5	46 (6.1)	35 (5.5)	

(CL- confidence limits)

Table 3: Association between hypertension and diabetes in the study population (n=1538)

Morbidity	Diabetes		P value[a]	OR (95% CI)	Gender-specific OR
Hypertension	**NO**	**YES**	<0.0001	3.76 (2.69-5.25)	Men: 4.03 (95% CI: 2.56-6.50)
NO	1087 (79.0)	81 (50.0)			Women: 3.42 (95% CI: 2.11 - 5.56)
YES	289 (21.0)	81 (50.0)			
Total	1376	162			

(a Compared using Pearson's Chi-squared test, OR – Odd's ratio, CI – Confidence interval)

from 9.1% to 12.2%. Overall prevalence of comorbidity ranged from 4.3% to 6.5% in the study population. On disaggregating by sex, prevalence of hypertension, diabetes and comorbidity among men was 26.4.3% (95% CL: 23.4% to 29.6%), 11.1% (95% CL: 8.9% to 13.4%) and 6.1% (95% CL: 4.6% to 7.9%), respectively. Among women it was 21.8% (95% CL: 19.0% to 24.8%), 10.1% (95% CL: 8.1% to 12.3%) and 5.5% (95% CL: 3.3% to 6.2%).

Hypertension prevalence was found to be significantly higher among men (Chi-square value 4.45, P=0.03). However, diabetes (Chi-square value 0.38, P=0.53) and comorbidity prevalence did not differ significantly between men and women (Chi-square value 1.79, P=0.18) as shown in Table 2.

Amongst persons with hypertension (n=370), about one fifth (21.8%) were found to have diabetes; and amongst persons with diabetes (n=162), one half (50.0%) were found to have hypertension. The overall odds of hypertension for persons with diabetes were 3.76 (OR 95% CI: 2.6 to 5.2) in comparison to those without diabetes. On stratifying for gender, odds of comorbidity among men were 4.03 (95% CI: 2.56 to 6.50), and among women 3.42 (95% CI: 2.11 to 5.56), respectively (Table 3).

For further analysis, the study population was grouped into four outcome categories: the referent category were persons without hypertension and diabetes (NHD) comprising of 1087 persons, among whom 564 (51.9%) were women. The second category comprised of 289 persons with HTN, with 134 (46.4%) women. The third category comprised of 81 persons with DM among whom 43 (53.1%) were women. The final category comprised of persons with CM; there were 81 persons with comorbidity among whom 35 (43.2%) were women (Table 3). As shown in Table 4, among men, there was a significant association between morbidity pattern and age, ethnicity, educational attainment, marital status, occupational status, smoking status, alcohol use (P<0.0001),

Table 4: Hypertension, diabetes and comorbidity outcomes across socio-demographic, behavioural and biological risk factors among men (n=762)

Variables	Men				P value[a]
	NHD	HTN	DM	CM	
Number (n)	523	155	38	46	
Age groups (years)					
18-29	173 (33.1)	6 (3.9)	0	0	
30-49	228 (43.6)	61 (39.4)	19 (50.0)	8 (17.4)	<0.0001***
≥ 50	122 (23.3)	88 (56.7)	19 (50.0)	38 (82.6)	
Marital status					
Single/Widowed	136 (26.0)	12 (7.7)	4 (10.5)	2 (4.4)	<0.0001***
Currently married	387 (74.0)	143 (92.3)	34 (89.5)	44 (95.6)	
Ethnicity					
Bahun and *Chhetri*	554 (50.9)	139 (48.1)	53 (65.4)	45 (55.6)	
Adibasi-Janajati and others	533 (49.0) 34.57	51.90 150 (51.9)	28 (34.6)	44.44 36 (44.4)	0.04*
Educational attainment					
Secondary and above	317 (60.7)	68 (43.9)	22 (57.9)	31 (67.4)	0.001**
Primary and lower	205 (39.3)	87 (56.1)	16 (42.1)	15 (32.6)	
Occupational status					
Working/Studying	445 (85.1)	119 (76.7)	21 (55.3)	30 (65.2)	<0.0001***
Homemaker/Retired/Unemployed	78 (14.9)	36 (23.2)	17 (44.7)	16 (34.7)	
SES					
Upper and middle	415 (79.4)	121 (78.1)	33 (86.8)	39 (84.8)	0.581
Lower	108 (20.7)	34 (21.9)	5 (13.2)	7 (15.2)	
Smoking status					
Never smoker	438 (83.7)	100 (64.5)	26 (68.4)	33 (71.7)	<0.0001***
Ever smoker	85 (16.3)	55 (35.5)	12 (31.6)	13 (28.3)	
Alcohol use					
Never user	362 (69.2)	83 (53.5)	24 (63.2)	25 (54.4)	0.002**
Ever user	161 (30.8)	72 (46.5)	14 (36.8)	21 (45.6)	
BMI status (kg/m2)					
Normal weight (18.5-22.9)	187 (35.8)	40 (25.8)	13 (34.2)	11 (23.9)	
Overweight (23-24.9)	130 (24.9)	27 (17.4)	10 (21.1)	8 (21.7)	0.009**
Obese (≥ 25)	206 (39.4)	88 (56.7)	17 (44.7)	25 (54.3)	
Family h/o diabetes					
No	505 (96.6)	150 (96.8)	34 (89.5)	39 (84.8)	0.002**
Yes	18 (3.4)	5 (3.2)	4 (10.5)	7 (15.2)	
Physical activity level					
Sufficiently active	88 (16.8)	19 (12.3)	6 (15.8)	5 (10.9)	0.42
Insufficiently active	435 (83.2)	136 (87.7)	32 (84.2)	41 (89.1)	
Central Obesity measures					
WC (cm)					
Normal	239 (57.0)	40 (28.9)	14 (40.0)	8 (19.5)	<0.0001***
Increased (M ≥ 90/ F ≥ 80)	180 (42.9)	98 (71.0)	21 (60.0)	33 (80.5)	
Waist to height ratio					
Normal	139 (26.6)	16 (10.3)	9 (23.7)	3 (6.5)	<0.0001***
Increased (> 0.5)	384 (73.4)	139 (89.7)	29 (76.3)	43 (93.5)	

a Compared using Pearson's Chi-squared test

*Significant P value < 0.05 **Highly significant P value < 0.01 ***Very highly significant P value < 0.0001

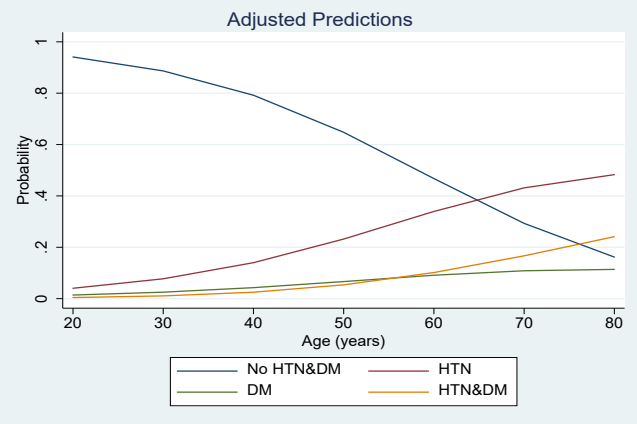

Fig. 3: Marginsplot depicting the overall probability of hypertension, diabetes and comorbidity in relation to age among the study population (n=1538)

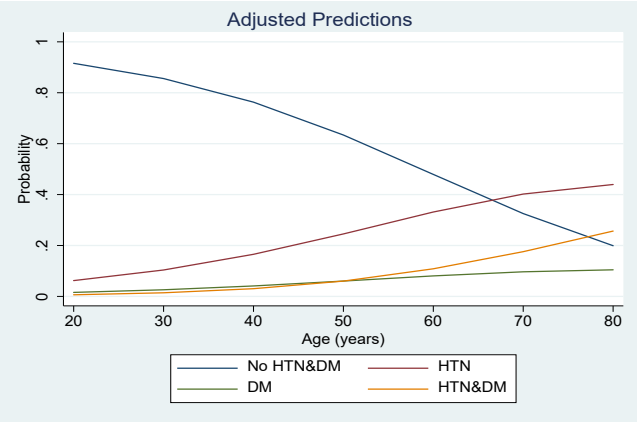

Fig. 4: Marginsplot depicting adjusted predictions for probability of hypertension (HTN), diabetes (DM) and comorbidity (CM) for men aged 20 to 80 years (n=762)

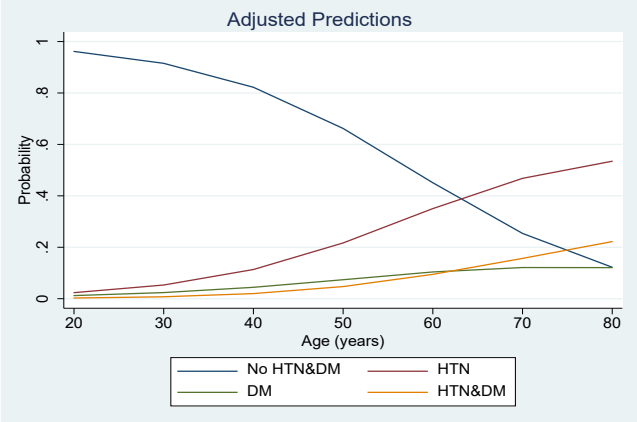

Fig. 5: Marginsplot depicting adjusted predictions for probability of hypertension (HTN), diabetes (DM) and comorbidity (CM) for women aged 20 to 80 years (n=776)

family history of diabetes (P=0.002), BMI status (P=0.009) and central obesity measures (P < 0.0001).

Among women, there was a significant association between morbidity outcomes and age, educational attainment, occupational status, smoking status, alcohol use, BMI (P <0.0001) family history of diabetes(P=0.002) and central obesity measures (increased WC: P=0.003 and WtHtR P=0.02) as shown in Table 5.

The results of multinomial logistic regression for morbidity outcomes among men is shown in Table 6. Overall, odds for HTN increased significantly by a factor of 1.06 (95% CI: 1.05–1.07) for a one-year increase in age. For diabetes, odds increased significantly by a factor of 1.06 (95% CI: 1.04–1.08) for a one-year increase in age. For comorbid diabetes and hypertension; the odds increased significantly by a factor of 1.11 (95% CI: 1.09–1.14) for a one-year increase in age.

Among adult men, in crude analyses, there was a significant association between comorbidity and age (P<0.0001), marital status (P=0.005), occupational status, smoking status, alcohol use, family history of diabetes, BMI status (P=0.002) and central obesity measures (P<0.0001). After adjusting for age, among men being currently married (adjOR=5.8 [1.24-26.96], P value =0.025), alcohol ever use (adjOR =2.44 [1.25-4.74], P value =0.008), a family history of diabetes (adjOR 9.09 (3.72-25.66), P value <0.0001), generalized obesity (BMI ≥25 kg/m2) (adjOR =1.18 [1.15-5.8], P value =0.021) and increased waist circumference (adjOR =4.68 [2.01-10.88], P value <0.0001) and increased waist to height ratio (adjOR =4.53 [1.31-15.62], P value =0.017) remained significantly associated with increased odds for comorbid diabetes and hypertension. After adjusting for age, odds of comorbidity among those with primary or lower level of education decreased by a factor of 0.23 (adjOR [0.11-0.50], P value <0.0001) in comparison to those with secondary or higher level of education.

Among adult women, in crude analyses, there was a significant association between comorbidity and age, marital status, occupational status, smoking status, alcohol use, family history of diabetes, BMI status and central obesity measures. After adjusting for age, being currently married, (adjOR =4.11 [1.43-11.74], P value =0.008), alcohol ever use (adjOR =4.15 [1.83-9.42], P value =0.001), a family history of diabetes (adjOR =7.95 [2.76-22.85], P value <0.0001) and generalized obesity (BMI ≥25 kg/m2) (adjOR =5.13 [1.70-15.48], P value =0.003) remained significantly associated with increased odds for comorbid diabetes and hypertension (Table 7).

The marginsplot showed that overall probability (adjusted predictions) of HTN, DM and comorbidity outcomes at age 80 years

Table 5: Hypertension, diabetes and comorbidity outcomes across socio-demographic, behavioral and biological risk factors among women (n=776)

Variables	Women				P value[a]
	NHD	HTN	DM	CM	
Number (n)	564	134	43	35	
Age (years)					
18-29	165 (29.3)	1	1	0	<0.0001***
30-49	295 (52.3)	46 (34.3)	16 (37.2)	10 (28.6)	
≥ 50	104 (18.4)	87 (64.9)	26 (60.5)	25 (71.4)	
Marital status					
Single/Widowed	110 (19.7)	34 (25.4)	3 (6.9)	7 (20.0)	0.058
Currently married	447 (80.3)	100 (74.6)	40 (93.1)	28 (80.0)	
Ethnicity					
Bahun and *Chhetri*	291 (51.6)	66 (49.3)	25 (58.1)	17 (48.6)	0.765
Adibasi-Janajati and others	273 (48.4)	68 (50.7)	18 (41.8)	18 (51.4)	
Educational attainment					
Secondary and above	271 (48.1)	21 (15.7)	10 (23.3)	6 (17.1)	<0.0001***
Primary and lower	293 (51.9)	113 (84.3)	33 (76.7)	29 (82.9)	
Occupational status					
Employed/Studying	215 (38.1)	26 (19.5)	6 (13.9)	6 (17.1)	<0.0001***
Homemaker/Retired/Unemployed	349 (61.9)	107 (80.5)	37 (86.1)	29 (82.9)	
SES					
Upper and middle	454 (30.8)	106 (79.1)	31 (72.1)	30 (85.7)	0.471
Lower	110 (19.5)	28 (21.9)	12 (27.9)	5 (14.3)	
Smoking status					
Never smoker	541 (95.9)	124 (92.5)	36 (83.7)	29 (82.9)	<0.0001***
Ever smoker	23 (4.1)	10 (7.5)	7 (16.3)	6 (17.1)	
Alcohol use					
Never user	508 (90.2)	97 (72.4)	36 (83.7)	23 (65.7)	<0.0001***
Ever user	55 (9.8)	37 (27.6)	7 (16.3)	12 (34.2)	
BMI status (kg/m2)					
Normal weight (18.5-22.9)	182 (32.3)	19 (14.2)	11 (25.6)	5 (14.3)	<0.001***
Overweight (23-24.9)	113 (20.0)	20 (14.9)	9 (20.9)	6 (17.4)	
Obese (≥ 25)	269 (47.7)	95 (70.9)	23 (53.5)	24 (68.6)	
Family h/o diabetes					
No	548 (97.2)	130 (97.0)	36 (83.7)	27 (77.1)	0.002***
Yes	16 (2.8)	4 (3.0)	7 (16.3)	8 (22.9)	
Physical activity level					
Sufficiently active	40 (7.1)	9 (6.7)	3 (6.9)	0	0.470
Insufficiently active	524 (92.9)	125 (93.3)	40 (93.1)	35 (100.0)	
Central Obesity measures					
WC (cm)					
Normal	121 (26.3)	14 (11.9)	8 (19.1)	4 (11.7)	0.003**
Increased (M ≥ 90/ F ≥ 80)	340 (73.7)	103 (88.1)	34 (80.9)	30 (88.3)	
Waist to height ratio					
Normal	93 (16.5)	10 (7.5)	3 (6.9)	4 (11.4)	0.02**
Increased (> 0.5)	471 (83.5)	124 (92.5)	40 (93.1)	31 (88.6)	

Table 6: Crude and Age adjusted Odds Ratios from multinomial logistic regression for hypertension, diabetes and comorbidity outcomes among men (n=762)

Characteristic	HTN vs NDH		DM vs NDH		CM vs NDH	
	Crude OR	Adjusted OR[a]	Crude OR	Adjusted OR[a]	Crude OR	Adjusted OR[a]
Age (years)	1.06 (1.05 - 1.07) ***	-	1.06 (1.04-1.08) ***	-	1.11 (1.09-1.14) ***	-
Marital status						
Single/Widowed	Ref	Ref	Ref	Ref	Ref	Ref
Currently married	4.18 (2.25-7.7) ***	2.43 (1.23-4.8) **	2.98 (1.04-8.57) *	1.73 (0.58-5.16)	7.73 (1.84-32.32) **	5.8 (1.24-26.96) *
Ethnicity						
Bahun and *Chhetri*	Ref	Ref	Ref	Ref	Ref	Ref
Adibasi-Janajati and others	1.14 (.79-1.63)	1.47 (0.99-2.17)	.36 0.007 (.17 - .76) **	0.45 (0.21-0.97) *	.65 (.35 - 1.20)	0.94 (0.49-1.83)
Educational attainment						
Secondary and above	Ref	Ref	Ref	Ref	Ref	Ref
Primary and lower	1.98 (1.38-2.84) ***	1.09 (0.72-1.63)	1.12 (.58-2.19)	0.57 (0.27-1.2)	.75 (.39-1.42)	0.23 (0.11-0.50) ***
Occupational status						
Working/Studying	Ref	Ref	Ref	Ref	Ref	Ref
Homemaker/Retired/ Unemployed	1.72 (1.10-2.68) *	.59 (0.34-1.01)	4.61 (2.3-9.14) ***	2.25 (1.01-5.02)*	3.04 (1.50-5.80) **	0.65(0.29-1.44)
Smoking status						
Never smoker	Ref	Ref	Ref	Ref	Ref	Ref
Ever smoker	2.83 (1.89-4.24) ***	2.3 (1.49-3.53) ***	2.38 (1.15-4.89) *	1.93 (0.92-4.05)	2.03 (1.03-4.02) *	1.5 (0.72-3.11)
Alcohol use						
Never user	Ref	Ref	Ref	Ref	Ref	Ref
Ever user	1.95 (1.35-2.81) ***	2.10 (1.4-3.12) ***	1.31 (0.66-2.6)	1.39 (0.69-2.82)	1.88 (1.02-3.47) *	2.44 (1.25-4.74) **
BMI status (kg/m2)						
Normal weight (18.5-22.9)	Ref	Ref	Ref	Ref	Ref	Ref
Overweight (23-24.9)	1.69 (0.86-3.31)	1.06 (0.60-1.89)	1.31 (0.52-3.27)	0.95 (0.37-2.4)	1.93 (0.57-6.48)	1.93 (0.57-6.48)
Obese (≥ 25)	3.38 (1.02-3.47) ***	2.01 (1.27-3.19) **	1.41 (0.67-2.97)	0.93 (0.73-5.05)	3.24 (1.21-8.66) *	1.18 (1.15-5.8) *
Family h/o diabetes						
No	Ref	Ref	Ref	Ref	Ref	Ref
Yes	0.93 (0.34-2.56)	1.14 (0.40-3.23)	3.3 (1.05-10.29) *	4.05 (1.26-13.19) *	5.03 (1.98-12.76) **	9.09 (3.72-25.66) ***
Central obesity measures (n = 633)						
WC (cm)						
Normal	Ref	Ref	Ref	Ref	Ref	Ref
Increased (M ≥ 90/ F ≥ 80)	3.25 (2.14-4.92) ***	2.68 (1.73-4.16) ***	1.99 (0.98-4.02)	1.64 (0.80-3.37)	5.47 (2.47-12.14) ***	4.68 (2.01-10.88) ***
Waist to height ratio						
Normal	Ref	Ref	Ref	Ref	Ref	Ref
Increased (> 0.5)	3.14 (1.80-5.46) ***	2.6 (1.45-4.68) **	1.16 (0.53-2.52)	0.96 (0.43-2.14)	5.18 (1.58-16.99) **	4.53 (1.31-15.62) **

*Significant P value < 0.05 **Highly significant P value < 0.01 ***Very highly significant P value < 0.0001, Ref: Reference group; For multinomial logistic regression, referent category is persons without hypertension or diabetes [NHD (n= 564)]. Each category of morbidity hypertension alone [HTN (n=134)], diabetes alone [DM (n=43)] and comorbidity [CM (n=35)] was compared to the referent group.

Table 7: Crude and Age adjusted Odds Ratios from multinomial logistic regression for hypertension, diabetes, and comorbidity outcomes among women (n=776)

Characteristic	HTN vs NDH		DM vs NDH		CM vs NDH	
	Crude OR	Adjusted OR[a]	Crude OR	Adjusted OR[a]	Crude OR	Adjusted OR[a]
Age (years)	1.09 (1.07 - 1.10) ***	-	1.07 (1.05- 1.09) ***	-	1.11 (1.08- 1.14) ***	-
Marital status						
Single/Widowed	Ref	Ref	Ref	Ref	Ref	Ref
Currently married	0.72 (.46- 1.12)	1.44 (.93- 2.21)	3.28 (.99- 10.8)	1.73 (.58- 5.16)	.98 (.41- 2.31)	5.8 (1.24- 26.96) *
Ethnicity						
Bahun and *Chhetri*	Ref	Ref	Ref	Ref	Ref	Ref
Adibasi-Janajati and Others	1.09 (.75- 1.6)	1.44 (.93- 2.73)	.76 (.40 -1.43)	.96 (0.50- 1.84)	1.12 (.57 - 2.23)	1.57 (.72- 3.27)
Educational attainment						
Secondary and above	Ref	Ref	Ref	Ref	Ref	Ref
Primary and lower	4.97 (3.03- 8.15) ***	1.54 (0.87- 2.73)	3.05 (1.47- 6.31) **	1.14 (0.49- 2.64)	4.47 (1.82- 10.93) **	0.74 (0.25- 2.22)
Occupational status						
Working/Studying	Ref	Ref	Ref	Ref	Ref	Ref
Homemaker/Retired/ Unemployed	2.53 (1.59- 4.02) ***	1.12 (0.34- 1.01)	3.79 (1.57- 9.15) **	2.08 (0.83- 5.21)	2.97 (1.21- 7.28) *	0.99 (0.84- 1.17)
Smoking status						
Never smoker	Ref	Ref	Ref	Ref	Ref	Ref
Ever smoker	1.89 (.88- 4.08)	.86 (.36- 2.02)	4.57 (1.83- 11.37) **	2.35 (0.89- 6.17)	4.86 (1.83- 12.87) **	1.97 (0.37- 2.64)
Alcohol use						
Never user	Ref	Ref	Ref	Ref	Ref	Ref
Ever user	3.52 (2.20- 5.63) ***	3.05 (1.79- 5.20) ***	1.79 (0.76- 4.22)	1.56 (0.65- 3.78)	4.81 (2.27- 10.21) ***	4.15 (1.83- 9.42) **
BMI status (kg/m2)						
Normal weight (18.5- 22.9)	Ref	Ref	Ref	Ref	Ref	Ref
Overweight (23-24.9)	1.69 (0.86- 3.31)	2.7 (0.99- 4.72)	1.31 (0.52- 3.27)	1.45 (.55- 3.80) **	1.93 (0.57- 6.48)	3.07 (0.81- 8.95)
Obese (≥ 25)	3.38 (1.99- 5.73) ***	4.11 (2.19- 7.73) **	1.41 (0.67- 2.97)	1.44 (.65- 3.18) **	3.24 (1.21- 8.66) *	5.13 (1.70- 15.48) **
Family h/o diabetes						
No	Ref	Ref	Ref	Ref	Ref	Ref
Yes	1.05 (0.34- 3.20)	.80 (0.24- 2.62)	6.65 (2.5- 17.2) ***	5.15 (1.89- 14.03) **	10.14 (3.99- 25.78) ***	7.95 (2.76- 22.85) ***
Central Obesity measures n = 654						
WC (cm)						
Normal	Ref	Ref	Ref	Ref	Ref	Ref
Increased (M ≥ 90/ F ≥ 80)	2.61 (1.40- 4.74) **	2.39 (1.22- 4.69) **	1.51 (.68- 3.35)	1.31 (0.57- 3.02)	2.66 (.92- 7.73)	2.81 (.88- 8.95)
Waist to height ratio						
Normal	Ref	Ref	Ref	Ref	Ref	Ref
Increased (> 0.5)	2.44 (1.23- 4.84) ***	2.04 (0.94- 4.46)	2.63 (0.79- 8.68)	2.14 (0.62- 7.35)	1.53 (.52- 4.43)	1.37 (.42- 4.41)

*Significant P value < 0.05 **Highly significant P value < 0.01 ***Very highly significant P value < 0.0001, Ref: Ref group

was about 50%, 6% and 22%, respectively in comparison to 2%, 1% and 0% at age 20 years (Fig. 3). On disaggregation for sex, among men the probability (adjusted predictions) of HTN, DM and comorbidity at age 40 years was about 18%, 5% and 4% and at 80 years increased to 42%, 6% and 22%, respectively in comparison to 4%, 1% and 0% at age 20 years (Fig. 4). Among women the probability (adjusted predictions) of HTN, DM and comorbidity at age 40 years was about 12%, 5% and 2% and at age 80 years was about 58%, 12% and 22% respectively in comparison to 2%, 1% and 0% at age 20 years among women (Fig. 5).

DISCUSSION

Overall, the study findings reveal that the prevalence of hypertension was significantly higher among men (23% to about 30%) in comparison to women (22% to 25%). However, prevalence rate of diabetes at 9% to 13% among men was like that among women at 8% to 12%. Comorbid diabetes and hypertension prevalence was marginally higher among men (5% to 8%) in comparison to women (3% to 6%) though this difference did not reach statistical significance. Notably, one-half of all persons with diabetes (n =162) in the study population were found to have hypertension. Men with diabetes were found to have 300% increased odds (OR 4.3, 95% CI: 2.56 -6.50) while women with diabetes had 240% increased odds of hypertension. Hence, association between diabetes and hypertension appeared to be more robust among men.

Looking at previous studies in Nepal, in 2015, a large cross-sectional community-based study among 4200 adults aged between 15 to 69 years, reported a lower prevalence of comorbidity of 2% that ranged from 1.5% to 2.7%. Comorbidity prevalence was reported to be higher among males (2.5% vs 1.6%), in urban areas (2.8% vs 1.8%). However, gender-specific risk for comorbidity was not significant (F 1.15, 0.74-1.80).[17] Looking at other countries in the SA region, rates of hypertension and diabetes that were similar to Nepal were reported in Bhutan, among 2,800 adults aged between 25 to 74 years. The prevalence of diabetes and hypertension was 8.6% and 28.3% among men and 7.7% and 20.9% among women. Over one-half of persons (54.1%) with diabetes had hypertension.[18]

However, in Bangladesh, a nationally representative survey (n = 7521) among adults aged 35 years and above, reported higher prevalence of co-morbidity among women (5.7% vs 3.2%). The risk of co-morbidity was 80% (OR 1.8, 95% CI 1.2-2.8) higher among women in comparison to men. Higher education, urban residence and increased BMI were associated with comorbidity.[19] In comparison, the screening for the twin epidemic (SITE) study (n =15,662) in India reported a much higher prevalence of comorbidity among adults at about 21%. The prevalence of hypertension among PWDs was also higher at almost 60%. However, gender specific rates for comorbidity were not reported. [20]

In the present study, among the biological risk factors, age was a robust predictor for comorbidity with a one-year increase associated with 11% increase in odds for comorbidity. Age was a significant effect modifier among both men and women as the robustness of odds ratios for most characteristics decreased when age was held constant. It is pertinent to note that family history of diabetes and alcohol use were the only characteristics that became more robust when age was held constant.

The margins plot showed that the probability of comorbid hypertension and diabetes would exceed that of diabetes at age 50 years among men and at about 65 years for women. However, by the age of 80 years the probability of comorbidity was similar among men and women. Though men with diabetes had higher odds of hypertension, there was no significant gender difference in the prevalence of comorbidity in the study population.

Other biological risk factors that were robustly associated with comorbid diabetes and hypertension and common to both men and women were family history of diabetes and obesity (BMI >=25 kg/m^2). However, measures of central obesity such as increased waist circumference and increased waist to height ratio were associated with increased relative risk of comorbidity among men alone.

Among behavioural risk factors, though alcohol use was higher among men, its association with comorbidity was more robust among women (300% vs 144% increased odds). Among sociodemographic risk factors, being currently married was associated with higher odds for comorbidity for both women and men. However, higher level of education was associated with increased odds of comorbidity among men; while the reverse was observed among women. However, after adjusting for age, the association with educational status remained significant for men alone.

There have been regional variations in the association of risk factors as seen from national level surveillance studies for non-

communicable diseases across South Asia and Asia-Pacific region. The cardiometabolic risk reduction in South Asia (CARRS) study reported that among PWDs, the odds of hypertension were higher among women 1.64 (95% CI 1.2-2.3) in comparison to men 1.2 (95% CI 0.97-1.6).[21]

Looking from the lens of hypertension, in the present study about one-fifth of persons with hypertension (n =370) had diabetes. However, about one third of persons with hypertension (n =2426) aged 40 years and above were found to have diabetes with higher rates among women in Bangladesh, Pakistan and Sri Lanka. [21]

A more recent analysis of data from Korea National Health and Nutrition Examination survey (2008-11) reported that comorbid diabetes and hypertension was more robustly associated with fat and lean mass than diabetes and hypertension. The association between comorbidity and body fat variables was more robust in women than in men aged fifty years and above.[22]

In China, comorbid diabetes and hypertension were found to be higher among older persons, women, those with higher education, single and increased waist circumference. More importantly, comorbidity was significantly associated with higher risk of cardiovascular disease due to a synergistic and additive effect.[23] Hence, there is consistent evidence in literature that persons with comorbidity were older, had higher education, were more sedentary, had raised BMI and increased waist circumference.[24]

Comorbid diabetes and hypertension are known to be associated with raised triglyceride levels, cardiovascular and chronic renal disease. However, evidence from systematic reviews suggests that diabetes and comorbidity may be more severe for women with a 50% excess risk of mortality due to cardiovascular disease.[25,26] But, it is argued that this may be an artifact due to better life expectancy among women without diabetes in comparison to men without diabetes.[27] More pertinently, the influence of sex and gender differences on diabetes and hypertension need to be evaluated to enable a gender-sensitive approach to prevention, diagnosis, treatment and optimal care.[28]

Limitations: Though anthropometric and risk factor (SBP, DBP) assessment was carried out by trained medical students using a standardized proforma and measurement procedure to minimize measurement bias, it still needs to considered. Misclassification may have occurred for persons categorized as with no diabetes or hypertension (NDH) as blood sugar levels was not assessed. Lived experiences of women and men with diabetes, hypertension and comorbidity were not considered in this study.

In conclusion, the study findings suggest that in an urban community in Nepal, prevalence of comorbid diabetes and hypertension was marginally higher among men. Though this difference did not reach statistical significance, the odds of comorbidity were higher for men. Older age, being currently married, alcohol use, family history of diabetes, and obesity were associated with comorbidity for both men and women. Most of these associations were more robust for men, however, alcohol use and obesity were more robust for women. Central obesity measures were associated with comorbidity among men. A paradoxical relationship was seen for educational level with lower educational status associated with higher risk among women and higher education with higher risk for men.

Though comorbidity rates appear to be lower in comparison to other countries in South Asia, the rising burden of non-communicable diseases with about 70% proportionate mortality rate in Nepal emphasize the need for tailored public health interventions that address modifiable risk factors among men and women. Further research may help to identify the role of biological, behavioural and socio-demographic risk factors on cardiovascular risk and hard outcomes such as cardiovascular events and mortality among men and women with comorbid diabetes and hypertension in Nepal.

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