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Interaction of multiple risk factors and population attributable fraction for type 2 diabetes and hypertension among adults aged 15–49 years in Northeast India



Strong P. Marbaniang^{a,*}, Hemkothang Lhungdim^a, Shekhar Chauhan^b,
Shobhit Srivastava^c

^a Department of Public Health and Mortality Studies, International Institute for Population Sciences, Mumbai, 400088, India

^b Department of Population Policies and Programmes, International Institute for Population Sciences, Mumbai, 400088, India

^c Department of Mathematical Demography and Statistics, International Institute for Population Sciences, Mumbai, 400088, India

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ABSTRACT

Aims: The aim is to assess the association and population attributable fraction (PAF) of multiple risk factors combination for diabetes and hypertension among adults in the Northeast region of India.

Methods: Data used is from the Indian Demographic Health Survey conducted in 2015–16. The study comprised 107,766 respondents (95,153 females and 12,613 males) aged 15–49 years. We examined four modifiable risk factors: smoking, alcohol consumption, aerated drinks consumption, and overweight or obesity. PAF was calculated using the relative risk from the multivariable logistic regression models.

Results: Overweight or obesity in conjunction with smoking was associated with 43.9% of patients with diabetes. Smoking in conjunction with alcohol and overweight or obesity contributed to 53% of patients with diabetes (PAF = 53%). The three risk factors combination (i.e., smoking, alcohol, and overweight or obesity) is associated with the most hypertension cases (PAF = 50.7%). Experiencing all four risk factors is associated with 50.3% of patients with hypertension. In women, the four-risk combination contributed the most hypertension cases (PAF = 46.8%).

Conclusions: Overweight or obesity was the single most significant factor leading to hypertension and diabetes among the study population. Also, smoking, alcohol, and overweight or obesity together are prominent risk factors for hypertension and diabetes.

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1. Introduction

Globally, about one-third of the adult population has the problem of hypertension, and nearly one-tenth of the adult population suffers from diabetes [1]. A global action plan was signed to prevent and control non-communicable diseases, which aimed to reduce hypertension by 25% between 2010 and 2025 and focus on halting diabetes by 2025 [2]. Hypertension and diabetes are the leading causes of heart attack and strokes [3].

It was found that the percentage of disability-adjusted life years (DALYs) which attribute to non-communicable diseases raised from 31% of the total DALYs in 1990 to 55% in 2016 [3]. The crude prevalence of hypertension was 25.3%. It was 7.5% for diabetes in

India [3]. Historically, the NCD Risk Factor Collaboration (NCD-RisC) also estimated the age-standardized prevalence of hypertension and diabetes for men and women from 1980 to 2014. The prevalence of hypertension and diabetes increased from 24.5% to 26.6% and 3.7%–9.1% among men, and among women, the prevalence of hypertension and diabetes increased from 22.7% to 24.7% and 4.6% and 8.3% from 1980 to 2014, respectively [4].

The significant risk factors for hypertension and diabetes were tobacco and alcohol use [5]. It was found that smokeless tobacco consumption was significantly associated with increased high blood pressure [5]. Moreover, it was also revealed that smoking increases the risk of hypertension among adults [6]. There is a spurious relationship between alcohol consumption and hypertension. It was argued that lowering alcohol intake lowers blood pressure in a dose-dependent manner with an evident threshold effect [7]. Previous studies also revealed that consumption of soft drinks was significantly associated with elevated blood pressure

* Corresponding author.

E-mail address: strongmarbaniang@yahoo.com (S.P. Marbaniang).

[8]. Diabetes was significantly associated with smoked tobacco, but the relationship was not significant with smokeless tobacco consumption [7]. The individuals who smoke tobacco had a 30 to 40% significantly higher likelihood of developing type-2 diabetes than individuals who do not smoke tobacco [9].

Moreover, several studies had found a significant association between smoking and diabetes [9]. It was argued that smokeless tobacco is a significant risk factor for type-2 diabetes [9]. Further, it was revealed that nicotine consumption in any form increases the risk of type-2 diabetes among adults [9]. Alcohol consumption was also identified as one of the significant risk factors for diabetes mellitus [10]. It was argued that long-term ingestion of alcohol among people with diabetes who were not adequately nourished could cause severe consequences [10]. Heavy drinking, particularly among people with diabetes, also can lead to the accumulation of certain acids in the blood that may result in severe health conditions [10]. It was further argued that frequent sugar-sweetened beverage consumption was positively associated with high chances of type-2 diabetes mellitus [11].

There are other risk factors for hypertension and diabetes [12]. Obesity is one of the significant risk factors for hypertension and diabetes [13]. Moreover, individuals from the higher wealth quintile had a higher probability of reporting hypertension and diabetes in India [13]. Previous studies concluded that 70 % and 90 % of the population burden of hypertension and diabetes was among individuals from higher wealth quintiles [14].

Previous studies had provided evidence for various risk factors associated with hypertension and diabetes among adults globally and in India. However, region-specific predictors for hypertension and diabetes are not yet explored in India. The adults from the Northeast region had the highest odds for consumption tobacco of smoking and smokeless tobacco [15]. Additionally, out of 10.2 million substance users, more than 65 % live in Assam [16]. A wide variation exists in the prevalence and intensity of substance use across the states in Northeastern states [16].

Interestingly, the prevalence of smoking in Northeast India (NEI) is far higher than that observed in Western countries [17]. The above-stated statistics craves the curiosity about how hypertension and diabetes prevalence varies in the Northeastern states and does substance use, and use of aerated drinks are associated with their varied prevalence. Therefore, the present study aims to determine the Population Attributable Fraction (PAF) for multiple risk factors combination for Diabetes and Hypertension among adults in the Northeast region of India.

2. Methods

2.1. Study location

The study focuses on the Northeastern region of India comprising eight states, namely Assam, Arunachal Pradesh, Manipur, Meghalaya, Mizoram, Nagaland, Sikkim, and Tripura (Fig. 1). The region has a hilly terrain inhabited mainly by tribal people belonging to different cultures and ethnic communities. It has over 45 million, which is 3.76 % of India's population and a population density of 159 persons per square km.

2.2. Data source and participants

The present study focuses on Northeast India. Data used in the analysis were drawn from the nationally representative Indian Demographic Health Survey (IDHS), also known as the National Family Health Survey (NFHS-4). IDHS data was downloaded from the DHS website [18] after obtaining the necessary permissions. Since this study uses publicly available secondary data, and the

respondents are de-identified, the institutional review board (IRB) exempted it from seeking approval. A detailed description of the survey can be seen elsewhere [19].

The sample for this study comprised 107, 766 respondents (95,153 females and 12, 613 males) aged 15–49 years. Males consisted only 12% of the total sample size because the survey had collected information from males in only 15% of the sampled households. In the sample, 6868 respondents had diabetes, and 17,348 respondents had hypertension.

2.3. Defining outcome variables

Diabetes. Blood glucose was measured on a blood sample drawn from the fingertips using Free Style Optium H Glucometer. Usually, fasting blood glucose level is used to determine the presence or absence of diabetes in an individual. However, in NFHS-4, random blood samples were collected for measuring blood glucose. According to the NFHS-4 guidelines, the threshold value of blood glucose was above 140 mg/dl, which an individual is regarded as diabetic [19].

Hypertension: Blood pressure was measured with an OMRON Blood Pressure monitor. Blood pressure readings were taken on three separate occasions with an interval of 5 min between readings. The first reading was discarded, and the average of the last two readings was calculated. A respondent was classified as hypertensive if the average systolic blood pressure ≥ 140 mmHg, or average diastolic blood pressure ≥ 90 mmHg, or if the person was taking antihypertensive medication to lower blood pressure at the time of the survey [19].

The binary outcome variables diabetes and hypertension were coded as 1 for a “Yes” (meaning presence of diabetes or hypertension) and 0 for a “No” (meaning absence).

Overweight and Obesity: The study categorized continuous body mass index (BMI) according to the classification guidelines for the Asian Indians as recommended by Misra et al. [20]. A respondent is classified as overweight if the BMI value is in the range of 23–24.9 kg/m², obese if the BMI value is > 25 kg/m².

Alcohol intake: During the survey, the respondent were asked the question “Do you drink alcohol?” and the response was “Yes” or “No.” We coded the variable alcohol consumption as “0” for No and “1” for Yes.

2.4. Modifiable risk factors

In this study, we focused on four risk factors: smoking, alcohol consumption, aerated drinks consumption, overweight or obesity, and tobacco use. These risks were regarded as modified [i.e., the risk to stop (e.g., smoking) or control (e.g., overweight or obesity)]. To simplify the analysis, we dichotomized the risk factors as 0 for “risk factor not present” and 1 for “risk factor present.”

2.5. Control variables

In the multivariate logistic regression, we adjusted for the age and household wealth index of the respondent.

2.6. Statistical analysis

The present study used descriptive statistics followed by bivariate and multivariate logistic regression analysis to identify the association between the modifiable risk factors with diabetes and hypertension among adults. The modifiable risk factors which are significantly associated with diabetes and hypertension (at a 5% level of significance) were included in the multivariate model to examine their interaction effects. Relative risk (RR) was estimated

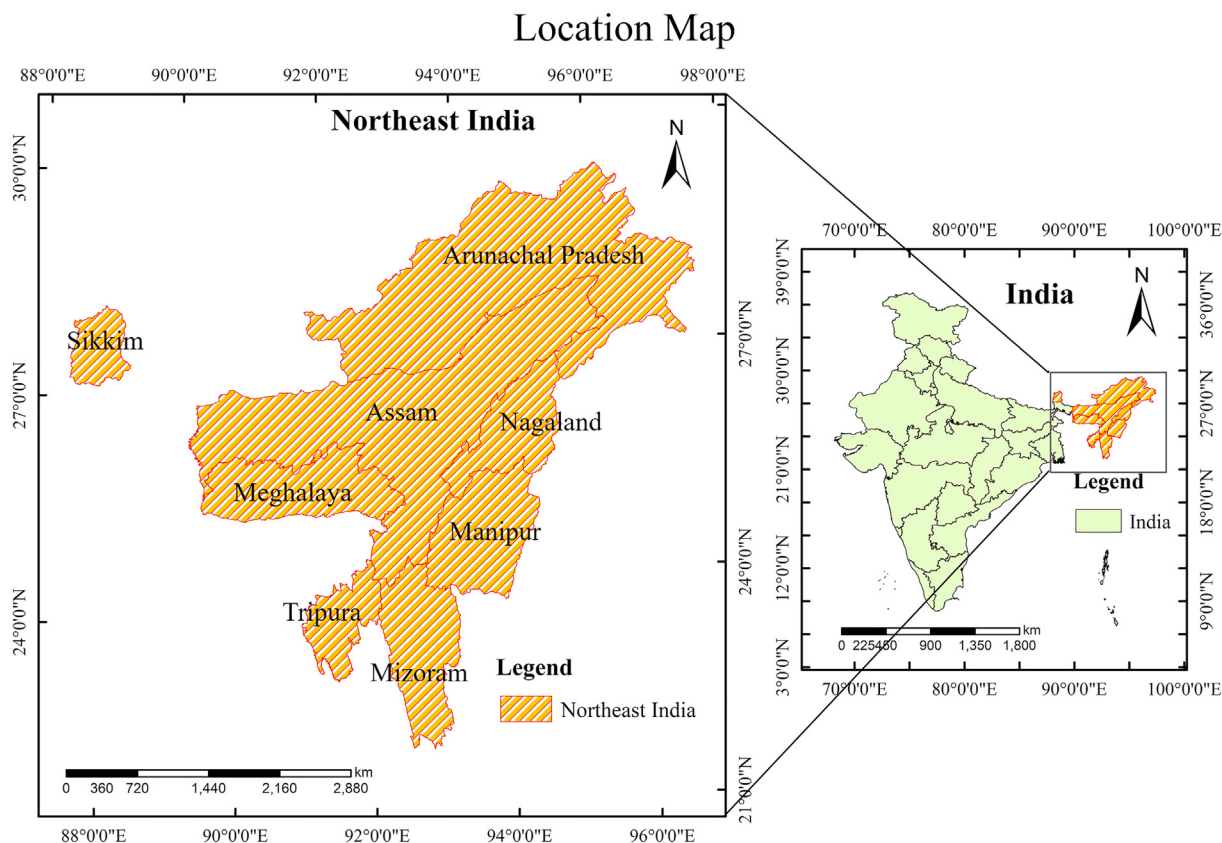


Fig. 1. Title: **Map showing the location of the study area.** Source: Figure construct by the authors.
Source: Figure construct by the authors

using bivariate and multivariate logistic regression. The population attributable fraction (PAF) was then calculated for all modifiable risk factor combinations in which the RR was greater than 1. PAF measures the proportion of disease or mortality attributable to a risk factor. PAF estimates the percentage reduction in the prevalence of disease that would occur if the exposure to the risk would be reduced to the counterfactual scenario with all other factors remaining the same [21,22].

The PAF for the population was calculated as

$$PAF = \frac{P*(RR - 1)}{P*(RR - 1) + 1}$$

Here *P* is the prevalence of exposure to each risk factor combination, and *RR* is relative risk in the exposed compared to the unexposed group. After fitting the multivariate logistic model, the PAF estimates for all the risk factor combinations were computed using *punaf* STATA command [23]. All the analysis was performed in STATA version 15 (StataCorp, Texas).

3. Results

The study sample consisted of 107,766 individuals. Of the total participants, 11.7% were male, and 88.3% were female (Table 1). The majority of the respondents were between the ages 15–29 years (50 %) and belonged to the poorer household (36.7 %). Overall prevalence of tobacco use was 6.7% with only 5.9% of the women use tobacco. A high prevalence of diabetes (7.4 %) and hypertension (20 %) was found among male respondents, while among the females, the prevalence of diabetes and hypertension was 5.7% and

16.9%, respectively.

In the Bivariate analysis (Table 2), male and female respondents between 40 and 49 years were respectively 3.1 and 3.9 times more likely to have diabetes than respondents with 15–29 years of age. Smoking was associated with 1.6 times increased in diabetes risk among female, while alcohol was associated with diabetes risk among male (RR = 1.2; 95 % CI: 1.1, 1.4). The risk of hypertension was 1.1 times greater among those who smoke than those who did not smoke. The relative risk of hypertension incidence increased by more than twofold if an individual is obese.

Since tobacco use was not statistically significant in hypertension and diabetes, we did not include it in the multivariate logistic regression analysis. The multivariate logistic regression model in Tables 3 and 4 included age and household wealth index as the covariate variables. Overweight or obesity alone was associated with 36.8 % of the patients with diabetes; however, overweight or obesity in conjunction with smoking was associated with 43.9 % of patients with diabetes. In conjunction with aerated drinks, overweight or obesity contributed to an additional 30.8 % of patients with diabetes. The risk combination associated with most cases of diabetes was therefore smoking in conjunction with alcohol and overweight or obesity (PAF = 53.0 %). The presence of aerated drinks conferred an additional 37.8 % of patients with diabetes to this combination. The combination of overweight or obesity along with smoking and alcohol consumption is associated with 42.6 % of patients with diabetes in women (Additional file: Table A2). Further, overweight or obesity alone was attributable to 35.2 % of patients with hypertension. In conjunction with alcohol, overweight or obesity was attributable to 48.4 % of patients with hypertension (Table 4). The three risk factors combination (i.e.,

Table 1
Distribution of respondents 15–49 years according to selected background characteristics. NFHS 2015–16.

Background Characteristics	Male (n = 12,613)	Female (n = 95,153)	All (n = 107,766)
Age			
15–29	46.9	50.4	50.0
30–39	29.2	27.9	28.0
40–49	23.8	21.7	22.0
Wealth Index			
Poorest	17.1	18.2	18.0
Poorer	36.8	36.7	36.7
Middle	22.7	22.4	22.4
Rich	15.9	15.2	15.2
Richest	7.6	7.6	7.6
Smoking			
No	74.4	99.5	96.5
Yes	25.6	0.5	3.5
Alcohol			
No	59.2	93.0	89.0
Yes	40.8	6.9	11.0
Aerated Drinks			
No	26.4	28.1	27.9
Yes	73.5	71.7	72.0
Overweight or Obesity			
No	70.5	72.2	72.0
Yes	29.5	27.8	28.0
Tobacco Use			
No	87.0	94.1	93.3
Yes	13.0	5.9	6.7
Diabetic	7.4	5.7	5.9
Hypertensive	20.0	16.9	17.3

Table 2
Bivariate Relative Risk and 95 % confidence interval for diabetes and hypertension among individuals 15–49 years. NFHS 2015–16.

Background Characteristics	Diabetes			Hypertension		
	Male	Female	All	Male	Female	All
Age	RR (95 % CI)	RR (95 % CI)	RR (95 % CI)	RR (95 % CI)	RR (95 % CI)	RR (95 % CI)
15–29	Ref	Ref	Ref	Ref	Ref	Ref
30–39	1.9 (1.6, 2.2) ***	2.4 (2.2, 2.6) ***	2.3 (2.2, 2.5) ***	2.2 (2.0, 2.4) ***	2.5 (2.4, 2.6) ***	2.4 (2.3, 2.5) ***
40–49	3.1 (2.7, 3.6) ***	3.9 (3.7, 4.1) ***	3.8 (3.6, 4.0) ***	2.9 (2.7, 3.2) ***	3.9 (3.8, 4.1) ***	3.8 (3.6, 3.9) ***
Wealth Index						
Poorest	Ref	Ref	Ref	Ref	Ref	Ref
Poorer	0.8 (0.8, 0.9) **	1.2 (1.1, 1.4) ***	1.1 (1.1, 1.3) ***	1.0 (0.9, 1.1)	1.0 (0.9, 1.1)	1.0 (0.9, 1.0)
Middle	0.9 (0.7, 1.1)	1.4 (1.3, 1.5) ***	1.3 (1.2, 1.4) ***	1.1 (0.9, 1.2)	1.0 (0.9, 1.1)	1.0 (0.9, 1.0)
Rich	1.0 (0.9, 1.3)	1.7 (1.5, 1.8) ***	1.6 (1.4, 1.7) ***	1.4 (1.2, 1.6) ***	1.1 (1.1, 1.2) ***	1.1 (1.0, 1.1) ***
Richest	1.2 (0.9, 1.5)	1.9 (1.7, 2.1) ***	1.8 (1.6, 2.0) ***	1.5 (1.3, 1.7) ***	1.0 (0.9, 1.1)	1.0 (1.0, 1.1) ***
Smoking						
No	Ref	Ref	Ref	Ref	Ref	Ref
Yes	1.0 (0.9, 1.1)	1.6 (1.4, 1.8) ***	1.4 (1.3, 1.5) ***	1.0 (0.9, 1.1)	0.9 (0.8, 0.9) ***	1.1 (1.0, 1.2) ***
Alcohol						
No	Ref	Ref	Ref	Ref	Ref	Ref
Yes	1.2 (1.1, 1.4) ***	1.1 (1.0, 1.2)	1.2 (1.2, 1.3) ***	1.4 (1.3, 1.5) ***	1.4 (1.4, 1.5) ***	1.5 (1.4, 1.5) ***
Aerated Drinks						
No	Ref	Ref	Ref	Ref	Ref	Ref
Yes	0.8 (0.7, 0.9) ***	0.9 (0.9, 1.1) **	0.9 (0.8, 0.9) ***	0.9 (0.9, 1.0)	0.9 (0.8, 0.9) ***	0.9 (0.8, 0.9) ***
Overweight or Obesity						
No	Ref	Ref	Ref	Ref	Ref	Ref
Yes	1.7 (1.5, 1.9) ***	2.0 (1.9, 2.1) ***	2.0 (1.9, 2.1) ***	2.1 (2.0, 2.2) ***	2.1 (1.9, 2.1) ***	2.1 (2.1, 2.1) ***
Tobacco Use						
No	Ref	Ref	Ref	Ref	Ref	Ref
Yes	0.9 (0.8, 1.1)	1.4 (1.3, 1.6) ***	1.1 (0.9, 1.2)	0.9 (0.8, 1.0)	0.9 (0.8, 1.0)	0.9 (0.9, 1.0)

RR: Relative Risk; CI: confidence interval; ** p-value<0.05; ***p-value<0.01.

smoking, alcohol, and overweight or obesity) is associated with the most hypertension cases (PAF = 50.7 %). Experiencing all four risk factors is associated with 50.3 % of patients with hypertension. In men, the three-risk factor combination (i.e., alcohol, aerated, and overweight or obesity) is associated with the most hypertension cases (PAF = 51.6 %). However, in women, the four-risk combination contributed the most hypertension cases (PAF = 46.8 %) (Additional file: [Table A1 and A2](#)).

4. Discussion

Chronic diseases such as hypertension and diabetes have been studied widely by various researchers in India [13,24,25]. Not only in India, but the studies pertaining to hypertension and diabetes have also been widely undertaken across the globe [26,27]. However, with an abundance of literature available on prevalence and determinants of hypertension and diabetes, studies quantifying the contribution of

Table 3
Multivariate relative risk and population attributable fraction (PAF) of diabetes among individuals 15–49 years. NFHS 2015–16.

Smoking	Alcohol	Aerated Drinks	Overweight or Obesity	Number of exposed	Exposure Prevalence	Diabetes Cases	RR ^a (95 % CI)	PAF (%)
0	0	0	0	14,300	13.3	731	Ref	
One Risk								
1	0	0	0	617	0.6	50	1.2 (0.9, 1.6)	15.5
0	0	0	1	5585	5.2	582	1.6 (1.4, 1.8) ***	36.8
0	0	1	0	46,117	42.8	2009	1.0 (0.9, 1.0)	Na
0	1	0	0	1563	1.5	110	1.2 (0.9, 1.4)	15.1
Two Risk								
1	0	0	1	310	0.3	42	1.8 (1.3, 2.4) ***	43.9
1	0	1	0	1186	1.1	77	1.2 (0.9, 1.5)	16.3
0	0	1	1	23,620	21.9	2161	1.4 (1.3, 1.6) ***	30.8
1	1	0	0	444	0.4	37	1.5 (1.1, 2.0) **	31.3
0	1	0	1	627	0.6	46	1.1 (0.8, 1.5)	8.13
0	1	1	0	5814	5.4	328	1.1 (0.9, 1.2)	6.9
Three Risk								
1	0	1	1	703	0.7	79	1.6 (1.3, 2.1) ***	39.2
1	1	0	1	187	0.2	27	2.1 (1.5, 3.1) ***	53.0
1	1	1	0	1716	1.6	115	1.3 (1.1, 1.6) ***	24.9
0	1	1	1	3966	3.7	373	1.4 (1.3, 1.6) ***	29.2
Four Risk								
1	1	1	1	1011	0.9	101	1.6 (1.3, 1.9) ***	37.8
Total				107,766	100.0	6868		

RR: Relative Risk; CI: confidence interval; ** p-value<0.05; ***p-value<0.01; ^a Model with age and wealth index as the covariates; 0 = risk factor not present; 1 = risk factor present; Na-Not available.

Table 4
Multivariate relative risk and population attributable fraction (PAF) of hypertension among individuals 15–49 years. NFHS 2015–16.

Smoking	Alcohol	Aerated Drinks	Overweight or Obesity	Number of exposed	Exposure Prevalence	Hypertension Cases	RR ^a (95 % CI)	PAF (%)
0	0	0	0	14,300	13.3	1869	Ref	
One Risk								
1	0	0	0	617	0.6	63	0.6 (0.5, 0.8) ***	Na
0	0	0	1	5585	5.2	1336	1.5 (1.4, 1.6) ***	35.2
0	0	1	0	46,117	42.8	4804	0.9 (0.9, 0.9) **	Na
0	1	0	0	1563	1.5	377	1.5 (1.3, 1.6) ***	33.4
Two Risk								
1	0	0	1	310	0.3	64	1.2 (0.9, 1.5)	16.0
1	0	1	0	1186	1.1	113	0.8 (0.6, 0.9) ***	Na
0	0	1	1	23,620	21.9	5502	1.6 (1.5, 1.8) ***	37.7
1	1	0	0	444	0.4	76	1.2 (0.9, 1.5)	16.9
0	1	0	1	627	0.6	202	1.9 (1.7, 2.2) ***	48.4
0	1	1	0	5814	5.4	937	1.2 (1.1, 1.3) ***	17.8
Three Risk								
1	0	1	1	703	0.7	164	1.5 (1.3, 1.8) ***	35.2
1	1	0	1	187	0.2	60	2.0 (1.6, 2.5) ***	50.7
1	1	1	0	1716	1.6	273	1.3 (1.2, 1.5) ***	24.0
0	1	1	1	3966	3.7	1220	1.9 (1.8, 2.1) ***	49.3
Four Risk								
1	1	1	1	1011	0.9	288	2.0 (1.8, 2.2) ***	50.3
Total				107,766	100.0	17,348		

RR: Relative Risk; CI: confidence interval; ** p-value<0.05; ***p-value<0.01; ^a Model with age and wealth index as the covariates; 0 = risk factor not present; 1 = risk factor present; Na-Not available.

a risk factor to hypertension and diabetes using population attributable fraction (PAF) are somewhat limited in the Indian context [22,28]. This study, along with examining the predictors of hypertension and diabetes, quantified four modifiable risk factors: smoking, aerated drinks, overweight or obesity, and alcohol in explaining the effects of risk factor combination for hypertension and diabetes among individuals aged 15–49 years in Northeast India.

5. Determinants of hypertension and diabetes among study population

Recent years have observed a rapid rise in the prevalence of hypertension and diabetes in India. This could be attributed to the sedentary lifestyle, urbanization, and consumption of energy-dense and fibre/micronutrient-poor food [29,30]. This study noticed that the risk of hypertension and diabetes increased with an increase in

the age of the study population. Previous studies agree with this finding [31,32]. Increasing age is a potential risk factor to develop diabetes and hypertension as with an increase in age, physical activity declines, leading to the onset of hypertension and diabetes [33,34]. Physical activity involves changes in body weight and glucose tolerance, thereby reducing hypertension and diabetes [35]. Furthermore, with an increase in age, people tend to follow a sedentary lifestyle and a sedentary lifestyle is a cause of hypertension and diabetes [36].

The study found that people from the richest wealth quintile were more likely to have diabetes than their poorest counterparts. Previously studies unanimously concluded that increasing wealth is a risk factor for diabetes [13,14]. The easy availability of unhealthy food choices, high energy-rich food, and decreased physical activity among people from the richest wealth quintile explain the high risk of diabetes.

6. Risk factors for hypertension and diabetes based on PAF analysis

Hypertension and diabetes frequently occur together. It is because hypertension and diabetes are governed by common metabolic pathways and share common etiological factors [3,37]. Since hypertension and diabetes share common etiological factors, the same risk factors (smoking, alcohol, aerated drinks, and overweight or obesity) are utilized to categorize the risk of both chronic conditions, namely; hypertension and diabetes.

The four important modifiable risk factors examined in this study are smoking, alcohol, aerated drinks, and overweight or obesity. Except for overweight or obesity, the relative risk of diabetes due to a single risk factor is not significant. The risk of diabetes could be reduced by 37% (36.7 %) if an individual controls his overweight or obesity. Furthermore, the risk of hypertension can be reduced by 35% if an individual gets control over his overweight or obesity. Previous studies identified obesity as a precursor for diabetes and hypertension [38,39]. Obesity is predominantly contemplated as a combined result of dysfunction of the feeding centre in the brain, imbalance in energy intake and expenditure, and genetic variations leading to increased risk of hypertension and diabetes [3]. It is worth noting that obesity is by large determined by genes; approximately 50–90% of the variation in weight results from genetic proclivity [40]. Chronic mental stress, resulting from the contemporary lifestyle, is frequently associated with physiological and psychological disturbances, which may indirectly be leading to an increased risk of hypertension and diabetes [41,42]. Lack of physical activities may result in obesity, leading to hypertension and diabetes [3]. However, smoking and alcohol as a risk factor for diabetes were not significant in the multivariate model; they tend to contribute towards the onset of diabetes as it was found that the risk of diabetes could be averted by almost 31% if an individual relinquishes smoking (15.48 %) and alcohol consumption (15.15 %).

Controlling smoking and overweight or obesity, aerated drinks and overweight or obesity, and smoking and alcohol could reduce the onset of diabetes by 43.9%, 30.8%, and 31.3%, respectively. The study critically highlighted that the combination of risk factors matters when it comes to the onset of diabetes. The percentage of contribution towards the risk of diabetes was higher for combined factors of smoking and obesity. A study examining the combined effect of smoking and obesity on diabetes highlighted that there would be 2.84 times the relative excess risk of diabetes due to the additive interaction of smoking and obesity [43]. Smoking worsens the prognosis of patients with diabetes as evidence suggests that smoking increases insulin resistance, worsens diabetes control, and may further induce diabetes [44].

The risk of diabetes for any combination of three risk factors was significant, and the high prevalence of diabetes was associated with the combined effect of smoking, alcohol, and overweight or obesity. This study noted that 53 % of patients with diabetes might be eliminated if individuals quit smoking, alcohol and maintained healthy body weight. Bertoglia et al., in their study, noticed that a combination of smoking, alcohol, and obesity along with a sedentary lifestyle were risk factors for diabetes [45]. Utilizing PAF methodology, they found that obesity and smoking were the most significant risk factors after sedentary lifestyles causing diabetes, and together these three risk factors explained 82 % of the prevalence rate of diabetes [45]. Furthermore, exposure to all four risk factors increased the risk of diabetes by 1.60 times, i.e., 38 % of diabetes cases might be prevented if someone quit smoking, alcohol, and aerated drinks along with control body weight.

From the given four sets of risk factors in the study, any combination of three risk factors leads to a higher risk of hypertension.

The risk of hypertension was higher for the combination of smoking, alcohol, and overweight or obesity, followed by alcohol, aerated drinks, and overweight or obesity. Previous studies highlighted a higher risk of hypertension among those who smoke and consume alcohol and aerated drinks along with having obesity [46,47]. Obesity leads to a rise in body weight, promoting cardiac output and peripheral resistance of arterioles, leading to hypertension [48]. Furthermore, rapid urbanization leads to change in dietary habits and reduced physical activity; these two factors are further linked to increased risk of obesity, resulting in hypertension [49].

Denouncing all four risk factors (alcohol, smoking, obesity, and aerated drinks) would reduce the chances of hypertension by almost 50%, as outlined in the study. Smoking can give rise to blood viscosity, further stimulating the adrenergic nervous system and contributing to hypertension development [46]. Several studies indicated that increased nicotine levels might increase nervous system activities and release epinephrine and vasopressin hormones, which could be attributed to the higher risk of hypertension [50].

7. Limitations and strengths of the study

This study has some noteworthy limitations. The data on alcohol and smoking are self-reported and, therefore, could be affected by social desirability. Furthermore, the cross-sectional nature of the data did not allow us to examine the causality. Despite the above limitations, the study has potential strengths too. The information regarding hypertension and diabetes was diagnosed, thereby providing an actual prevalence of the disease.

8. Conclusion

This study employed the PAF approach to examine the effects of risk factor combinations for hypertension and diabetes by considering the four modifiable risk factors: smoking, alcohol, aerated drinks, and obesity. The study is critical in presenting the risk of hypertension and diabetes by various combinations of risk factors. Overweight or obesity was the single most significant factor leading to hypertension and diabetes among the study population. The study found that denouncing all four risk factors together would decline the risk of hypertension by 50% and that of diabetes by 38%. Also, smoking, alcohol, and obesity together is a prominent risk factor for hypertension and diabetes. Smoking and alcohol cessation programs could help in mitigating the risk of hypertension and diabetes. The focus should be on curbing the onset of obesity, and for this, policy-makers shall target various measures to improve physical activity and dietary patterns among the population. It is suggested to promote the importance of physical activity and healthy dietary patterns through various mass-media channels.

Declaration of competing interest

No conflict of interest to declare related to this publication.

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Appendix A. Supplementary data

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Author contributions

Conceptualization: SPM, HL; Data curation: SPM; Formal analysis: SPM; Investigation: SPM HL; Methodology: SPM; Supervision: HL; Writing original draft: SPM, SC, SS; Witting review and editing: SPM, HL, SC, SS. All authors reviewed and approved the final version for submission.

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