Clustering of metabolic and behavioural risk factors for cardiovascular diseases among the adult population in South and Southeast Asia: findings from WHO STEPS data

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Summary

Background The aim of this study is to assess the current status of metabolic and behavioural risk factors for cardiovascular diseases among the adult population in South and Southeast Asia using World Health Organization (WHO) STEPS data.

Methods We used WHO STEPS surveys data in ten South and Southeast Asian countries. Weighted mean estimates of prevalence of five metabolic risk factors and four behavioural risk factors were calculated by country and overall region. We used random-effects meta-analysis to generate country and regional pooled estimates of metabolic and behavioural risk factors, using the DerSimonian and Laird inverse-variance method.

Finding Around 48,434 participants aged 18–69 years were included in this study. Overall 32.00% (95% CI: 31.15–32.36) of individuals in the pooled sample had one metabolic risk factor, 22.10% (95% CI: 21.73–22.47) had two, and 12.38% had three or more (95% CI: 9.09–14.00). Twenty-four percent (95% CI: 20.00–29.00) of individuals in the pooled sample had only one behavioural risk factor, 49.00% (95% CI: 42.00–56.00) had two, and 22.00% had three or more (95% CI: 16.00–29.00). Risk of high three or more metabolic risk factors was higher among women, those of older age, and those with a higher education.

Interpretation The existence of multiple metabolic and behavioural risk factors among the South and Southeast Asian population demand appropriate prevention strategies to halt the progress of non-communicable disease burden within the region.

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Keywords: CVD; NCDs; Southeast Asia

Introduction

The general assembly of the United Nations, under the Sustainable Development Goals (SDG-3.4), set a target to reduce premature mortality from non-communicable diseases by a third by 2030.[1] In 2018, the third UN High-Level Meeting expanded the non-communicable disease (NCD) agenda from four to five leading causes of death (cardiovascular diseases, cancer, respiratory diseases, diabetes and mental disorders), and from four to five main risk factors (air pollution, tobacco use, harmful use of alcohol, unhealthy diets and physical inactivity) (5 × 5 Agenda). It is estimated that 80% of NCDs are preventable because the majority of NCDs are driven by

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Research in context

Evidence before this study

We systematically searched (TB and RDG) PubMed, EMBASE, CINHAL with a combination of MeSH heading terms and keywords. The key words used in the search ("health behaviors" OR "metabolic risk factors" OR "diabetes" OR "type 2 diabetes" OR "hypertension" OR "cholesterol" OR "overweight" OR "obesity" OR "body mass index" OR "BMI" OR "central obesity" OR "lifestyle risk behaviors" OR "health risk behaviors" OR "tobacco" OR smok* OR "alcohol" OR "physical activity" OR "physical inactivity" OR "overweight" OR "obesity" OR "fruit intake" OR "vegetable intake" OR "diet") and ("adult" OR and ("Bangladesh" OR "Bhutan" OR "Cambodia" OR "Lao People's Democratic Republic" OR "Myanmar" OR "Nepal" OR "Pakistan" OR "Sri Lanka" OR "Timor-Leste" OR "Viet Nam"). If TB and RDG did not reach agreement, the small group (AAM, TB, RDG NT, LBL and AG) discussed discrepancies to reach a consensus. We did not find any comparative study clustering of metabolic and behavioural risk factors among adult population in South and Southeast.

Added value of this study

To the best of our knowledge, this is the first study to estimate comprehensively the population level clustering of metabolic and behavioural risk factors among adult populations in ten South and Southeast Asian countries. We used latest data from the World Health Organization (WHO) STEPwise approach to surveillance (STEPS) surveys, for those aged 18–69 years, to show the geographic variation in prevalence of clustering of metabolic and behavioural risk factors in ten countries.

Implications of all the available evidence

This study suggests that a large proportion of adults in all countries are exposed to clustering of metabolic and behavioural risk factors, though there is large variation in prevalence. More than 10% of the adult population had three or more metabolic risk factors and more than 20% had three or more behavioural risk factors. In all countries, insufficient fruits/vegetable consumption and physical inactivity were the two most common behavioural risk factors.

behavioural risk factors.[2] Of the five main NCDs, cardiovascular diseases (CVD) including coronary heart disease and stroke, kill more people globally that any other diseases. CVDs are responsible for an estimated 17.8 million deaths globally, of which 10.8 million occur within Asia.[3]

Asia is the most populous continent, accounting for close to 60% of the world population, with more than 655 million (around 8.5% of the world's population) residing in South and Southeast Asia.[4] Due to this large population along with diversity of ethnicities, cultures, socioeconomic status, diversity of food and health care systems, South and Southeast Asian countries are facing many challenges in CVD prevention.[3] A recent review reported that many South and South Asian countries including India, Nepal and Pakistan are in the early stages of 'CVD epidemics'. Within most of these countries a high proportion of CVD deaths are considered premature; whilst deaths due to communicable, maternal, neonatal, and nutritional diseases (CMNND) remain high. This means that many of South and Southeast Asian countries face a challenge of a double burden of CVD and CMNND.[3]

There are a number of established risk factors for CVD, that are both metabolic (diabetes, hypertension, total cholesterol, BMI and central obesity) and behavioural risk factors (insufficient fruits and vegetable consumption, sugar, salt and fat consumption, smoking, alcohol consumption, physical inactivity). A pooled analysis of prospective data from the Asian Cohort Consortium reported that BMI had a U-shaped association with the risks of CVD death,[5] demonstrating that both underweight and overweight/obesity are associated with increased CVD risk. In addition, hypertension is prevalent in many South and Southeast Asian countries because of the low awareness, detection, treatment, management and control rates.[6] According to the NCD Risk Factor Collaboration (NCD-RisC) report, many South and Southeast Asian countries, including Indonesia, Thailand, Malaysia, and Cambodia have experienced consistent increases in levels of total cholesterol.[6] A recent global burden study found that there were large gaps between current and optimal intake levels for 10 healthy foods, 5 unhealthy foods and nutrients in the region, which have a great impact on CVD mortality and morbidity. A recent study by Vajdi, M., et al. reported that 53% of deaths in adults are due to unhealthy lifestyles.[7]

A study by Kontis et al. in 2014 reported that reducing the prevalence of behavioural risk factors including smoking and the harmful use of alcohol can be key in reducing the mortality due to CVD.[8] Timely intervention, through lifestyle modification can delay the progression of CVD risk.[9] To combat the burden of CVD, as well as other NCDs, many South and Southeast Asian countries have taken a number of initiatives including implementing World Health Organization Package of Essential Noncommunicable Disease Interventions (WHO PEN),[10] five technical packages of evidence-based interventions in primary health care setting.[11] Despite all these initiatives many South and Southeast Asian countries still face the burden of CVD because of a lack of screening and routine national surveillance, cost-effective interventions and proper policy implications.[12] A recent study reported that there is less implementation of NCD policies in low-income countries.[13]

The challenges of identifying the high-risk within populations especially in settings with low work force and inadequate access to health services.[14,15] Recent studies emphasise the clustering of multiple risk factors rather than single risk factor as multiple clustering of risk factors is associated with a higher risk of CVD. In South and Southeast Asian countries prevalence and determinates of individual CVDs and risk factors has been well reported. However, little effort has been made to study the clustering of metabolic and behavioural risk factors for CVD, despite them being important in the targeting, prevention, and management of CVD at an early stage. This study aims: 1) to determine the prevalence of metabolic and behavioural risk factors of CVD in South and Southeast Asian countries with a particular focus on the clustering of these risk factors, 2) to assess factors associated with clustering of metabolic and behavioural risk factors in South and Southeast Asin counties.

Methods

Study design, setting and sampling

This study utilized World Health Organization (WHO) STEPwise approach to surveillance (STEPS) survey data in South and Southeast Asian countries. These surveys were nationally representative and conducted between 2010 and 2019 in ten South and Southeast Asian countries namely Bangladesh, Bhutan, Cambodia, Lao People's Democratic Republic, Myanmar, Nepal, Pakistan, Sri Lanka, Timor-Leste and Viet Nam. The survey included adults aged 18–69 years and employed a two-stage, stratified probability-based sampling technique for data collection.[16] The detailed methodology, sample size calculation and sample collection procedure are available elsewhere.[11]

Study variables

The outcome variable of this study is the clustering of metabolic and behavioural risk factors of CVD. The metabolic risk factors that were included were diabetes, hypertension, total cholesterol, overweight/obesity and central obesity. The behavioural risk factors were smoking, current alcohol intake, insufficient fruits and vegetable intake, and low physical activity. The following sociodemographic variables were included: age in years, gender, education. The detailed Definitions of the study variables are given in Table 1.

Statistical analysis

Prevalence of individual risk factors were calculated through weighting collected data to ensure samples were representative of the adult population of the country they were collected in. This involved using strata and primary sampling units at the country level. Weighted mean prevalence with corresponding 95% CIs were then reported by country and sex. The overall pooled estimate of metabolic and behavioural risk factors was generated for individual countries to allow cross-country comparisons. Pooled prevalence by region, with associated 95% confidence intervals (CI), were also presented. Heterogeneity was examined using the I^2-statistic and a high level of inconsistency (I^2 > 50%) warranted the use of a random effect assumption in analysis. Metabolic and behavioural risk factors were categorized into four groups: 1) No risk factors; 2) 1 risk factor; 3) 2 risk factors; 4) ≥3 risk factors. Logistic regression was used to assess the association between individual level sociodemographic factors with the presence of one or more NCD risk factors in an individual. Stata Version 16 was used for statistical analysis. We only consider complete cases.

Ethical considerations

STEPS received ethical approval from country specific ethics review boards. Written informed consent was taken from the participants before data collection.[21] We obtained permission to use the dataset from the NCD Microdata Repository of WHO in January 2021. We used de-identified data, so this study was exempted from review by the institutions' Institutional Review Board.

Results

We included data from 10 countries, including 48,434 participants aged 18–69 years. Of these ten countries, 13.98% of participants in the pooled data were from Bangladesh, 11.13% from Bhutan, 10.40% from Cambodia, 4.98% from Lao People's Democratic Republic, 15.97% from Myanmar, 10.51% from Nepal, 13.58% from Pakistan, 8.75% from Sri Lanka, 4.46% from Timor-Leste and 6.25% from Viet Nam. More than half (61%) of the total sample were female (n = 28,742), compared to 18,256 (39%) males (Table 2).

Metabolic risk factors

More than thirty percent (32.00%, 95% CI: 31.15–32.36) of individuals in the pooled sample had only one metabolic risk factor, 22.10% (95% CI: 21.73–22.47) had two, and 12.38% had three or more (95% CI: 9.09–14.00) (Fig. 1). The prevalence of three or more risk factors ranged from 5.96% (95% CI: 5.34–6.65%) in Cambodia to 17.50% (95% CI: 16.50–18.53%) in Bhutan. Out of ten countries only three countries (30%) had a prevalence of three or more risk factors <10% and seven countries (70%) had a prevalence between 10 and 20%. The prevalence of two risk factors ranged from 13.14% (95% CI: 12.23–14.10%) in Cambodia to 31.80% (95% CI: 30.57–33.05%) in Bhutan. In four countries (40%) the prevalence of two risk factors was between 10 and 20%, in five countries (50%) the prevalence was between 20 and 30% and in Bhutan the prevalence was

Variable	Definition
Demographic variables	
Age (in years)	Participant's age in years (0 = 18–29; 1 = 30–49; 2 = 50–69).
Gender	Participant's gender (0 = male; 1 = female).
Education	Participant's highest educational attainment (0 = No formal schooling; 1 = Up to primary; 2 = Up to secondary; 3 = College and higher).
Metabolic risk factors	
Hypertension	Blood Pressure (BP): ≥130 mmHg systolic or ≥85 mmHg diastolic or currently taking antihypertensive medication.[17]
Diabetes	Fasting Blood Glucose (FBG): ≥100 mg/dl or currently taking medication.[17]
Total cholesterol	Serum Triglycerides: ≥150 mg/dl or currently taking medication.[18]
Central obesity	Whether the participant has an abnormal waist-hip ratio. An abnormal waist-hip ratio was defined as >0.90 for males and >0.85 for females.[18]
Overweight/obesity	BMI was calculated as weight (kg)/height (m^2).BMI was categorized according to Asia-specific cut-off [0 = Normal and underweight (BMI <23.0 kg/m^2), 1 = overweight (BMI between 23.0 kg/m^2 and <27.5 kg/m^2) and 2 = obesity (BMI ≥27.5 kg/m^2)].[19]
Behavioural risk factors	
Current Smoking	Current smoking status of participants (No; Yes). Current smoking was defined as smoking in the previous 30 days of the survey.[18]
Current alcohol intake	Current alcohol intake status of participants (No; Yes). Current alcohol intake was defined as intake in the previous 30 days of the survey.[18]
Insufficient fruit and vegetable intake	Whether the participant is taking insufficient fruit and vegetable (No; Yes). Inadequate fruits and vegetables were defined as intake less than 5 servings a day.[18]
Low physical activity	Whether the participants' physical activity is lower than the recommended amount (No; Yes). Adequate physical activity was defined as participating in at least 150 min of moderate-intensity aerobic physical activity per week or at least 75 min of vigorous-intensity aerobic physical activity per week.[20]

Table 1: **List of study variables.**

more than 30%. The prevalence of only one risk factor ranged from 26.97% (95% CI: 25.80–28.17%) in Bhutan to 47.08% (95% CI: 44.98–49.19%) in Timor-Leste (Fig. 1). Out of ten countries five countries (50%) had a prevalence of one risk factor >30%, in five countries (50%) the prevalence was between 10 and 20% (Fig. 2).

We also found variation in the prevalence of metabolic risk factors. The highest pooled prevalence for one metabolic risk factors was central obesity (51.57%; 95% CI: 43.10–59.03%). This ranged from 37.04% (95% CI: 35.71–38.38%) in Cambodia to 61.38% (95% CI: 60.20–62.55%) in Pakistan. The second highest pooled prevalence was overweight/obesity by BMI (27.88%; 95% CI: 21.47–34.29%), ranging from 17.47% (95% CI: 16.44–18.54%) in Cambodia to 39.60% (95% CI: 38.43–40.79%) in Pakistan. The pooled prevalence of hypertension was 25.18% (95% CI: 21.05–30.29%) with this lowest in Cambodia (13.89%; 95% CI: 12.97–14.88%) and highest in Pakistan (37.81%; 95% CI: 36.64–38.99%). This was higher than the pooled prevalence of cholesterol (8.86%; 95% CI: 4.59–12.13%) which ranged from 4.23% (95% CI: 3.71–4.82%) in Cambodia to 26.59% (95% CI: 22.73–30.86%) in Pakistan. Whilst the least prevalent metabolic risk factor was diabetes (5.50%; 95% CI: 3.27–7.74%) ranging from 2.56% (95% CI: 2.16–3.03%) in Cambodia to 15.61% (95% CI: 11.51–20.84%) in Pakistan.

Hypertension and central obesity were top two most prevalent risk factors in Bangladesh, Bhutan, Myanmar, Nepal and Cambodia. In Vietnam and Pakistan, hypertension and total cholesterol were the two most prevalent risk factors (Table 3). In Timor-Leste, hypertension and diabetes most two prevalent risk factors. Total

Country	Survey year	Unweighted Sample	Male	Female	Mean age (±SD)
Bangladesh	2018	6770	3185	3585	39.54 (0.14)
Bhutan	2019	5392	2108	3284	39.97 (0.18)
Cambodia	2010	5038	1794	3244	43.34 (0.15)
Lao People's Democratic Republic	2013	2410	969	1441	39.12 (0.25)
Myanmar	2014	7735	2699	5036	45.12 (0.122)
Nepal	2019	5089	1816	3273	40.17 (0.19)
Pakistan	2013	6575	2944	3631	36.5 (0.16)
Sri Lanka	2014	4237	1624	2613	44.35 (0.20)
Timor-Leste	2014	2161	903	1258	41.2 (0.30)
Viet Nam	2015	3027	1315	1712	43.8 (0.23)

Table 2: **Demographic characteristic of the study population.**

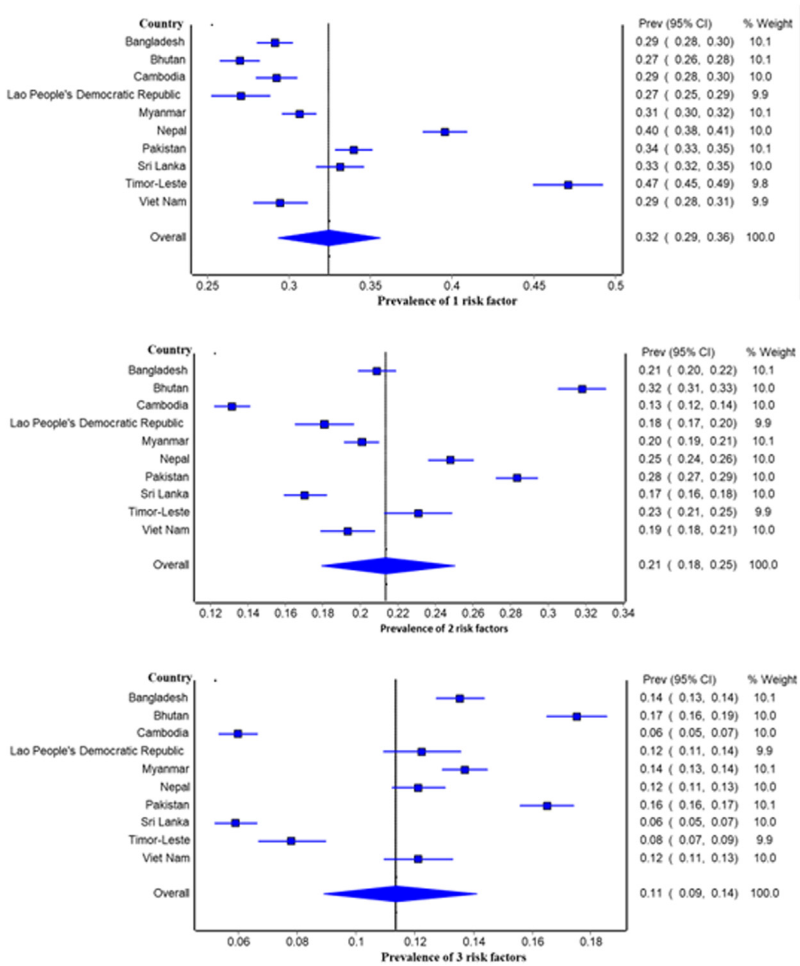

Fig. 1: **Clustering of metabolic risk factors among the adult population on South and Southeast Asian countries.**

cholesterol and overweight/obesity most the two prevalent risk factors in Lao People's Democratic Republic. In Sri Lanka, hypertension and diabetes were the two most prevalent risk factors (Table 3).

Behavioural risk factors

More than twenty percent (24.00%, 95% CI: 20.00–29.00) of individuals in the pooled sample had only one behavioural risk factor, 49.00% (95% CI: 42.00–56.00) had two, and 22.00% had three or more (95% CI: 16.00–29.00) (Fig. 3). The prevalence of three or more risk factors ranged from 13.00% (95% CI: 12.00–14.00%) in Sri Lanka to 51.00% (95% CI: 49.00–53.00%) in Lao People's Democratic Republic. Out of ten countries four countries (40%) had a prevalence of three or more risk factors between 20 and 30%, three countries (30%) had a prevalence between 10 and 20% and seven countries (70%) had a prevalence between 10 and 20%. In two countries the prevalence was >30% and in one country the prevalence was <10%. The prevalence of two risk factors ranged from 13.14% (95% CI: 12.23–14.10%) in Cambodia to 31.80% (95% CI: 30.57–33.05%) in Bhutan with a prevalence of two risk factors >30% in all countries. The prevalence of one risk factor ranged from 26.97% (95% CI: 25.80–28.17%) in Bhutan to 47.08% (95% CI: 44.98–49.19%) in Timor-Leste (Fig. 4). In six countries (60%) the prevalence of one risk factor was 20–30%, in two countries the prevalence was between 10 and 20% and in the remaining two countries prevalence was >30%. In all countries, insufficient fruits/vegetable consumption and physical inactivity were the two more common behavioural risk factors (Table 4).

According to pooled estimate, the risk of three or more metabolic risk factors was higher among women (OR: 1.57; 95% CI: 1.52–1.62), those of older age (OR: 3.43; 95% CI: 3.26–3.60), and those with a higher education (OR: 1.04; 95% CI: 1.01–1.23). On the other hand, for behavioural risk factors three or more metabolic risk factors was higher those of older age (OR: 1.19; 95% CI: 1.13–1.25).

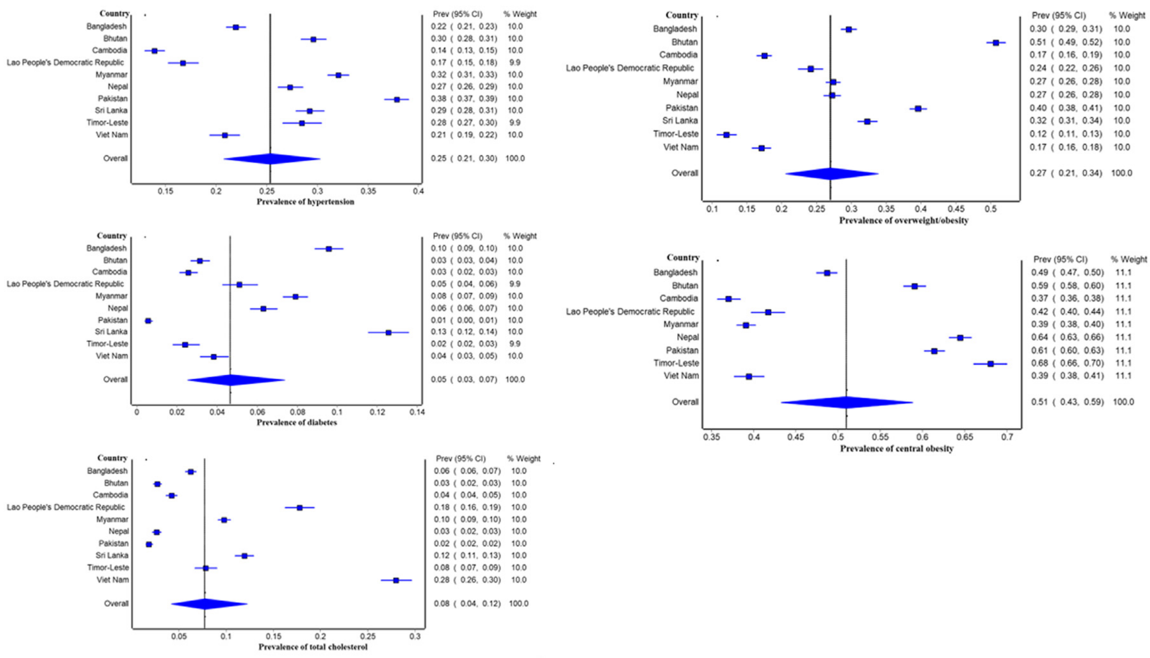

Fig. 2: Prevalence of individual metabolic risk factors among the adult population on South and Southeast Asian countries.

Discussion

This study provides contemporary evidence on the clustering of metabolic and behavioural risk factors for CVD in South and Southeast Asian countries. The overall findings from this study are consistent with global studies.[22] First, we found that more than ten percent of adults had three or more metabolic risk factors, and more than twenty percent of adults had three or more behavioural risk factors. Secondly, variation in prevalence of clustering of metabolic and behavioural risk factors was found between countries within the region. In all countries insufficient fruits and vegetable consumption and physical inactivity were two of the most common behavioural risk factors. We found

Country	Hypertension	Diabetes	Total cholesterol	Overweight/obesity	central obesity	1 risk factor	2 risk factors	≥3 risk factors
Bangladesh	21.95	9.57	6.25	29.6	48.66	29.12	20.87	13.53
Bhutan	29.62	3.13	2.73	50.74	59.05	26.97	31.8	17.5
Cambodia	13.89	2.56	4.23	17.47	37.04	29.22	13.14	5.96
Lao People's Democratic Republic	16.72	5.1	17.76	24.11	41.66	27.01	18.05	12.21
Myanmar	32.05	7.9	9.81	27.38	39.08	30.61	20.05	13.69
Nepal	27.29	6.31	2.65	27.24	64.43	39.54	24.8	12.1
Pakistan	37.81	15.61	26.59	39.6	61.38	33.95	28.32	16.48
Sri Lanka	29.24	12.53	11.92	32.71	NA	33.11	17.04	5.88
Timor-Leste	28.46	12.53	7.82	12.03	67.98	47.08	23.05	7.79
Viet Nam	20.81	3.83	27.98	17.08	39.44	29.44	19.3	12.1

Country	Insufficient fruits and vegetable consumtion	Physical ibactivity	Smoking	Alcohol	1 risk factor	2 risk factors	≥ 3 risk factors
Bangladesh	74.47	83.87	23.99	1.32	26.07	57.07	14.26
Bhutan	62.73	82.49	6.62	33.53	27.47	47.53	20.29
Cambodia	60.74	88.09	24.04	45.89	21.02	40.99	35.61
Lao People's Democratic Republic	88.05	79.54	28.8	57.76	10.33	37.59	50.95
Myanmar	74.09	93.02	22.51	2.25	21.82	59.56	16.86
Nepal	89.33	84.57	19	20.42	16.88	57.12	25.09
Pakistan	79.41	93.75	13.22	NA	21.1	68.06	9.72
Sri Lanka	51.1	92.45	12.16	15.55	40.17	43.99	13
Timor-Leste	64.65	81.07	31.48	16.34	26.84	44.84	23.42
Viet Nam	33.47	74.99	23.73	40.07	36.37	32.21	21.97

< 10%   10-20%   21-30%   > 30

Green colour shows prevalence less than 10%, blue colour shows prevalence 10-20%, pink colour show prevalenc 21-20% and red show the prevalence more than 30%.

Table 3: Burden of metabolic and behavioural risk factors among the adult population in South and Southeast Countries.

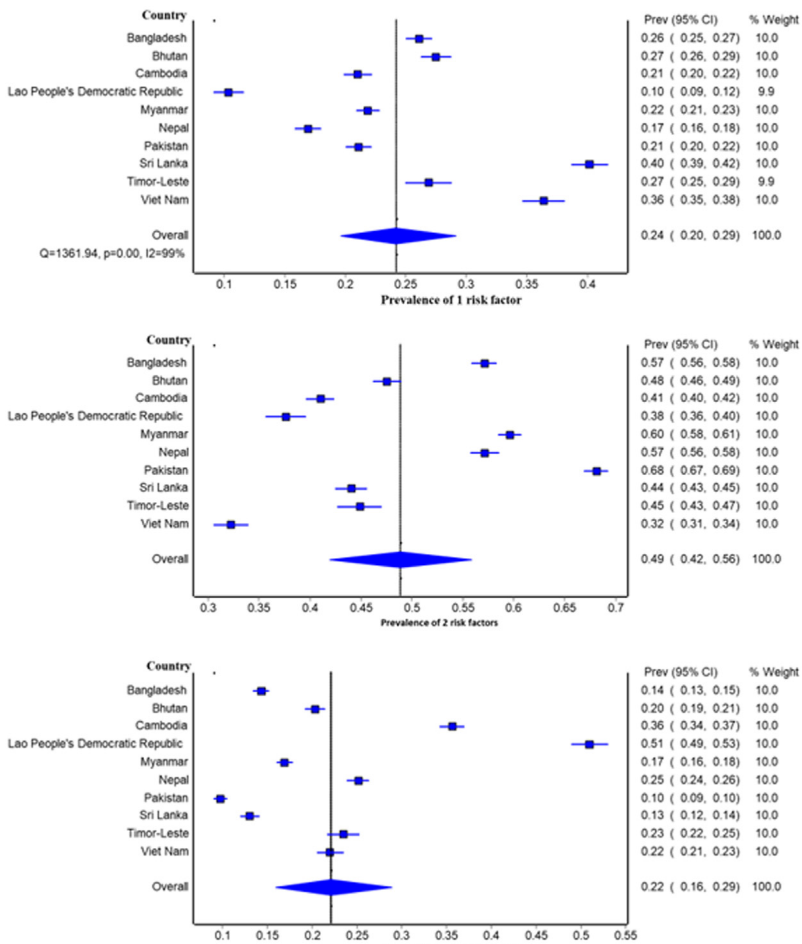

Fig. 3: Clustering of behavioural risk factors among the adult population on South and Southeast Asian countries.

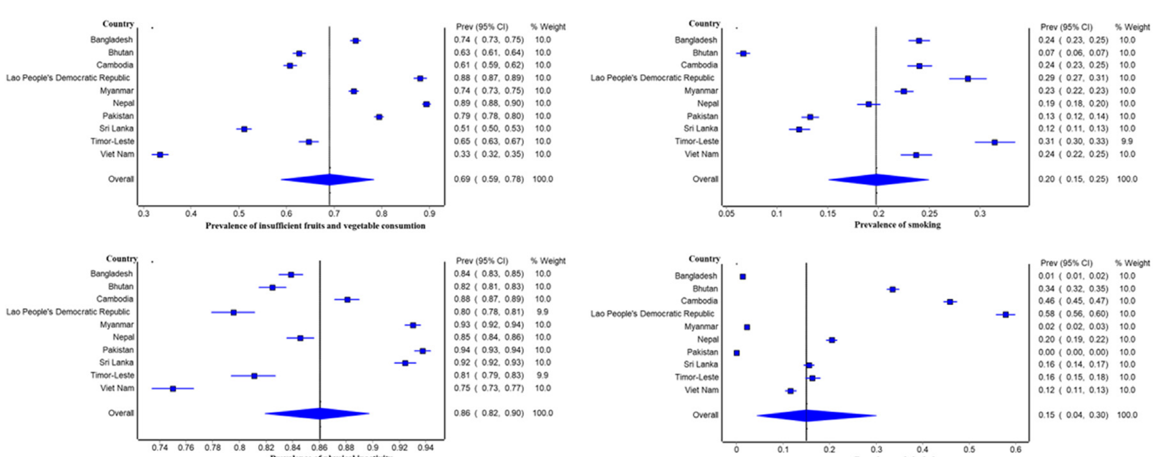

Fig. 4: Prevalence of individual behavioural risk factors among the adult population on South and Southeast Asian countries.

Country	Women	30–49 age	50–69 age	up to Primary	up to secondary	College and higher
	OR (95% CI)	OR (95% CI)	OR (95% CI)	OR (95% CI)	OR (95% CI)	OR (95% CI)
Metabolic risk factors*						
Bangladesh	1.59 (1.45–1.74)	3.12 (2.77–3.51)	4.56 (3.95–5.26)	0.99 (0.83–1.19)	1.12 (0.91–1.39)	2.09 (1.87–2.32)
Bhutan	1.5 (1.36–1.67)	3.27 (2.87–3.72)	4.7 (4–5.52)	1 (0.79–1.27)	1 (0.69–1.45)	1.08 (0.97–1.22)
Cambodia	1.19 (1.04–1.37)	3.71 (3.19–4.32)	5.01 (4.03–6.22)	0.94 (0.62–1.41)	0.92 (0.61–1.4)	1.1 (0.71–1.68)
Lao People's Democratic Republic	1.7 (1.55–1.86)	3.09 (2.79–3.43)	5.32 (4.65–6.08)	1.36 (1.2–1.54)	1.73 (1.47–2.02)	1.87 (1.67–2.1)
Myanmar	2.18 (1.93–2.45)	2.98 (2.47–3.6)	5.95 (4.87–7.26)	1.29 (1.11–1.5)	1.24 (1.02–1.51)	1.38 (1.2–1.59)
Nepal	3.28 (2.78–3.87)	2.68 (2.21–3.24)	6.97 (5.53–8.78)	1.63 (1.33–2.01)	2.4 (1.83–3.13)	2.92 (2.21–3.85)
Pakistan	2.02 (1.85–2.21)	2.84 (2.42–3.33)	5.9 (4.99–6.97)	1.17 (0.99–1.37)	1.21 (1.04–1.41)	1.68 (1.47–1.91)
Sri Lanka	3.21 (2.71–3.82)	2.38 (1.94–2.92)	3.59 (2.79–4.61)	1.42 (1–2.01)	1.14 (0.73–1.79)	1.63 (1.34–1.98)
Timor-Leste	1.47 (1.31–1.66)	3.05 (2.52–3.7)	7.43 (6.08–9.08)	0.91 (0.61–1.36)	1.26 (0.81–1.98)	1.4 (1.06–1.85)
Viet Nam	1.48 (1.29–1.69)	2.69 (2.17–3.32)	7.93 (6.34–9.93)	1.44 (1.02–2.05)	1.31 (0.85–2.01)	1.22 (0.94–1.6)
Overall	1.57 (1.52–1.62)	2.13 (2.04–2.22)	3.43 (3.26–3.6)	0.98 (0.92–1.03)	1.00 (1.00–1.06)	1.04 (1.01–1.23)
Behavioural risk factors						
Bangladesh	0.33 (0.3–0.37)	1.22 (1.09–1.38)	1.48 (1.27–1.71)	0.95 (0.78–1.15)	0.84 (0.67–1.05)	0.64 (0.57–0.71)
Bhutan	0.72 (0.65–0.8)	1.15 (1.01–1.31)	1.22 (1.04–1.44)	0.86 (0.67–1.09)	0.84 (0.57–1.23)	0.89 (0.79–1)
Cambodia	0.29 (0.25–0.34)	1.48 (1.26–1.73)	1.47 (1.17–1.85)	0.78 (0.49–1.22)	0.58 (0.36–0.91)	0.34 (0.21–0.55)
Lao People's Democratic Republic	0.55 (0.49–0.61)	1.39 (1.23–1.56)	2.03 (1.74–2.37)	0.89 (0.77–1.03)	0.73 (0.6–0.87)	0.55 (0.48–0.62)
Myanmar	0.17 (0.15–0.19)	1.21 (1.03–1.41)	0.79 (0.67–0.94)	0.78 (0.67–0.9)	0.69 (0.57–0.83)	0.52 (0.45–0.59)
Nepal	0.21 (0.18–0.26)	1.43 (1.18–1.74)	1.03 (0.82–1.29)	1.32 (1.07–1.63)	1.1 (0.83–1.46)	0.92 (0.69–1.23)
Pakistan	0.43 (0.39–0.48)	1.38 (1.18–1.61)	1.75 (1.49–2.05)	0.75 (0.63–0.9)	0.68 (0.58–0.81)	0.47 (0.41–0.55)
Sri Lanka	0.17 (0.14–0.2)	1.05 (0.86–1.29)	0.67 (0.52–0.86)	0.85 (0.6–1.21)	0.66 (0.42–1.03)	0.4 (0.33–0.49)
Timor-Leste	0.24 (0.21–0.27)	1.27 (1.07–1.51)	1.25 (1.05–1.5)	1.87 (1.26–2.78)	1.71 (1.09–2.7)	0.77 (0.59–1.02)
Viet Nam	0.07 (0.06–0.08)	1.14 (0.94–1.39)	0.81 (0.66–1)	0.69 (0.48–0.99)	0.97 (0.62–1.51)	0.33 (0.25–0.43)
Overall	0.32 (0.31–0.34)	1.24 (1.19–1.3)	1.19 (1.13–1.25)	1.24 (1.18–1.32)	0.97 (0.91–1.03)	0.56 (0.53–0.58)

*Men, 18–29 age and No Formal Schooling reference group.

Table 4: **Factors associated with multiple ("≥3 risk factors) metabolic and behavioural risk factors in South and Southeast Asian countries.**

that overweight/obesity and central obesity were the most common metabolic risk factors in South and Southeast Asian countries. Conversely, the risk of three or more metabolic risk factors was higher among women whilst the prevalence behavioural risk factors was higher among men.

The GBD (Global Burden of Disease) Obesity Collaborators reported that overweight/obesity is increasing in almost all countries, which will ultimately increase the risk of CVD, even after accounting for smoking and ill health.[23] We also found that hypertension was the third most prevalent metabolic risk factors in South and Southeast Asian countries. In many South and Southeast Asian countries uncontrolled high blood pressure remains untreated because of low awareness, screening and weak health systems.[24] An recent study by NCD-RisC team reported that hypertension control rates were below 10% in South and Southeast Asian countries and improvement in the control of high blood pressure has mainly been found in high income countries.[6] Even though hypertension can be easily detected through measuring blood pressure, at home or in a health centre, and can generally be treated effectively with medications that are largely considered low cost and widely available, less than half of adults with hypertension are diagnosed and treated, with even fewer - only around two in ten people - having it under control. This reveals several gaps in the treatment cascade for hypertension including awareness, diagnosis, treatment and control, all of which could prevent millions of avoidable NCD deaths.[25] In our study we also found that diabetes prevalence was more than 10% in around forty percent of South and Southeast Asian countries. According to a 2019 estimate, about 463 million adults were affected by T2DM globally, with many cases reported in South and Southeast Asia. This is of concern, as individuals with diabetes have a 2–3 fold increased risk of CVD and diabetes is the second biggest negative total effect on reducing global health adjusted life expectancy worldwide.[26]

We found that insufficient fruits and vegetable consumption and physical inactivity were the two most common behavioural risk factors. A systematic review and meta-analysis by Wang X et al. reported that the average reduction of mortality risk was 5% for each additional serving of fruits and vegetables per day.[27] Another recent multicounty cohort study reported that fruit intake was associated with lower risk of CVD and raw vegetable intake was strongly associated with a lower risk of total mortality.[28] Physical activity is strongly associated with CVD and other NCDs, encouraging WHO member states to agree to a 10% relative reduction in the prevalence of insufficient physical activity by 2025.[29] In our study we found that in all countries physical inactivity prevalence was greater than seventy percent. A recent global study analyzing 1.9 million participants reported that physical inactivity was increasing in South and Southeast Asian countries.[30] We also found that the prevalence of smoking was more than ten percent in all South and Southeast Asian countries except Bhutan. A recent GBD study by the 2019 Tobacco Collaborators reported that Ischaemic heart disease was the leading cause of deaths attributable to tobacco use in South and Southeast Asia.[2]

It is recommended that countries implement prevention approaches that target multiple risk factors, to tackle clustering and a number of individual risk factors, such approaches have been found to have a great impact at a lower cost than approaches that focus on individual risk factors. Although global leaders committed to reducing premature NCD mortality by a third, supported by WHO identification of a number of highly cost-effective NCD policy options, termed 'best buys' evidence for implementation and effectiveness of these best buys in LMICs is scarce. Leading to recommendations to implement and evaluate 'best buys' in national contexts, based on national priorities, within LMICs.[3] In addition WHO proposed a technical package for cardiovascular disease management in primary health care.[3] But a recent study also reported that NCD related policy implementation is decreasing over time. For example, Bhutan, Sri Lanka and Vietnam fully had set time-bound national targets based on WHO guidance. Bangladesh implemented 75% NCD policy/targets, Nepal and Timor-Leste implemented 50% NCD policy/targets, Cambodia and Lao People's Democratic Republic implemented 25% NCD policy/targets. But Myanmar and Pakistan had not implemented NCD policy/targets.[4]

In our study we found that women had a higher risk of clustering metabolic risk factors than men. This aligns with the recent Lancet women and cardiovascular disease Commission that reported that CVD is the leading cause of death in women. On the other hand, men had a higher risk than women for clustering of behavioural risk factors. In South and Southeast Asian country context behavioural risk factors smoking, alcohol, physical activity are more prevalent among males compared to female.[4] According to a recent study, tobacco related policy implementation was highest in Bangladesh (75%) and lowest in Nepal (0%). Alcohol related policy showed the highest level of implementation in Bangladesh (66.7%), Bhutan (66.7%) and Vietnam (66.7%) and the lowest in Lao People's Democratic Republic (16.7%) and Nepal (16.7%). Four countries namely Bangladesh, Bhutan, Lao People's Democratic Republic and Pakistan had no implementation of Physical activity less policy. Unhealthy diet reduction policy also less implemented in all ten countries.[13]

The study has several notable strengths and limitation. First, the findings are generalizable to the target population due to the utilization of a nationally representative sample. All data were cross-sectional in nature and collected from countries in various years, which limits our ability to make comparisons between countries. This highlights the need for consistent and regular data collection in all countries, in order to measure the progress of NCDs. Second, STEPS utilized a validated questionnaire and calibrated instruments for data collection, limiting the possibility of measurement error. Thirdly, heterogeneity was found in both the years of available data between countries and in the sample characteristics, we used random effects models to minimize bias. In addition, some bias may have been introduced during data collection for individual risk factors, for example diabetes was assessed using fasting blood glucose sample despite HbA1c being more accurate. For alcohol intake, data were not collected regarding the amount of alcohol the person drink. However, questions between surveys were consistent. All biochemical and anthropometric measurements were collected by trained staff following standardized procedures, ensuring none were self-reported, thereby avoiding bias in the outcome measures. Finally, due to the absence of information on wealth index/household income, we could not explore the effect of economic status on metabolic and behavioural risk factors.

Clustering of behavioural and metabolic risk factors was high among adults in South and Southeast Asia. Targeted interventions should be initiated and strengthened in order to influence long terms positive life-style changes. The findings of this study will give direction for intervention and policy implications.

Contributors

TB - conceptualisation of the study. TB, NT and AM - data curation and drafted the manuscript. TB and RDG - formal analysis. TB, NT, RDG, AG, LBR, KM and AM - interpreted the results, provided inputs on the original draft, critical review and editing. All authors approved the final version of the manuscript.

Data sharing statement

The analysis dataset for this specific manuscript available from the corresponding author upon request.

Declaration of interests

All authors declare no competing interests.

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