BMJ Open

High socioeconomic status associated with greater prevalence of NCD risk factors and co-morbidities in Bangladesh. Findings from a nationwide survey

Journal:	*BMJ Open*
Manuscript ID	bmjopen-2018-025538
Article Type:	Research
Date Submitted by the Author:	23-Aug-2018
Complete List of Authors:	Biswas, Tuhin; International Centre for Diarrhoeal Disease Research Bangladesh, Townsend, Nick Islam, Md.saimul; University of Rajshahi, Departmnet of Statistics; Islam, Md. Rajibul ; Health Intervention and Technology Assessment Program (HITAP),Ministry of Public Health, Nonthaburi, Thailand Das Gupta, Rajat; BRAC University James P Grant School of Public Health, Das, Sumon Mamun, Abdullah; University of Queensland, School of Population Health
Keywords:	Health services research < Health policies and all other topics, DIABETES & ENDOCRINOLOGY, Hypertension < CARDIOLOGY, obesity

Title: High socioeconomic status associated with greater prevalence of NCD risk factors and co-morbidities in Bangladesh. Findings from a nationwide survey

Authors:

Tuhin Biswas[1,2]*, Nick Townsend[3], Md. Saimul Islam[4],Md. Rajibul Islam[5], Rajat Das Gupta[6], Sumon Kumar Das[2], Abdullah Al Mamun[2]

Affiliations:

[1] Health Systems and Population Studies Division, icddr,b, Mohakhali, Dhaka, Bangladesh

[2]Institute for Social Science Research, The University of Queensland, Long Pocket Precinct, Indooroopilly, Queensland, Australia.

[3] Centre on Population Approaches for Non-Communicable Disease Prevention, Nuffield Department of Population Health, University of Oxford, Old Road Campus, Headington Oxford, OX3 7LF, England.

[4] University Rajshahi, Rajshahi, Bangladesh.

[5] Health Intervention and Technology Assessment Program (HITAP),Ministry of Public Health, Nonthaburi, Thailand.

[6] BRAC James P Grant School of Public Health, BRAC University, Mohakhali, Dhaka, Bangladesh.

***Corresponding author:**

Tuhin Biswas

Health Systems and Population Studies Division, icddr,b, Mohakhali, Dhaka, Bangladesh; Institute for Social Science Research, The University of Queensland, Long Pocket Precinct, Indooroopilly, Queensland, Australia.

Email: tuhin_sps04@yahoo.com, t.biswas@uqconnect.edu.au

ABSTRACT

Objectives: This study aimed to find out prevalence and distribution patterns of co-morbidity of non-communicable diseases (NCD) among the adult population in Bangladesh by measures of socio-economic status..

Design: This was a cross-sectional study.

Setting: This study used Bangladesh Demographic and Health Survey (2011) data.

Participants: Total 8,763 individual aged ≥35 years were included.

Primary and secondary outcome measures: The primary outcome was diabetes (DM), hypertension (HTN) and overweight/obesity. The study further assesses factors associated with co-morbidities, in particular socio-economic status.

Results: Of 8,763 adults**,** 12% had diabetes (DM), 27% hypertension (HTN) and 22%were overweight (BMI≥23kg/m^2). Just over 1% of the sample had all three conditions, 3% had both DM and HTN, 3% DM and overweight and 7% HTN and overweight. Diabetes, hypertension

and overweight was more prevalent amongst those who had higher education, were non-manual workers, were in the richer to richest socioeconomic status and lived in urban settings. Individuals in higher socio-economic status groups were also more likely to suffer from co-morbidity.

Conclusions: In contrast to more affluent countries, individual NCD risk factors and co-morbidities are more common in higher socio-economic status individuals. Public health approaches must consider this social patterning in tacking NCDs in the country.

Key words: Obesity, Overweight, Noncommunicable Disease, Bangladesh

STRENGTHS AND LIMITATIONS OF THE STUDY

- The biggest strength of the study is that it utilized validated measures to collect of socio-economic status and biomarker.
- The weakness of the study is the cross-sectional nature meaning that only associations can be inferred and causality cannot be determined.
- the study was representative only for the participants aged 35 years or older.

INTRODUCTION

According to the Global Burden of Disease report, Non-communicable diseases (NCDs) are the leading cause of death[1-3] with 80% of NCD mortality occurring in low- and middle-income countries (LMICs).[4-6]. The NCDs global status report (2014) showed that of 58 million deaths that occurred globally in 2012, 38 million - almost two thirds - were due to NCDs, comprising mainly cardiovascular diseases, cancers, diabetes and chronic lung diseases.[7] More than 40% of these deaths (16 million) were in individuals under the age of 70 years, often referred to as premature deaths. Deaths at these younger ages may be a greater demonstration of its burden, as many consider them preventable. It is alarming, therefore, that the majority of premature deaths (82%) occur in LMICs, with this problem likely to increase if the appropriate interventions are not implemented.

Like many LMICs, Bangladesh is undergoing rapid urbanization and changing patterns of diseases among the population [8, 9] with some suggesting the country is at an advanced phase of the third stage of the epidemiologic transition, with deaths from NCDs expected to increase very rapidly.[10] This increasing mortality from NCDs in the country is supported by high prevalence of the medical risk factors associated with NCDs. A recent WHO STEPS survey in Bangladesh reporting that 21% of the population had hypertension, 26% were overweight and 5% had documented diabetes.[11]

Of increasing concern is the issue of co-morbidity, in which individuals suffer from more than one of the risk factors at a time, with this thought to be highly predictive of end point diseases, disability and death.[12] However, most of the literature on co-morbidity of risk factors, including obesity, diabetes and hypertension, come predominantly from industrialised countries

[13-15] with evidence on NCD co-morbidity scant in less affluent countries, including Bangladesh. This is important as the patterning of NCDs is not uniform across countries of different income classification, with a higher prevalence of some NCD risk factors, such as diabetes, found in higher socio-economic groups in many studies in LMICs, contradicting those from higher income countries.[16]

With the rapid transition of under nutrition to over-nutrition in these LMICs, understanding co-morbidity and their correlates are important to develop NCD policy for individual countries. Despite the availability of nationwide survey, data in Bangladesh, the prevalence, and in particular the co-morbidity of NCD medical risk factors remains unmapped. This understanding of the burden and patterning of NCDs and their risk factors is important if Bangladesh is able to meet the Sustainable Development Goals (SDGs) target of reducing premature death from NCDs by one third by 2030.[17]

This study used 2011 Bangladesh Demography and Health Survey (BDHS) data to estimate the prevalence and pattern of NCD risk factors and co-morbidity among the general population aged 35 years and older, as well as determining their socio-demographic patterning and possible predictors of co-morbidity.

METHODS

study design

This study is based on secondary data analysis of the 2011 Bangladesh Demography and Health Survey (BDHS). The 2011 BDHS was a cross-sectional nationally representative survey

conducted between July and December 2011 through the collaboration of the National Institute of Population Research and Training (NIPORT), ICF International (USA), and Mitra and Associates. Participants in the BDHS were selected using probability sampling based on a two-stage cluster sample of households, and stratified by rural and urban areas in the seven administrative regions of Bangladesh. The detailed protocol and methods have been published previously.[18] In brief, 17,500 households were surveyed, of which one in three households were randomly selected for biomarker measurement. All men and women age 35 years and above were eligible for the biomarker test and total biomarker measures were collected from 8,835 individuals (male: 4524, female: 4311) who were eligible and were available during the time of data collection.[19] In our analysis, we included a sample 8763 cases after excluding missing values.

measurements of outcome

A data collection team including a health technician measured blood pressure, blood glucose concentration, body weight, and height using standard methods.[18] Diabetes (DM) was defined as fasting blood glucose level greater than or equal to 7.0 mmol/L or self-reported diabetes medication use.[20] Body mass index (BMI) was calculated as weight (kg)/height (m^2). Using Asian specific BMI cut-offs underweight was defined as <18.5 kg/m^2, overweight (higher BMI) as ≥23kg/m^2.[21] Hypertension (HTN) was defined as systolic blood pressure (SBP) ≥140 mmHg and diastolic blood pressure (DBP) ≥90 mmHg or self-reported anti-hypertensive medication use during the survey.[22] We categorized the co-morbidity into four group such as respondents having DM and HTN (group A), DM and overweight (group B), HTN and

overweight(group C) and group D in which individuals had all three conditions (DM, HTN and overweight).

socio-demographic factors

We categorized age as older (defined as 56 years and above) and younger (35 to 55 years) [23]. Education status was characterized by no education, preschool, primary, secondary and College or higher. Occupation was categorized manual and non-manual worker.[24].Wealth index was determine using principle component analysis using presence of household assets and overall method was describe in detail in the BDHS 2011 report. Place of residence (urban and rural) and sex (male and female) were also considered socio-demographic factors.

statistical analysis

HTN, DM, overweight and all possible combinations of the co-morbidity conditions were the main outcomes interest. For analysis purposes, all outcomes were made dichotomous (persons with/without risk factor).Sex, age, education, occupation, wealth index and place of residence were included in analysis as independent variables. The prevalence of DM, HTN, overweight and co-morbidity are shown in percentages. Using modified Poisson regression (PR) models with robust error variance; we calculated the prevalence ratio (PR) and 95% confidence interval for DM, HTN and overweight/obesity all analyses were adjusted for cluster and sample weight. The analysis was done using IBMSPSS 21. The authors followed the Strengthening the Reporting of Observational Studies in Epidemiology (STROBE) Statement in writing this manuscript (supplementary file 1).

ethical consideration

BDHS 2011 received ethical approval from ICF Macro Institutional Review Board, Maryland, USA and National Research Ethics Committee of Bangladesh Medical Research Council (BMRC), Dhaka, Bangladesh. Written informed consent was taken from the participants before the survey.

patient involvement

Patients were not involved in the study.

FINDINGS

The study population (n=8763) comprised 51% males, around 56% were 56 years of age or older, 62% reported no education, 25% were in manual employment, and 76% lived in rural location (Table 1).

Table-1: General characteristics of the study population

Variables	n	%
Sex		
Male	4480	51.13
Female	4283	48.87

Age		
Younger	3603	55.77
Older	2858	44.23
Education		
College or higher	592	6.75
Secondary	1129	12.88
Primary	1634	18.64
No education, preschool	5409	61.72
Occupation		
Manual	2142	24.89
Non-manual	6464	75.11
Wealth index		
Poorest	1696	19.36
Poorer	1671	19.06
Middle	1692	19.31
Richer	1784	20.35
Richest	1921	21.92
Place of residence		
Rural	6623	75.58
Urban	2140	24.42

Among the study population 12% had diabetes, 27% had HTN and 22%were classified as overweight (BMI≥23kg/m2).Predictive probability of diabetes, hypertension and BMI present in

figure-1. According to that probability of having diabetes and hypertension increasing by increasing age group. But probability having higher BMI is higher in younger age group compare to older age group. Prevalence of all these conditions were higher amongst males than females. The prevalence of group-1 (DM and HTN) and group 2 co-morbidities was 3%, 7% of the sample had group-3 co-morbidity (HTN and overweight), were as 1% had all three conditions (DM, HTN and overweight). Prevalence of all group of co-morbid condition was also higher in male compare to female except for group 2 (DM and overweight) (Figure 2).

The prevalence of individual conditions and all co-morbidities was higher amongst older individuals, those with a 'College or higher' education, 'non-manual' workers, people in the richest quintile for wealth index and those living in urban environments (Table 2).

183 **Table-2: Prevalence of individual conditions and comorbidities by characteristics**

Variables	Diabetes (%)	Hypertension (%)	Overweight (%)	Group-A (%) (Diabetes and hypertension)	Group-B(%) (Diabetes and overweight)	Group-C(%) (Hypertension and overweight)	Group-D(%) (Diabetes, hypertension and overweight)
Age							
Younger	10.2	19.2	24.6	2.2	3.5	8.5	1.4
Older	14.7	38.7	18.0	5.0	3.3	10.1	2.3
Education							
College or higher	22.1	33.2	46.1	7.8	8.5	17.5	4.2
Secondary	13.3	27.5	70.3	4.8	3.6	7.8	1.7
Primary	11.6	23.6	79.0	3.2	2.6	7.0	1.2

No education, preschool	9.5	28.0	86.7	2.5	1.3	5.2	0.8
Occupation							
Manual	6.8	14.4	10.5	1.0	.8	2.6	0.4
Non-manual	13.4	31.5	27.7	4.3	3.2	8.8	1.7
Wealth index							
Poorest	8.4	20.6	6.7	1.7	.6	2.2	0.4
Poorer	8.1	22.6	10.5	1.7	.5	2.9	0.3
Middle	8.2	24.2	14.6	1.9	1.0	3.4	0.4
Richer	11.8	28.8	27.8	3.4	2.5	9.3	1.2
Richest	20.8	38.6	47.9	8.2	8.0	17.5	4.3
Place of residence							

Rural	10.3	25.3	82.9	2.7	1.7	5.4	0.8
Urban	16.5	33.3	62.6	6.0	5.5	12.9	3.1

The prevalence ratio, from modified Poison regression models, of HTN, DM and overweight was significantly higher among those who completed higher education, those living in the urban areas, non-manual workers and richer to richest socioeconomic status. Although there was no sex disparities for diabetes, HTN and overweight was higher in males. The PR of overweight was the only condition which was significantly higher among younger participants (Table 3).

Table-3: Modified Poisson regression models showing prevalence ratios (PR) and 95% confidence intervals for diabetes, hypertension and overweight by demographic characteristics among Bangladeshi adults

Variables	Diabetes	Hypertension	Overweight
	PR (95% CI)	PR (95% CI)	PR (95% CI)
Sex			
Female	0.89 (0.74-1.08)	0.59 (0.53-0.65) **	0.7 (0.62-0.79) **
Male	Ref	Ref	Ref
Age #			
Older	1.48 (1.26-1.73) **	1.72 (1.56-1.88) **	0.75 (0.67-0.83) **
Younger	Ref	Ref	Ref
Education			
College or higher	1.71 (1.32-2.23) **	1.36 (1.15-1.61) **	2.11 (1.79-2.5) **
Secondary	1.16 (0.92-1.48)	1.13 (0.99-1.28)	1.56 (1.34-1.83) **
Primary	1.21 (0.99-1.48)	0.97 (0.87-1.08)	1.29 (1.12-1.5) **
No education, preschool	Ref	Ref	Ref

Occupation			
Non-manual##	1.54 (1.24-1.91) **	1.46 (1.28-1.68) **	1.62 (1.39-1.90) **
Manual	Ref	Ref	Ref
Wealth index			
Richest	1.63 (1.25-2.14) **	1.49 (1.29-1.72) **	4.3 (3.32-5.57) **
Richer	1.04 (0.79-1.35)	1.24 (1.08-1.42) **	3.07 (2.39-3.95) **
Middle	0.77 (0.58-1.03)	1.05 (0.91-1.21)	1.8 (1.38-2.36) **
Poorer	0.94 (0.71-1.24)	1.01 (0.87-1.16)	1.45 (1.09-1.92) **
Poorest	Ref	Ref	Ref
Place of residence			
Urban	1.1 (0.92-1.32)	1.05 (0.95-1.15)	1.09 (0.98-1.21)
Rural	Ref	Ref	Ref

Younger-(35–55 years and older (56 years or older) [23].

#*Non-manual category included sedentary workers, professionals (e.g., doctors, teachers, etc.), housewives, retired persons, those unable to work and unemployed [24].

**Statistical significance at $p<0.05$

In univariate Poisson regression models those in the richest quintile of wealth index had the highest prevalence ratio of all co-morbidity groups. These differences remained significant in all models in a stepwise process (Supplementary Table 1). In final models once controlling for sex, age, education, occupation and level of urbanisation, with those in the richest quintile 2.3 times as likely to have DM and HTN, 4.8 times as likely to have DM and overweight, 4.9 times as likely to have HTN and overweight and 4.0 times as likely to have all three co-morbidities than those in the poorest quintile. In these final models non-manual workers were also significantly more likely than manual workers to have all co-morbidity groups. Sex differences were lost, except for HTN and overweight in which females were 1.4 times as likely to experience both and older participants were significantly more likely to have DM and HTN and all co-morbidities (Table 4).

Table-4: Modified stepwise Poisson regression models showing prevalence ratios (PR) and 95% confidence intervals for co-morbidities by demographic characteristics among Bangladeshi adults.

Model	Group-A (Diabetes and hypertension)	Group-B (Diabetes and overweight)	Group-C (Hypertension and overweight)	Group-D (Diabetes, hypertension and overweight)
Model-1 (Wealth index)				
Wealth index				
Richest	3.94 (2.42-6.41)**	9.69 (4.84-19.4) **	6.83 (4.66-10) **	8.67 (3.65-20.56) **
Richer	1.52 (0.88-2.61)	3.39 (1.61-7.16) **	3.78 (2.53-5.64) **	2.44 (0.95-6.31)
Middle	0.9 (0.47-1.71)	1.63 (0.69-3.81)	1.3 (0.81-2.07)	1.17 (0.37-3.7)
Poorer	0.9 (0.47-1.73)	0.81 (0.31-2.16)	1.13 (0.7-1.84)	0.79 (0.24-2.64)
Poorest	Ref	Ref	Ref	Ref
Model-6 (Wealth index + sex+ age + education+ occupation+ place of residence)				
Wealth index				
Richest	2.32 (1.32-4.1) **	4.84 (2.26-10.4) **	4.85 (3.25-7.24) **	3.99 (1.58-10.11) **

Richer	1.12 (0.66-1.91)	2.22 (1.02-4.8)	3.03 (2.04-4.49)	1.59 (0.65-3.92)
Middle	0.74 (0.39-1.38)	1.23 (0.54-2.82)	1.1 (0.69-1.75)	0.9 (0.31-2.64)
Poorer	0.78 (0.41-1.48)	0.71 (0.27-1.88)	1.06 (0.65-1.7)	0.7 (0.22-2.24)
Poorest	Ref	Ref	Ref	Ref
Sex				
Female	0.67 (0.35-1.31)	0.91 (0.47-1.78)	1.44 (1.06-1.96) **	1.05 (0.46-2.36)
Male	Ref	Ref	Ref	Ref
Age				
Older	2.17 (1.58-2.99) **	0.87 (0.62-1.21)	1.11 (0.91-1.35)	1.61 (1.05-2.49) **
Younger	Ref	Ref	Ref	Ref
Education				
College or higher	1.38 (0.85-2.25)	1.53 (0.93-2.5)	1.09 (0.82-1.45)	1.4 (0.74-2.63)
Secondary	1.06 (0.68-1.65)	1.33 (0.8-2.19)	0.91 (0.68-1.2)	1.24 (0.65-2.38)
Primary	1.03 (0.69-1.53)	1.42 (0.89-2.26)	1.18 (0.93-1.5)	1.25 (0.69-2.28)
No education, preschool	Ref	Ref	Ref	Ref
Occupational				

Non-manual	3.27 (1.94-5.52) **	4.22 (2.26-7.9) **	3.04 (2.19-4.22) **	3.69 (1.63-8.36) **
Manual	Ref	Ref	Ref	Ref
Place of residence				
Urban	1.33 (0.9-1.95)	1.17 (0.8-1.72)	1.04 (0.85-1.27)	1.72 (0.99-3.01)
Rural	Ref	Ref	Ref	Ref

** Statistical significance at p<0.05

DISCUSSION

This is the first study in Bangladesh that investigated individual and co-morbid condition using nationally representative sample. We found that within the Bangladesh adult population, aged more than 35 years, the prevalence of diabetes was 12%, hypertension 27%and 22% were overweight. Diabetes, hypertension and overweight comparatively higher in male compare to female. More than 14% of the sample also had more than one condition, with 1.3% exhibiting all three. It was also reported that individual prevalence and co-morbidity were higher in high socio-economic status, and once controlling for several confounders those in the richest quintile of wealth index were significantly more likely than those in poorest quintile to exhibit co-morbidities.

In the current study, Overweight and diabetes risk seems greater among young people which is consistent with the study we conducted in Indonesia.[25] Diabetes, hypertension and overweight more prevalent in non-manual labour compare to manual labour, with consist of another study in Barbados.[26] Our study demonstrated male to be more vulnerable for co-morbid condition than females, which was completely opposite from other studies.[27, 28] On the other hand, our study revel that prevalence of individual condition (diabetes, hypertension and overweight) and co-morbidity higher in urban area compare to rural counterpart. These findings are consistent with study conducted in developing countries including Bangladesh.[29-34] Rapid growth of overweight in Bangladesh in becoming one of the major public health problems.[35-37] Because like other developing country Bangladesh also have experience on nutritional transition and increases in gross domestic product (GDP), which have also been associated with multiple shifts in food intake and reduced physical activity.[38] Recent study using four geographical region

data including Bangladesh reported that Every standard deviation higher of BMI was associated with 1.65 and 1.60 times higher probability of diabetes and 1.42 and 1.28 times higher probability of hypertension.[39]

This paper is the first to study Non-communicable diseases (NCDs) risk factor co-morbidities within a Bangladesh population. It uses a national representative dataset, the 2011 Bangladesh Demography and Health Survey (BDHS), resulting in a national representative sample with good power for statistical analysis.

Although, to the authors knowledge this is the first study on the prevalence of NCD risk factor co-morbidity in Bangladesh,a previous study had observed the association between anthropometric indices such as body mass index (BMI),waist circumference(WC) and waist hip ratio(WHR) and cardio metabolic risk indicators (FBG, SBP and DBP).[40] A further study in four geographical regions, including Bangladesh, reported that every standard deviation higher of BMI was associated with 1.65 and 1.60 times higher probability of diabetes and 1.42 and 1.28 times higher probability of hypertension, for men and women, respectively.[39]. Other studies have also found that HTN is a common co-morbid condition in DM, and vice versa,[41] whilst there is considerable evidence for an increased prevalence of HTN in diabetic persons from other populations.[42, 43]

Our study reported individual condition and co-morbidities higher in high socio-economic group. These findings conflict with trends reported by previous studies conducted in higher-income countries.[44, 45] However, another multicounty study in low income country (LIMs) reported the co-morbidity was more prevalent among the poor and less educated.[46] But one of the limitations of that study was self-reported diagnosis, which may introduce biases. Previous

research in INDEPTH Asian sites has reported inverse associations between co-morbidity and markers of socioeconomic status.[47]

The main implications of the this study are the increased burden of NCDs within Bangladesh, along with other LMICs and the patterning of more than one risk factors within individuals in the population. In contrast to findings from high income countries prevalence of individual risk factors and co-morbidities was higher in higher SES groups. This points to differences between countries in the population level determinants of NCDs and highlights that context specific interventions must be developed to counter them. As a first step, it is important that countries collect and analyse high quality health data to allow them to develop and target interventions.

STRENGTHS AND LIMITATIONS

Measurements were taken by health technicians, WHO measured blood pressure, blood glucose concentration, body weight, and height using standard methods including biomarker analysis and validated measures of socio-economic status collected. The main weakness of the study is the cross-sectional nature meaning that only associations can be inferred and causality cannot be determined. In addition although clinical measures of the diabetes, hypertension and overweight were taken, no measurements of blood lipids were taken in the survey, meaning that metabolic syndrome could not be investigated. Waist circumference and hip circumference were also not collected, limiting the analysis that could be performed. Finally although the study was

reported to be representative, only participants 35 years or older had measured anthropometry and biomarkers.

CONCLUSION

Several socio-demographic factors associated with DM, HTN, overweight and co-morbid condition. There is an urgent need to improve monitoring and management of NCDs through primary care linked programmes. Policy and system changes are essential to reduce risk in population. At the same time for prevention and control of NCDs needs "political will" societal and community support.

Contributors

TB, NT, SKD & AAM conceptualized the study. TB, NT, SKD, RDG & AAM designed the study and acquired the data. TB, SI & MRI conducted the data analysis. TB, NT, SI, MRI, SKD & AAM interpreted the data. TB, NT & RDG prepared the first draft. TB, NT, SKD & AAM participated in critical revision of the manuscript and contributed to its intellectual improvement. All authors went through the final draft and approved it for submission.

Funding

None.

Acknowledgments

The authors thank MEASURE DHS for permission to use data from the 2011 Bangladesh DHS. The authors are also grateful to Mr. Mehedi Hasan, PhD student, University of Queensland, Australia.

Competing Interests

None declared.

Patient consent

None Declared

Disclaimer

The authors are alone responsible for the integrity and accuracy of data analysis and the writing the manuscript.

Ethics approval

The datasets were obtained from DHS Programme with proper procedure. The study exempt from collecting ethical approval because the survey protocols were reviewed and approved by ICF Macro Institutional Review Board, Maryland, USA and National Research Ethics Committee of Bangladesh Medical Research Council (BMRC), Dhaka, Bangladesh.

Data sharing statement

The dataset of BDHS 2011 is available at the Demographic and Health Surveys Program. Extra data is available which is available on request at http://dhsprogram-com/what-we-do/survey/survey-display-349.cfm.

References:

1. Murray CJ, Vos T, Lozano R, et al. Disability-adjusted life years (DALYs) for 291 diseases and injuries in 21 regions, 1990–2010: a systematic analysis for the Global Burden of Disease Study 2010. *Lancet.* 2013;380(9859):2197-223. doi: 10.1016/S0140-6736(12)61689-4.

2. Lozano R, Naghavi M, Foreman K, et al. Global and regional mortality from 235 causes of death for 20 age groups in 1990 and 2010: a systematic analysis for the Global Burden of Disease Study 2010. *Lancet.* 2013;380(9859):2095-128. doi: 10.1016/S0140-6736(12)61728-0

3. Bennett D, Bisanzio D, Deribew A, et al. Global, regional, and national under-5 mortality, adult mortality, age-specific mortality, and life expectancy, 1970–2016: a systematic analysis for the Global Burden of Disease Study 2016. *Lancet.* 2017;390(10100):1084-1150. doi: 10.1016/s0140-6736(17)31833-0.

4. World Health Organization. Global status report on noncommunicable diseases 2010. Geneva: World Health Organization; 2011. 161 p.

5. Abegunde DO, Mathers CD, Adam T, et al. The burden and costs of chronic diseases in low-income and middle-income countries. *Lancet.* 2007;370(9603):1929-38. doi: 10.1016/S0140-6736(07)61696-1

6. Lee JT, Hamid F, Pati S, et al. Impact of noncommunicable disease multimorbidity on healthcare utilisation and out-of-pocket expenditures in middle-income countries: cross sectional analysis. *PLoS One.* 2015;10(7):e0127199. doi: 10.1371/journal.pone.0127199.

7. World Health Organization. Global status report on noncommunicable diseases 2014. Geneva: World Health Organization; 2015. 280 p.

8. Streatfield PK, Karar ZA. Population challenges for Bangladesh in the coming decades. J Health Popul Nutr. 2008;26(3):261.

9. National Institute of Population Research and Training (NIPORT), Mitra and Associates, ICF International. Bangladesh Urban Health Survey 2013.. Dhaka, Bangladesh, Calverton, Maryland, USA: NIPORT, Mitra and Associates, and ICF International., 2015.

10. Ahsan KZ, Alam MN, Streatfield PK, et al. Has Bangladesh Entered the Fourth Stage of the Epidemiologic Transition?. Proceedings of the International seminar on Mortality: Past, Present and Future; 2017Aug 7-8; the University of Campinas, Brazil.

11. Zaman MM, Bhuiyan MR, Karim MN, et al. Clustering of non-communicable diseases risk factors in Bangladeshi adults: an analysis of STEPS survey 2013. *BMC Public Health.* 2015;15(1):659. doi: 10.1186/s12889-015-1938-4.

12. Hillas G, Perlikos F, Tsiligianni I, et al. Managing comorbidities in COPD. *Int J Chron Obstruct Pulmon Dis*.2015;10:95. doi: 10.2147/COPD.S54473.

13. Shukla A, Kumar K, Singh A. Association between obesity and selected morbidities: a study of BRICS countries. *PloS One*. 2014;9(4):e94433. doi: 10.1371/journal.pone.0094433.

14. Wang J, Ma JJ, Liu J, et al. Prevalence and Risk Factors of Comorbidities among Hypertensive Patients in China. *Int J Med Sci.* 2017;14(3):201. doi: 10.7150/ijms.16974.

15. Bosu WK. The prevalence, awareness, and control of hypertension among workers in West Africa: a systematic review. *Glob Health Action.* 2015;8(1):26227. doi: 10.3402/gha.v8.26227.

16. Allen L, Williams J, Townsend N, et al. Socioeconomic status and non-communicable disease behavioural risk factors in low-income and lower-middle-income countries: a systematic review. *Lancet Glob Health.* 2017;5(3):e277-e89. doi: 10.1016/S2214-109X(17)30058-X.

17. Varghese C. Reducing premature mortality from non-communicable diseases, including for people with severe mental disorders. *World Psychiatry.* 2017;16(1):45-7. doi: 10.1002/wps.20376.

18. National Institute of Population Research and Training (NIPORT), Mitra and Associates, ICF International. Bangladesh Demographic and Health Survey 2011, Preliminary Report. Dhaka, Bangladesh, Calverton, Maryland, USA: NIPORT, Mitra and Associates, and ICF International., 2012.

19. Biswas T, Islam MS, Linton N, et al. Socio-economic inequality of chronic non-communicable diseases in Bangladesh. *PloS One.* 2016;11(11):e0167140. doi: 10.1371/journal.pone.0167140.

20. Akter S, Rahman MM, Abe SK, et al. Prevalence of diabetes and prediabetes and their risk factors among Bangladeshi adults: a nationwide survey. *Bull World Health Organ.* 2014;92(3):204-13A. doi: 10.2471/BLT.13.128371.

21. Ke-You G, Da-Wei F. The magnitude and trends of under-and over-nutrition in Asian countries. *Biomed Environ Sci.* 2001;14(1-2):53-60.

22. National Institute of Population Research and Training (NIPORT), Mitra and Associates, ICF International. Bangladesh Demographic and Health Survey 2011. Dhaka, Bangladesh, Calverton, Maryland, USA: NIPORT, Mitra and Associates, and ICF International., 2013.

23. Rahman M, Williams G, Al Mamun A. Hypertension and diabetes prevalence among adults with moderately increased BMI (23· 0–24· 9 kg/m 2): findings from a nationwide survey in Bangladesh. *Public Health Nutr.* 2017:1-8. doi: 10.1017/S1368980016003566.

24. Alam DS, Chowdhury MA, Siddiquee AT, et al. Prevalence and determinants of chronic obstructive pulmonary disease (COPD) in Bangladesh. *COPD.* 2015;12(6):658-67. doi: 10.3109/15412555.2015.1041101.

25. Hussain MA, Huxley RR, Al Mamun A. Multimorbidity prevalence and pattern in Indonesian adults: an exploratory study using national survey data. BMJ Open. 2015;5(12):e009810. doi: 10.1136/bmjopen-2015-009810.

26. Howitt C, Hambleton IR, Rose AM, et al. Social distribution of diabetes, hypertension and related risk factors in Barbados: a cross-sectional study. *BMJ Open.* 2015;5(12):e008869. doi: 10.1136/bmjopen-2015-008869.

27. Pearson TA. Education and income: double-edged swords in the epidemiologic transition of cardiovascular disease. *Ethn Dis.* 2003;13(2; SUPP/2):S2-158.

28. Agborsangaya CB, Lau D, Lahtinen M, et al. Multimorbidity prevalence and patterns across socioeconomic determinants: a cross-sectional survey. *BMC Public Health*. 2012;12(1):201. doi: 10.1186/1471-2458-12-201.

29. Rahman M, Williams G, Al Mamun A. Gender differences in hypertension awareness, antihypertensive use and blood pressure control in Bangladeshi adults: findings from a national cross-sectional survey. *J Health Popul Nutr*.2017;36(1):23. doi: 10.1186/s41043-017-0101-5.

30. Li G, Hu H, Dong Z, et al. Urban and suburban differences in hypertension trends and self-care: Three population-based cross-sectional studies from 2005-2011. *PloS One.* 2015;10(2):e0117999. doi: 10.1371/journal.pone.0117999.

31. Sola A, Chinyere O, Stephen A, et al. Hypertension prevalence in an urban and rural area of Nigeria. *J Med Sci.* 2013;4:149-54.

32. Dhungana RR, Pandey AR, Bista B, et al. Prevalence and associated factors of hypertension: a community-based cross-sectional study in municipalities of Kathmandu, Nepal. *Int J Hypertens.*2016;2016. doi: 10.1155/2016/1656938.

33. Chowdhury MAB, Uddin MJ, Haque MR, et al. Hypertension among adults in Bangladesh: evidence from a national cross-sectional survey. *BMC Cardiovasc Disord.* 2016;16(1):22. doi: 10.1186/s12872-016-0197-3.

34. Akter S, Rahman MM, Abe SK, et al. Prevalence of diabetes and prediabetes and their risk factors among Bangladeshi adults: a nationwide survey. *Bull World Health Organ.*2014;92(3):204-13A. doi: 10.2471/BLT.13.128371

35. Biswas T, Uddin MJ, Al Mamun A, et al. Increasing prevalence of overweight and obesity in Bangladeshi women of reproductive age: Findings from 2004 to 2014. *PloS One.* 2017;12(7):e0181080. doi: 10.1371/journal.pone.0181080.

36. Hoque ME, Hasan MT, Rahman M, et al. Double burden of underweight and overweight among Bangladeshi adults differs between men and women: evidence from a nationally representative survey. *Public Health Nutr.*2017;20(12):2183-91. doi: 10.1017/S1368980017000957.

37. Biswas T, Garnett SP, Pervin S, et al. The prevalence of underweight, overweight and obesity in Bangladeshi adults: Data from a national survey. *PloS One.* 2017;12(5):e0177395. doi: 10.1371/journal.pone.0177395.

38. Dietz WH. Double-duty solutions for the double burden of malnutrition. *Lancet.* 2017. doi: 10.1016/S0140-6736(17)32479-0.

39. Patel SA, Ali MK, Alam D, et al. Obesity and its relation with diabetes and hypertension: a cross-sectional study across 4 geographical regions. *Glob Heart.*2016;11(1):71-9. e4. doi: 10.1016/j.gheart.2016.01.003.

40. Bhowmik B, Afsana F, Ahmed T, et al. Obesity and associated type 2 diabetes and hypertension in factory workers of Bangladesh. *BMC Res Notes.*2015;8(1):460. doi: 10.1186/s13104-015-1377-4.

41. Pradeepa R. The rising burden of diabetes and hypertension in southeast asian and african regions: need for effective strategies for prevention and control in primary health care settings. *Int J Hypertens.* 2013;2013. doi: 10.1155/2013/409083.

42. Berraho M, El Achhab Y, Benslimane A, et al. Hypertension and type 2 diabetes: a cross-sectional study in Morocco (EPIDIAM Study). *Pan Afr Med J.* 2012;11(1).

43. Hashemizadeh H, Sarvelayati D. Hypertension and Type 2 Diabetes: A Cross-sectional Study in Hospitalized Patients in Quchan, Iran. *Iran J Diabetes Obesity.* 2013;5(1):21-6.

44. Connolly V, Unwin N, Sherriff P, et al. Diabetes prevalence and socioeconomic status: a population based study showing increased prevalence of type 2 diabetes mellitus in deprived areas. *J Epidemiol Community Health*.2000;54(3):173-7.

45. Glover JD, Hetzel DM, Tennant SK. The socioeconomic gradient and chronic illness and associated risk factors in Australia. *Aust New Zealand Health Policy.* 2004;1(1):8. doi: 10.1186/1743-8462-1-8.

46. Hosseinpoor AR, Bergen N, Mendis S, et al. Socioeconomic inequality in the prevalence of noncommunicable diseases in low-and middle-income countries: results from the World Health Survey. *BMC Public Health.* 2012;12(1):474. doi: 10.1186/s12889-015-2227-y.

47. Van Minh H, Ng N, Juvekar S, et al. Self-reported prevalence of chronic diseases and their relation to selected sociodemographic variables: a study in INDEPTH Asian sites, 2005. *Prev Chronic Dis*.2008;5(3).

Figures:

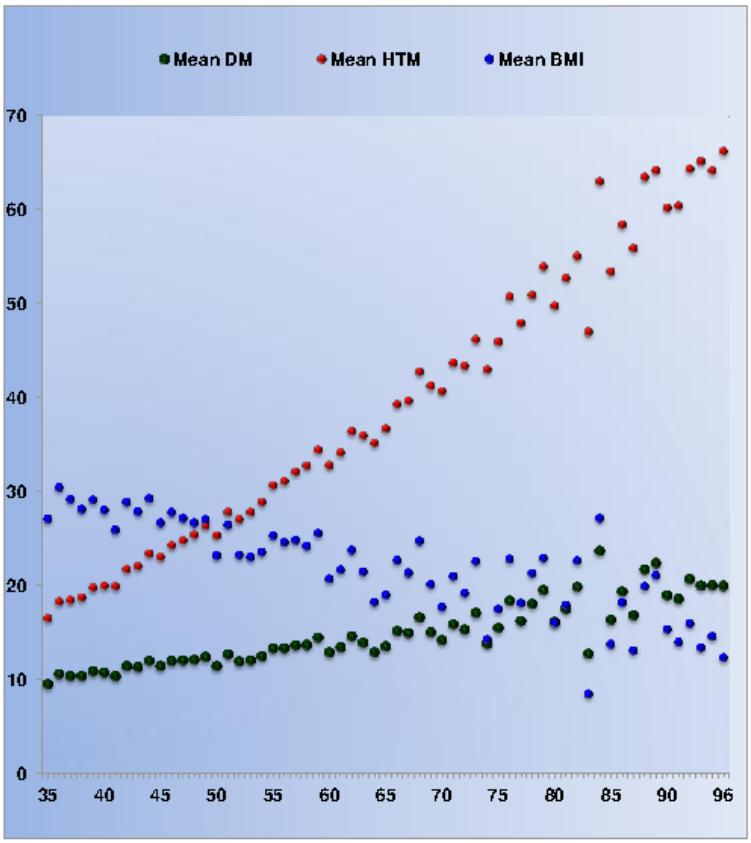
Fig 1. Predictive probability of diabetes, hypertension and BMI by age

Fig 2. Prevalence of diabetes, hypertension, overweight and co-morbidity by sex among Bangladeshi adults

Supplementary Materials:

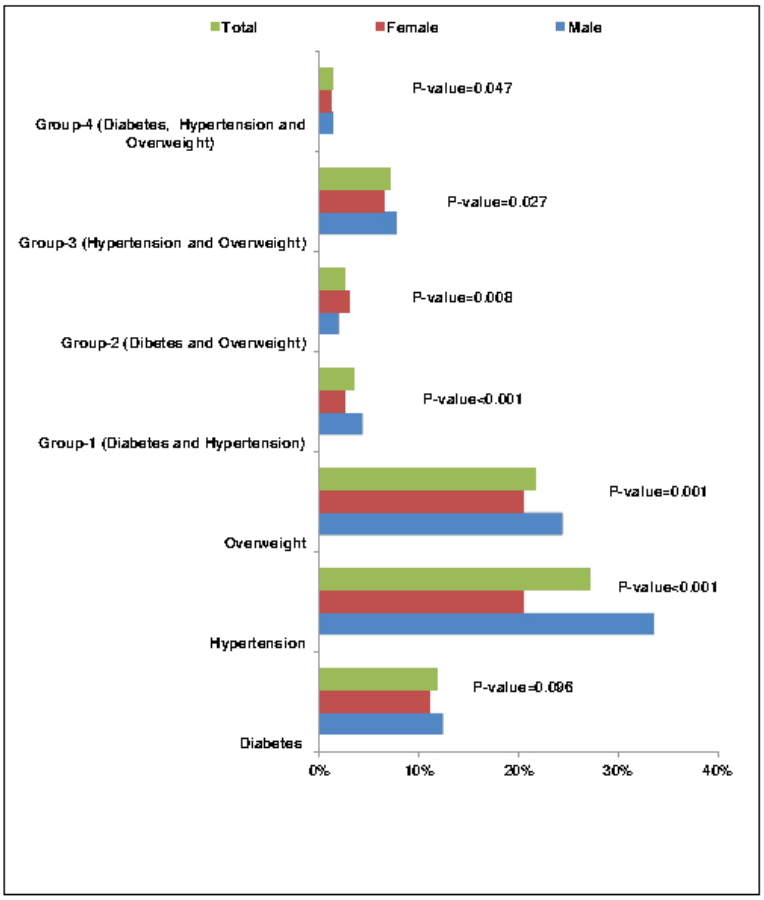
Supplementary File 1: STROBE Checklist

Supplementary File 2: Supplementary Table 1: Modified stepwise Poisson regression models showing prevalence ratios (PR) and 95% confidence intervals for co-morbidities by demographic characteristics among Bangladeshi adults.



Predictive probability of diabetes, hypertension and BMI by age

215x279mm (72 x 72 DPI)



Prevalence of diabetes, hypertension, overweight and co-morbidity by sex among Bangladeshi adults

215x279mm (72 x 72 DPI)

Supplementary Table 1: Modified stepwise Poisson regression models showing prevalence ratios (PR) and 95% confidence intervals for co-morbidities by demographic characteristics among Bangladeshi adults.

	Group-A (Diabetes and hypertension)	Group-B (Diabetes and overweight)	Group-C (Hypertension and overweight)	Group-D (Diabetes, hypertension and overweight)
Model-1 (Wealth index)				
Wealth index				
Richest	3.94 (2.42-6.41)**	9.69 (4.84-19.4) **	6.83 (4.66-10) **	8.67 (3.65-20.56) **
Richer	1.52 (0.88-2.61)	3.39 (1.61-7.16) **	3.78 (2.53-5.64) **	2.44 (0.95-6.31)
Middle	0.9 (0.47-1.71)	1.63 (0.69-3.81)	1.3 (0.81-2.07)	1.17 (0.37-3.7)
Poorer	0.9 (0.47-1.73)	0.81 (0.31-2.16)	1.13 (0.7-1.84)	0.79 (0.24-2.64)
Poorest	Ref	Ref	Ref	Ref
Model-2 (Wealth index + sex)				
Wealth index				
Richest	3.93 (2.42-6.39) **	9.68 (4.84-19.35) **	6.88 (4.7-10.08) **	8.69 (3.68-20.5) **
Richer	1.51 (0.88-2.6)	3.39 (1.61-7.14) **	3.82 (2.56-5.69) **	2.45 (0.96-6.3)
Middle	0.9 (0.47-1.71)	1.62 (0.69-3.8)	1.31 (0.82-2.09)	1.17 (0.37-3.69)
Poorer	0.89 (0.47-1.71)	0.81 (0.31-2.15)	1.16 (0.72-1.89)	0.8 (0.24-2.63)
Poorest	Ref	Ref	Ref	Ref
Sex				
Female	0.85 (0.43-1.66)	0.95 (0.49-1.85)	1.66 (1.22-2.26) **	1.21 (0.53-2.74)
Male	Ref	Ref	Ref	Ref
Model-3 (Wealth index + sex+ age)				
Wealth index				
Richest	4.04 (2.49-6.56) **	9.65 (4.82-19.3) **	6.92 (4.73-10.13) **	8.82 (3.74-20.82) **
Richer	1.51 (0.88-2.59)	3.4 (1.61-7.14) **	3.81 (2.55-5.67) **	2.44 (0.95-6.26)
Middle	0.88 (0.46-1.67)	1.63 (0.7-3.81)	1.3 (0.81-2.07)	1.15 (0.37-3.65)
Poorer	0.86 (0.45-1.64)	0.82 (0.31-2.15)	1.15 (0.71-1.87)	0.78 (0.24-2.57)
Poorest	Ref	Ref	Ref	Ref
Sex				
Female	0.75 (0.39-1.46)	0.97 (0.5-1.88)	1.61 (1.18-2.19) **	1.13 (0.5-2.54)
Male	Ref	Ref	Ref	Ref
Age				
Older	2.34 (1.71-3.2) **	0.88 (0.65-1.2)	1.23 (1.03-1.47) **	1.6 (1.05-2.42) **
Younger	Ref	Ref	Ref	Ref
Model-4 (Wealth index + sex+ age + education)				
Wealth index				
Richest	3.62 (2.16-6.07) **	7.84 (3.74-16.45) **	6.76 (4.55-10.03) **	7.56 (3.11-18.42) **
Richer	1.45 (0.84-2.51)	2.98 (1.37-6.5)	3.77 (2.53-5.63) **	2.24 (0.87-5.8)
Middle	0.87 (0.46-1.64)	1.5 (0.65-3.5)	1.28 (0.81-2.05)	1.1 (0.36-3.36)

Poorer	0.85 (0.45-1.63)	0.78 (0.29-2.09)	1.15 (0.71-1.86)	0.77 (0.23-2.51)
Poorest	Ref	Ref	Ref	Ref
Sex				
Female	0.76 (0.39-1.49)	1.04 (0.53-2.05)	1.62 (1.18-2.22) **	1.19 (0.52-2.71)
Male	Ref	Ref	Ref	Ref
Age				
Older	2.45 (1.79-3.36) **	0.97 (0.7-1.34)	1.25 (1.04-1.51) **	1.72 (1.11-2.65) **
Younger	Ref	Ref	Ref	Ref
Education				
College or higher	1.54 (0.96-2.5)	1.73 (1.06-2.83) **	1.21 (0.91-1.61)	1.59 (0.85-2.97)
Secondary	0.97 (0.62-1.51)	1.22 (0.74-2.01)	0.84 (0.64-1.12)	1.12 (0.59-2.15)
Primary	0.96 (0.64-1.42)	1.35 (0.85-2.14)	1.13 (0.9-1.43)	1.17 (0.65-2.11)
No education, preschool	Ref	Ref	Ref	Ref
Model-5 (Wealth index + sex+ age + education+ occupation)				
Wealth index				
Richest	2.72 (1.6-4.61) **	5.3 (2.54-11.05) **	4.97 (3.37-7.33) **	5.47 (2.32-12.91) **
Richer	1.18 (0.69-2.04)	2.29 (1.06-4.95) **	3.06 (2.06-4.53) **	1.79 (0.71-4.49)
Middle	0.75 (0.4-1.41)	1.24 (0.54-2.85)	1.11 (0.7-1.76)	0.93 (0.31-2.76)
Poorer	0.78 (0.41-1.49)	0.72 (0.27-1.88)	1.06 (0.65-1.7)	0.7 (0.22-2.26)
Poorest	Ref	Ref	Ref	Ref
Sex				
Female	0.67 (0.35-1.31)	0.91 (0.47-1.78)	1.44 (1.06-1.96) **	1.05 (0.47-2.37)
Male	Ref	Ref	Ref	Ref
Age				
Older	2.13 (1.54-2.94) **	0.86 (0.62-1.19)	1.11 (0.91-1.34)	1.54 (1.00-2.38) **
Younger	Ref	Ref	Ref	Ref
Education				
College or higher	1.4 (0.86-2.28)	1.54 (0.94-2.51)	1.09 (0.82-1.45)	1.44 (0.77-2.71)
Secondary	1.05 (0.67-1.64)	1.32 (0.8-2.18)	0.9 (0.68-1.2)	1.22 (0.63-2.35)
Primary	1.03 (0.69-1.53)	1.41 (0.89-2.25)	1.18 (0.93-1.49)	1.24 (0.68-2.26)
No education, preschool	Ref	Ref	Ref	Ref
Occupational				
Non-manual	3.32 (1.97-5.59) **	4.25 (2.27-7.97) **	3.04 (2.19-4.23) **	3.79 (1.67-8.61) **
Manual	Ref	Ref	Ref	Ref
Model-5 (Wealth index + sex+ age + education+ occupation+ place of residence)				
Wealth index				
Richest	2.32 (1.32-4.1) **	4.84 (2.26-10.4) **	4.85 (3.25-7.24) **	3.99 (1.58-10.11) **
Richer	1.12 (0.66-1.91)	2.22 (1.02-4.8)	3.03 (2.04-4.49)	1.59 (0.65-3.92)
Middle	0.74 (0.39-1.38)	1.23 (0.54-2.82)	1.1 (0.69-1.75)	0.9 (0.31-2.64)
Poorer	0.78 (0.41-1.48)	0.71 (0.27-1.88)	1.06 (0.65-1.7)	0.7 (0.22-2.24)

Poorest	Ref	Ref	Ref	Ref
Sex				
Female	0.67 (0.35-1.31)	0.91 (0.47-1.78)	1.44 (1.06-1.96) **	1.05 (0.46-2.36)
Male	Ref	Ref	Ref	Ref
Age				
Older	2.17 (1.58-2.99) **	0.87 (0.62-1.21)	1.11 (0.91-1.35)	1.61 (1.05-2.49) **
Younger	Ref	Ref	Ref	Ref
Education				
College or higher	1.38 (0.85-2.25)	1.53 (0.93-2.5)	1.09 (0.82-1.45)	1.4 (0.74-2.63)
Secondary	1.06 (0.68-1.65)	1.33 (0.8-2.19)	0.91 (0.68-1.2)	1.24 (0.65-2.38)
Primary	1.03 (0.69-1.53)	1.42 (0.89-2.26)	1.18 (0.93-1.5)	1.25 (0.69-2.28)
No education, preschool	Ref	Ref	Ref	Ref
Occupational				
Non-manual	3.27 (1.94-5.52) **	4.22 (2.26-7.9) **	3.04 (2.19-4.22) **	3.69 (1.63-8.36) **
Manual	Ref	Ref	Ref	Ref
Place of residence				
Urban	1.33 (0.9-1.95)	1.17 (0.8-1.72)	1.04 (0.85-1.27)	1.72 (0.99-3.01)
Rural	Ref	Ref	Ref	Ref

STROBE 2007 (v4) Statement—Checklist of items that should be included in reports of *cross-sectional studies*

Title of the study: **High socioeconomic status associated with greater prevalence of NCD risk factors and co-morbidities in Bangladesh. Findings from a nationwide survey**

Section/Topic	Item #	Recommendation	Reported on page #
Title and abstract	1	(*a*) Indicate the study's design with a commonly used term in the title or the abstract	1
		(*b*) Provide in the abstract an informative and balanced summary of what was done and what was found	3-4
Introduction			
Background/rationale	2	Explain the scientific background and rationale for the investigation being reported	6-7
Objectives	3	State specific objectives, including any prespecified hypotheses	7
Methods			
Study design	4	Present key elements of study design early in the paper	7-8
Setting	5	Describe the setting, locations, and relevant dates, including periods of recruitment, exposure, follow-up, and data collection	7-8
Participants	6	(*a*) Give the eligibility criteria, and the sources and methods of selection of participants	7-8
Variables	7	Clearly define all outcomes, exposures, predictors, potential confounders, and effect modifiers. Give diagnostic criteria, if applicable	8-9
Data sources/ measurement	8*	For each variable of interest, give sources of data and details of methods of assessment (measurement). Describe comparability of assessment methods if there is more than one group	8-9
Bias	9	Describe any efforts to address potential sources of bias	9
Study size	10	Explain how the study size was arrived at	9
Quantitative variables	11	Explain how quantitative variables were handled in the analyses. If applicable, describe which groupings were chosen and why	9
Statistical methods	12	(*a*) Describe all statistical methods, including those used to control for confounding	9
		(*b*) Describe any methods used to examine subgroups and interactions	Not applicable

		(*c*) Explain how missing data were addressed	Not applicable
		(*d*) If applicable, describe analytical methods taking account of sampling strategy	Not applicable
		(*e*) Describe any sensitivity analyses	Not applicable
Results			
Participants	13*	(a) Report numbers of individuals at each stage of study—eg numbers potentially eligible, examined for eligibility, confirmed eligible, included in the study, completing follow-up, and analysed	10-12
		(b) Give reasons for non-participation at each stage	Not applicable
		(c) Consider use of a flow diagram	Not applicable
Descriptive data	14*	(a) Give characteristics of study participants (eg demographic, clinical, social) and information on exposures and potential confounders	10-12
		(b) Indicate number of participants with missing data for each variable of interest	Not applicable
Outcome data	15*	Report numbers of outcome events or summary measures	11-22
Main results	16	(*a*) Give unadjusted estimates and, if applicable, confounder-adjusted estimates and their precision (eg, 95% confidence interval). Make clear which confounders were adjusted for and why they were included	11-22
		(*b*) Report category boundaries when continuous variables were categorized	Not applicable
		(*c*) If relevant, consider translating estimates of relative risk into absolute risk for a meaningful time period	Not applicable
Other analyses	17	Report other analyses done—eg analyses of subgroups and interactions, and sensitivity analyses	Not applicable
Discussion			
Key results	18	Summarise key results with reference to study objectives	23
Limitations	19	Discuss limitations of the study, taking into account sources of potential bias or imprecision. Discuss both direction and magnitude of any potential bias	25-26
Interpretation	20	Give a cautious overall interpretation of results considering objectives, limitations, multiplicity of analyses, results from similar studies, and other relevant evidence	23-25
Generalisability	21	Discuss the generalisability (external validity) of the study results	23-25
Other information			
Funding	22	Give the source of funding and the role of the funders for the present study and, if applicable, for the original study on which the present article is based	26

*Give information separately for cases and controls in case-control studies and, if applicable, for exposed and unexposed groups in cohort and cross-sectional studies.

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

BMJ Open

High socioeconomic status is associated with greater prevalence of NCD risk factors and comorbidities in Bangladesh. Findings from a nationwide survey

Journal:	*BMJ Open*
Manuscript ID	bmjopen-2018-025538.R1
Article Type:	Research
Date Submitted by the Author:	26-Nov-2018
Complete List of Authors:	Biswas, Tuhin; International Centre for Diarrhoeal Disease Research Bangladesh, Townsend, Nick Islam, Md.saimul; University of Rajshahi, Departmnet of Statistics; Islam, Md. Rajibul ; Health Intervention and Technology Assessment Program (HITAP),Ministry of Public Health, Nonthaburi, Thailand Das Gupta, Rajat; BRAC University James P Grant School of Public Health, Das, Sumon Mamun, Abdullah; University of Queensland, School of Population Health
Primary Subject Heading:	Epidemiology
Secondary Subject Heading:	Public health, Diabetes and endocrinology, Cardiovascular medicine
Keywords:	Overweight, DIABETES & ENDOCRINOLOGY, Hypertension < CARDIOLOGY

Title: High socioeconomic status is associated with greater prevalence of NCD risk factors and comorbidities in Bangladesh. Findings from a nationwide survey

Authors:

Tuhin Biswas[1,2*], Nick Townsend[3], Md. Saimul Islam[4],Md. Rajibul Islam[5], Rajat Das Gupta[6,7], Sumon Kumar Das[2], Abdullah Al Mamun[2]

Affiliations:

[1] Universal Health Coverage, Health Systems and Population Studies Division, icddr,b, Mohakhali, Dhaka, Bangladesh

[2]Institute for Social Science Research, The University of Queensland, Long Pocket Precinct, Indooroopilly, Queensland, Australia.

[3] Department for Health, University of Bath, United Kingdom

[4] University Rajshahi, Rajshahi, Bangladesh.

[5] Health Intervention and Technology Assessment Program (HITAP),Ministry of Public Health, Nonthaburi, Thailand.

[6] Centre for Non-Communicable Diseases and Nutrition, BRAC James P Grant School of Public Health, BRAC University, Dhaka, Bangladesh

[7] Centre for Science of Implementation and Scale-Up, BRAC James P Grant School of Public Health, BRAC University, Dhaka, Bangladesh

***Corresponding author:**

Biswas Tuhin

Health Systems and Population Studies Division, icddr,b, Mohakhali, Dhaka, Bangladesh; Institute for Social Science Research, The University of Queensland, Long Pocket Precinct, Indooroopilly, Queensland, Australia.

Email: uhin_sps0@yahoo.com

ABSTRACT

Objectives: This study aimed to examine the prevalence and distribution in the comorbidity of non-communicable diseases (NCD) among the adult population in Bangladesh by measures of socioeconomic status (SES).

Design: This was a cross-sectional study.

Setting: This study used Bangladesh Demographic and Health Survey (2011) data.

Participants: Total 8,763 individuals aged ≥35 years were included.

Primary and secondary outcome measures: The primary outcome measures were diabetes (DM), hypertension (HTN) and overweight/obesity. The study further assesses factors associated with comorbidities, in particular socioeconomic status.

Results: Of 8,763 adults**,** 12% had DM, 27% HTN and 22% were overweight (BMI≥23kg/m^2). Just over 1% of the sample had all three conditions, 3% had both DM and HTN, 3% DM and overweight and 7% HTN and overweight. Diabetes, hypertension and overweight were more prevalent those who had higher education, were non-manual workers, were in the richer to richest socioeconomic status and lived in urban settings. Individuals in higher SES groups were also more likely to suffer from comorbidities.

Conclusions: In contrast to more affluent countries, individuals with NCD risk factors and comorbidities are more common in higher socio-economic status individuals. Public health approaches must consider this social patterning in tackling NCDs in the country.

Key words: Overweight, Diabetes, Hypertension, Non-communicable Disease, socioeconomic status, Bangladesh

STRENGTHS AND LIMITATIONS OF THE STUDY

- The biggest strength of the study is that it utilized a large dataset nationally representative of the Bangladesh population, collected using measures that have been designed and validated through previous data collections in the country.
- Data collection included clinical measures of blood pressure, blood glucose concentration, body weight, and height collected by a health technician.
- The main weakness of the study is that it is cross-sectional in nature, meaning that only associations can be inferred and causality cannot be determined.

INTRODUCTION

According to the Global Burden of Disease report, non-communicable diseases (NCDs) are the leading cause of death worldwide[1-3] and that 80% of this NCD mortality actually occurs in low- and middle-income countries (LMICs)[4-6]. Similarly, the 2014 NCDs global status report showed that of 58 million deaths that occurred globally in 2012, 38 million - almost two thirds - were due to NCDs, with these deaths most due to the four most common NCDs: cardiovascular diseases, cancers, diabetes and chronic lung diseases.[7.] In addition, the report showed that more than 40% of these deaths (16 million) occurred were in individuals under the age of 70 years, often referred to as premature deaths[7]. Deaths at younger ages may be a greater demonstration of its burden, as many consider them preventable. It is alarming, therefore, that the majority of premature deaths (82%) occur in LMICs, with this problem likely to increase if appropriate preventative actions are not taken at a population level.

Like many LMICs, Bangladesh is undergoing rapid urbanization with changing patterns of diseases among the population[8, 9], with some suggesting that the country is at an advanced phase of the third stage of the epidemiologic transition, with deaths from NCDs expected to increase rapidly in the coming years.[10] This increasing mortality from NCDs in the country is supported by high prevalence of the medical risk factors associated with NCDs. A recent WHO STEPS survey in Bangladesh reported that 21% of the population had hypertension, 26% were overweight and 5% had documented diabetes.[11]

These high prevalence figures, raise concerns of comorbidity, in which individuals suffer from more than one of the risk factors at a time, with this thought to be highly predictive of end point diseases, disability and death.[12]. There is evidence of comorbidity risk for factors including

obesity, diabetes and hypertension, predominantly coming from industrialized countries [13-15] and developing nations[16-18]; however evidence on NCD comorbidity scant in Bangladesh. This is important as the patterning of NCDs is not uniform across countries of different income classification, with a higher prevalence of some NCD risk factors, such as diabetes, found in higher socio-economic groups in many studies in LMICs, contradicting those from higher income countries.[19]

With the development of a double burden from both over- and under-nutrition in these LMICs, understanding comorbidity and their correlates is important if we are to develop NCD preventative policies contextualized for these countries. Despite the availability of nationwide survey data in Bangladesh, the prevalence, and in particular the comorbidity of NCD medical risk factors remains unmapped. This understanding of the burden and patterning of NCDs and their risk factors is important if Bangladesh is able to meet the Sustainable Development Goals (SDGs) target of reducing premature death from NCDs by one third by 2030.[20]

This study used 2011 Bangladesh Demography and Health Survey (BDHS) data to estimate the prevalence and pattern of NCD risk factors and comorbidity among the general population aged 35 years and older, as well as determining their socio-demographic patterning and possible predictors of comorbidity .

METHODS

Study design

This study used data from the 2011 Bangladesh Demography and Health Survey (BDHS). The 2011 BDHS is a cross-sectional nationally representative survey that was conducted between

July and December 2011 through the collaboration of the National Institute of Population Research and Training (NIPORT), ICF International (USA), and Mitra and Associates. Participants in the BDHS were selected using probability sampling based on a two-stage cluster sample of households, and stratified by rural and urban areas in the seven administrative regions of Bangladesh. The detailed protocol and methods have been published previously.[21] In brief, 17,500 households were surveyed, of which one in three households were randomly selected for biomarker measurement (blood glucose, blood pressure). All men and women age 35 years and above were eligible for the biomarker measures, with these collected from a final sample of 8,835 individuals (male: 4524, female: 4311). [22] We included 8763 cases in our analytical sample, after excluding cases with missing values.

Measurements of outcomes

A data collection team, including a health technician, measured blood pressure, blood glucose concentration, body weight, and height using standard methods.[21] Diabetes (DM) was defined as a fasting blood glucose level greater than or equal to 7.0 mmol/L or self-reported diabetes medication use.[23] Body mass index (BMI) was calculated as weight (kg)/height (m^2). We used Asian specific BMI cut-offs to define underweight as <18.5 kg/m^2 and overweight and obese (higher BMI) as ≥23kg/m^2.[24] Hypertension was defined as systolic blood pressure (SBP) ≥140 mmHg and diastolic blood pressure (DBP) ≥90 mmHg or self-reported anti-hypertensive medication use during the survey.[25] We then categorized comorbidity into four groups such as respondents having DM and HTN (group A), DM and overweight (group B), HTN and overweight (group C) and group D in which individuals had all three conditions (DM, HTN and overweight).

Socio-demographic factors

We categorized age as older (defined as 56 years and above) and younger (35 to 55 years).[26] Education status was characterized into five levels: 1) no education, 2) preschool, 3) primary, 4) secondary and 5) college or higher. We categorized occupation as manual or non-manual worker and used principle component analysis to determine a wealth index was as described in the BDHS 2011 report.[21] Place of residence (urban and rural) and sex (male and female) were also included as important factors.

Statistical analysis

HTN, DM, overweight and obese (hereafter overweight) and all possible combinations of the comorbidity conditions were the main outcomes of interest. For analysis purposes, all outcomes were dichotomized into persons with or without the risk factor. Sex, age, education, occupation, wealth index and place of residence were included in analysis as independent variables. We calculated the prevalence of DM, HTN, overweight through percentage in the sample and used modified Poisson regression (PR) models with robust error variance to calculate prevalence ratios (PR) and 95% confidence interval for DM, HTN and overweight. These analyses were adjusted for cluster and sample weight and were done using IBMSPSS 21 (IBM Corp. Released 2012. IBMSPSS Statistics for Windows, Version 21.0. Armonk, NY: IBM Corp.).

Ethical consideration and patient involvement

Patients were not involved in the study. BDHS 2011 received ethical approval from ICF Macro Institutional Review Board, Maryland, USA and National Research Ethics Committee of

Bangladesh Medical Research Council (BMRC), Dhaka, Bangladesh. Written informed consent was taken from the participants before the survey was completed.

FINDINGS

The study population (n=8763) comprised 51% males, around 56% were 56 years of age or older, 62% reported no education, 25% were in manual employment, and 76% lived in rural locations (Table 1).

Table-1: General characteristics of the study population

Variables	n	%
Sex		
Male	4480	51.13
Female	4283	48.87
Age		
Younger	3603	55.77
Older	2858	44.23
Education		
College or higher	592	6.75
Secondary	1129	12.88
Primary	1634	18.64
No education, preschool	5409	61.72
Occupation		
Manual	2142	24.89
Non-manual	6464	75.11

Wealth index		
Poorest	1696	19.36
Poorer	1671	19.06
Middle	1692	19.31
Richer	1784	20.35
Richest	1921	21.92
Place of residence		
Rural	6623	75.58
Urban	2140	24.42

Among the sample 12% had diabetes, 27% had HTN and 22% were classified as overweight (BMI≥23kg/m^2). The probability of having diabetes and hypertension increased by increasing age group, whilst the probability of being overweight was higher in the younger age group (Figure 1). Prevalence of all these conditions were higher amongst males than females. The prevalence of group A (DM and HTN, n=270) and group B (DM and overweight, n=191) comorbidities was 3%, whilst 7% of the sample had group C comorbidity (HTN and overweight, n=513). One percent (1%) of the sample all three conditions (DM, HTN and overweight=104). Prevalence of all groups of comorbidity was higher in males than females, except for group B (DM and overweight) (Figure 2). The prevalence of individual conditions and all comorbidities was higher amongst older individuals, those with a 'College or higher' education, 'non-manual' workers, people in the richest quintile for wealth index and those living in urban environments (Table 2).

Variables	Diabetes (%, 95% CI)	Hypertension (%, 95% CI)	Overweight (%, 95% CI)	Group-A (%, 95% CI) (Diabetes and hypertension)	Group-B (%, 95% CI) (Diabetes and overweight)	Group-C (%, 95% CI) (Hypertension and overweight)	Group-D (%, 95% CI) (Diabetes, hypertension and overweight)
Age							
Younger	10.2 (9-11.5)	19.2 (17.4-21.1)	24.6 (22.7-26.5)	2.2 (1.7-2.9)	3.5 (2.8-4.4)	8.5 (7.4-9.8)	1.4 (1-2)
Older	14.7 (12.9-16.7)	38.7 (36.3-41.2)	18 (16.2-20)	5 (4.1-6.1)	3.3 (2.5-4.3)	10.1 (8.8-11.5)	2.3 (1.6-3.2)
Education							
Higher	22 (18.7-25.8)	33.1 (29.4-37)	53.9 (49-58.8)	7.7 (5.6-10.6)	8.6 (6.4-11.4)	17.5 (14.5-21)	4.3 (2.8-6.5)
Secondary	13.3 (11.4-15.4)	27.5 (24.9-30.3)	29.7 (26.4-33.2)	4.8 (3.7-6.1)	3.6 (2.6-4.8)	7.8 (6.3-9.8)	1.8 (1.1-2.9)
Primary	11.6 (10.2-13.3)	23.6 (21.4-25.9)	21 (18.6-23.6)	3.2 (2.5-4.3)	2.5 (1.9-3.4)	7.1 (5.8-8.5)	1.2 (0.8-1.8)
No education, preschool	9.5 (8.3-10.8)	28 (26.1-30)	13.3 (11.9-15)	2.5 (1.9-3.1)	1.2 (0.9-1.8)	5.2 (4.4-6.1)	0.8 (0.5-1.3)
Occupation							
Manual	6.8 (5.6-8.2)	14.4 (12.7-16.3)	10.5 (9.2-12.1)	1 (0.6-1.6)	0.8 (0.4-1.3)	2.7 (2-3.5)	0.4 (0.2-0.9)
Non-manual	13.4 (12.3-14.6)	31.5 (29.8-33.1)	27.7 (25.8-29.6)	4.3 (3.7-5)	3.2 (2.6-3.9)	8.8 (7.9-9.8)	1.7 (1.3-2.2)
Wealth index							
Poorest	8.4 (6.9-10.2)	20.6 (18.3-23.1)	6.6 (5.2-8.5)	1.7 (1.1-2.6)	0.6 (0.3-1.4)	2.2 (1.5-3.3)	0.4 (0.1-1.1)

169 **Table-2: Prevalence of individual conditions and comorbidities by characteristics**

Poorer	8.1 (6.4-10.2)	22.6 (20-25.4)	10.4 (8.6-12.7)	1.7 (1-2.8)	0.5 (0.2-1.2)	2.9 (2.1-4)	0.3 (0.1-0.9)
Middle	8.2 (6.7-9.9)	24.2 (21.9-26.6)	14.6 (12.3-17.2)	2 (1.3-2.9)	1 (0.5-1.8)	3.4 (2.5-4.7)	0.4 (0.2-1.1)
Richer	11.8 (9.9-14)	28.8 (26.4-31.3)	27.8 (24.7-31.1)	3.5 (2.6-4.7)	2.5 (1.8-3.5)	9.3 (7.9-11)	1.2 (0.7-1.9)
Richest	20.8 (18.6-23.3)	38.6 (36.3-41.1)	47.9 (44.8-51)	8.3 (6.8-10)	8 (6.5-9.8)	17.6 (15.6-19.7)	4.3 (3.2-5.7)
Place of residence							
Urban	16.5 (14.6-18.5)	33.3 (31.1-35.5)	37.4 (34.3-40.7)	6 (4.9-7.3)	5.5 (4.4-6.8)	12.9 (11.3-14.6)	3.1 (2.3-4.2)
Rural	10.3 (9.3-11.3)	25.3 (23.5-27.1)	17.1 (15.6-18.6)	2.7 (2.2-3.3)	1.7 (1.2-2.3)	5.4 (4.7-6.3)	0.8 (0.5-1.3)

170

The prevalence ratio (PR), from modified Poison regression models, of HTN, DM and overweight was significantly higher among those who had completed higher education, those living in urban areas, non-manual workers and those in the richer to richest socioeconomic status. Although there was no sex disparities for diabetes, HTN and overweight was higher amongst males. Overweight was the only condition that was significantly higher among younger participants (Table 3).

Table-3: Modified Poisson regression models showing prevalence ratios (PR) and 95% confidence intervals for diabetes, hypertension and overweight by demographic characteristics among Bangladeshi adults

Variables	Diabetes	Hypertension	Overweight
	PR (95% CI)	PR (95% CI)	PR (95% CI)
Sex			
Female	0.89 (0.74-1.08)	0.59 (0.53-0.65) **	0.7 (0.62-0.79) **
Male	Ref	Ref	Ref
Age #			
Older	1.48 (1.26-1.73) **	1.72 (1.56-1.88) **	0.75 (0.67-0.83) **
Younger	Ref	Ref	Ref
Education			
College or higher	1.71 (1.32-2.23) **	1.36 (1.15-1.61) **	2.11 (1.79-2.5) **
Secondary	1.16 (0.92-1.48)	1.13 (0.99-1.28)	1.56 (1.34-1.83) **
Primary	1.21 (0.99-1.48)	0.97 (0.87-1.08)	1.29 (1.12-1.5) **
No education, preschool	Ref	Ref	Ref

Occupation			
Non-manual##	1.54 (1.24-1.91) **	1.46 (1.28-1.68) **	1.62 (1.39-1.90) **
Manual	Ref	Ref	Ref
Wealth index			
Richest	1.63 (1.25-2.14) **	1.49 (1.29-1.72) **	4.3 (3.32-5.57) **
Richer	1.04 (0.79-1.35)	1.24 (1.08-1.42) **	3.07 (2.39-3.95) **
Middle	0.77 (0.58-1.03)	1.05 (0.91-1.21)	1.8 (1.38-2.36) **
Poorer	0.94 (0.71-1.24)	1.01 (0.87-1.16)	1.45 (1.09-1.92) **
Poorest	Ref	Ref	Ref
Place of residence			
Urban	1.1 (0.92-1.32)	1.05 (0.95-1.15)	1.09 (0.98-1.21)
Rural	Ref	Ref	Ref

Younger-(35–55 years and older (56 years or older) [23].

#*Non-manual category included sedentary workers, professionals (e.g., doctors, teachers, etc.), housewives, retired persons, those unable to work and unemployed [24].

**Statistical significance at $p<0.05$

In univariate Poisson regression models, those in the richest quintile of wealth index had the highest PR for all comorbidity groups. These differences remained significant in all models in a stepwise process (**Supplementary Table 1**). In final models, once controlling for sex, age, education, occupation and urbanization, those in the richest quintile were 2.3 times as likely to have DM and HTN, 4.8 times as likely to have DM and overweight, 4.9 times as likely to have HTN and overweight and 4.0 times as likely to have all three comorbidities, than those in the poorest quintile. In these final models, non-manual workers were also significantly more likely than manual workers to have all comorbidity groups. Sex differences were lost on controlling for other factor for all comorbidities groups, except Group C (HTN and overweight), for which females were 1.4 times as likely to experience both. Older participants were significantly more likely to have group A comorbidity (DM and HTN） DM and Group D (all comorbidities) (Table 4).

Table-4: Modified stepwise Poisson regression models showing prevalence ratios (PR) and 95% confidence intervals for comorbidities by demographic characteristics among Bangladeshi adults.

Model	Group-A (Diabetes and hypertension)	Group-B (Diabetes and overweight)	Group-C (Hypertension and overweight)	Group-D (Diabetes, hypertension and overweight)
Model-1 (Wealth index)				
Wealth index				
Richest	3.94 (2.42-6.41)**	9.69 (4.84-19.4) **	6.83 (4.66-10) **	8.67 (3.65-20.56) **
Richer	1.52 (0.88-2.61)	3.39 (1.61-7.16) **	3.78 (2.53-5.64) **	2.44 (0.95-6.31)
Middle	0.9 (0.47-1.71)	1.63 (0.69-3.81)	1.3 (0.81-2.07)	1.17 (0.37-3.7)
Poorer	0.9 (0.47-1.73)	0.81 (0.31-2.16)	1.13 (0.7-1.84)	0.79 (0.24-2.64)
Poorest	Ref	Ref	Ref	Ref
Model-6 (Wealth index + sex+ age + education+ occupation+ place of residence)				
Wealth index				
Richest	2.32 (1.32-4.1) **	4.84 (2.26-10.4) **	4.85 (3.25-7.24) **	3.99 (1.58-10.11) **

Richer	1.12 (0.66-1.91)	2.22 (1.02-4.8)	3.03 (2.04-4.49)	1.59 (0.65-3.92)
Middle	0.74 (0.39-1.38)	1.23 (0.54-2.82)	1.1 (0.69-1.75)	0.9 (0.31-2.64)
Poorer	0.78 (0.41-1.48)	0.71 (0.27-1.88)	1.06 (0.65-1.7)	0.7 (0.22-2.24)
Poorest	Ref	Ref	Ref	Ref
Sex				
Female	0.67 (0.35-1.31)	0.91 (0.47-1.78)	1.44 (1.06-1.96) **	1.05 (0.46-2.36)
Male	Ref	Ref	Ref	Ref
Age				
Older	2.17 (1.58-2.99) **	0.87 (0.62-1.21)	1.11 (0.91-1.35)	1.61 (1.05-2.49) **
Younger	Ref	Ref	Ref	Ref
Education				
College or higher	1.38 (0.85-2.25)	1.53 (0.93-2.5)	1.09 (0.82-1.45)	1.4 (0.74-2.63)
Secondary	1.06 (0.68-1.65)	1.33 (0.8-2.19)	0.91 (0.68-1.2)	1.24 (0.65-2.38)
Primary	1.03 (0.69-1.53)	1.42 (0.89-2.26)	1.18 (0.93-1.5)	1.25 (0.69-2.28)
No education, preschool	Ref	Ref	Ref	Ref
Occupational				

Non-manual	3.27 (1.94-5.52) **	4.22 (2.26-7.9) **	3.04 (2.19-4.22) **	3.69 (1.63-8.36) **
Manual	Ref	Ref	Ref	Ref
Place of residence				
Urban	1.33 (0.9-1.95)	1.17 (0.8-1.72)	1.04 (0.85-1.27)	1.72 (0.99-3.01)
Rural	Ref	Ref	Ref	Ref

** Statistical significance at p<0.05

DISCUSSION

This is the first study in Bangladesh that investigated individual and comorbid conditions using a nationally representative sample. We found that within the Bangladesh adult population, aged more than 35 years, the prevalence of diabetes was 12%, hypertension 27% and overweight 22%. Diabetes, hypertension and overweight were comparatively higher in males than females. More than 14% of the sample also had more than one condition, with 1.3% exhibiting all three. We also found that individual prevalence and comorbidity were higher in those of a higher socioeconomic status. Once controlling for several confounders, those in the richest quintile of wealth index were significantly more likely than those in the poorest quintile to exhibit comorbidities.

These findings demonstrate an alarming burden of NCDs within Bangladesh, with the rapid growth of overweight in the country becoming a particular public health concern.[27-29] As with many other developing countries, Bangladesh is experiencing a nutritional transition and increases in gross domestic product (GDP), which have been associated with multiple shifts in food intake and reduced physical activity.[30]

Although, to the authors knowledge, this is the first study on the prevalence of NCD risk factor comorbidity in Bangladesh using a nationally representative sample, a previous study had found an association between anthropometric indices such as body mass index (BMI),waist circumference(WC), waist hip ratio (WHR) and cardio metabolic risk indicators (FBG, SBP and DBP).[31] A further study in four geographical regions, including Bangladesh, reported that every standard deviation higher of BMI was associated with 1.65 and 1.60 times higher probability of

diabetes and 1.42 and 1.28 times higher probability of hypertension, for men and women, respectively.[32] Other studies have also found that HTN is a common comorbid condition in DM, and vice versa,[41] whilst there is considerable evidence for an increased prevalence of HTN in diabetic persons from other populations.[33, 34]

In the current study, overweight and diabetes risk was greater among young people which is consistent with a similar study conducted in Indonesia.[35] Diabetes, hypertension and overweight were more prevalent in non-manual labor compared to manual labor, which was similar to findings from a study in Barbados.[36] However, the present study found males were more likely to suffer comorbidities than females, contradicting findings from previous studies.[37,38] We also found that the prevalence of individual conditions (diabetes, hypertension and overweight) along with the comorbidity of them, was higher in urban areas compared to rural, which is consistent with a number of studies conducted in developing countries, including Bangladesh.[39-44]

Within our study we found a higher prevalence of individual conditions and comorbidities in higher socioeconomic groups. These findings conflict with trends reported by previous studies conducted in higher-income countries.[45, 46] However, another multi-country study reported that comorbidity was more prevalent among the poor and less educated in low income countries.[47] However, these findings were based on self-reported diagnosis, which may introduce concerns of report and recall bias. Previous research in INDEPTH Asian sites has reported inverse associations between comorbidity and markers of socioeconomic status.[48]

The main implications of the present study are the increased burden of NCDs within Bangladesh, along with other LMICs, and the patterning of more than one risk factor within individuals in the population. In contrast to findings from high income countries, prevalence of

individual risk factors and comorbidities was higher in higher SES groups. This points to differences between countries in the population level determinants of NCDs and highlights that context specific interventions must be developed to counter them. As a first step, it is important that countries collect and analyse high quality health data to allow them to develop and target interventions.

STRENGTHS AND LIMITATIONS

The main strengths of the study were the large nationally representative sample and the collection of blood pressure, blood glucose concentration, body weight, and height measurements by health technicians follow standard methods, including biomarker analysis, along with validated measures of socio-economic status. The main weakness of the study is the cross-sectional nature, meaning that only associations can be inferred and causality cannot be determined. In addition although clinical measures of diabetes, hypertension and overweight were taken, no measurements of blood lipids were taken in the survey, meaning that metabolic syndrome could not be investigated. Waist and hip circumference were also not collected, limiting the analysis that could be performed. Finally although the study was reported to be representative, only participants 35 years or older had measured anthropometry and biomarkers meaning that the findings reflect this population of adults in the country.

CONCLUSION

In contrast to more affluent countries, individuals of higher socio-economic status in Bangladesh are more likely to exhibit NCD risk factors and comorbidities than individuals from with lower SES status. It is important that we identify the patterning of these conditions within countries if we are to develop effective public health approaches contextualized to the population. This can be done through improved monitoring and surveillance of NCDs, linked to primary care programmes. Such approaches also need policy and system changes, supported by "political will", societal and community support.

Contributors

TB, NT, SKD & AAM conceptualized the study. TB, NT, SKD, RDG & AAM designed the study and acquired the data. TB, SI & MRI conducted the data analysis. TB, NT, SI, MRI, SKD & AAM interpreted the data. TB, NT & RDG prepared the first draft. TB, NT, SKD & AAM participated in critical revision of the manuscript and contributed to its intellectual improvement. All authors went through the final draft and approved it for submission.

Funding

None.

Acknowledgments

The authors thank MEASURE DHS for permission to use data from the 2011 Bangladesh DHS. The authors are also grateful to Mr. Mehedi Hasan, PhD student, University of Queensland, Australia.

Competing Interests

None declared.

Patient consent

None Declared

Disclaimer

The authors are alone responsible for the integrity and accuracy of data analysis and the writing the manuscript.

Ethics approval

The datasets were obtained from DHS Programme with proper procedure. The study exempt from collecting ethical approval because the survey protocols were reviewed and approved by ICF Macro Institutional Review Board, Maryland, USA and National Research Ethics Committee of Bangladesh Medical Research Council (BMRC), Dhaka, Bangladesh.

Data sharing statement

The dataset of BDHS 2011 is available at the Demographic and Health Surveys Program. Extra data is available which is available on request at http://dhsprogram-com/what-we-do/survey/survey-display-349.cfm.

References:

1. Murray CJ, Vos T, Lozano R, et al. Disability-adjusted life years (DALYs) for 291 diseases and injuries in 21 regions, 1990–2010: a systematic analysis for the Global Burden of Disease Study 2010. *Lancet.* 2013;380(9859):2197-223. doi: 10.1016/S0140-6736(12)61689-4.

2. Lozano R, Naghavi M, Foreman K, et al. Global and regional mortality from 235 causes of death for 20 age groups in 1990 and 2010: a systematic analysis for the Global Burden of Disease Study 2010. *Lancet.* 2013;380(9859):2095-128. doi: 10.1016/S0140-6736(12)61728-0

3. Bennett D, Bisanzio D, Deribew A, et al. Global, regional, and national under-5 mortality, adult mortality, age-specific mortality, and life expectancy, 1970–2016: a systematic analysis for the Global Burden of Disease Study 2016. *Lancet.* 2017;390(10100):1084-1150. doi: 10.1016/s0140-6736(17)31833-0.

4. World Health Organization. Global status report on noncommunicable diseases 2010. Geneva: World Health Organization; 2011. 161 p.

5. Abegunde DO, Mathers CD, Adam T, et al. The burden and costs of chronic diseases in low-income and middle-income countries. *Lancet.* 2007;370(9603):1929-38. doi: 10.1016/S0140-6736(07)61696-1

6. Lee JT, Hamid F, Pati S, et al. Impact of noncommunicable disease multimorbidity on healthcare utilisation and out-of-pocket expenditures in middle-income countries: cross sectional analysis. *PLoS One.* 2015;10(7):e0127199. doi: 10.1371/journal.pone.0127199.

7. World Health Organization. Global status report on noncommunicable diseases 2014. Geneva: World Health Organization; 2015. 280 p.

8. Streatfield PK, Karar ZA. Population challenges for Bangladesh in the coming decades. J Health Popul Nutr. 2008;26(3):261.

9. National Institute of Population Research and Training (NIPORT), Mitra and Associates, ICF International. Bangladesh Urban Health Survey 2013.. Dhaka, Bangladesh, Calverton, Maryland, USA: NIPORT, Mitra and Associates, and ICF International., 2015.

10. Ahsan KZ, Alam MN, Streatfield PK, et al. Has Bangladesh Entered the Fourth Stage of the Epidemiologic Transition?. Proceedings of the International seminar on Mortality: Past, Present and Future; 2017Aug 7-8; the University of Campinas, Brazil.

11. Zaman MM, Bhuiyan MR, Karim MN, et al. Clustering of non-communicable diseases risk factors in Bangladeshi adults: an analysis of STEPS survey 2013. *BMC Public Health.* 2015;15(1):659. doi: 10.1186/s12889-015-1938-4.

12. Hillas G, Perlikos F, Tsiligianni I, et al. Managing comorbidities in COPD. *Int J Chron Obstruct Pulmon Dis*.2015;10:95. doi: 10.2147/COPD.S54473.

13. Roberts KC, Rao DP, Bennett TL, et al. Prevalence and patterns of chronic disease multimorbidity and associated determinants in Canada. *Health Promot Chronic Dis Prev Can.* 2015 ;35(6):87-94.

14. Wang J, Ma JJ, Liu J, et al. Prevalence and Risk Factors of Comorbidities among Hypertensive Patients in China. *Int J Med Sci.* 2017;14(3):201. doi: 10.7150/ijms.16974.

15. Hurst C, Thinkhamrop B. The association between hypertension comorbidity and microvascular complications in type 2 diabetes patients: A nationwide cross-sectional study in Thailand. *Diabetes Metab J.* 2015;39(5):395-404. doi: 10.4093/dmj.2015.39.5.395

19. Allen L, Williams J, Townsend N, et al. Socioeconomic status and non-communicable disease behavioural risk factors in low-income and lower-middle-income countries: a systematic review. *Lancet Glob Health.* 2017;5(3):e277-e89. doi: 10.1016/S2214-109X(17)30058-X.

20. Varghese C. Reducing premature mortality from non-communicable diseases, including for people with severe mental disorders. *World Psychiatry.* 2017;16(1):45-7. doi: 10.1002/wps.20376.

21. National Institute of Population Research and Training (NIPORT), Mitra and Associates, ICF International. Bangladesh Demographic and Health Survey 2011, Preliminary Report. Dhaka, Bangladesh, Calverton, Maryland, USA: NIPORT, Mitra and Associates, and ICF International., 2012.

22. Biswas T, Islam MS, Linton N, et al. Socio-economic inequality of chronic non-communicable diseases in Bangladesh. *PloS One.* 2016;11(11):e0167140. doi: 10.1371/journal.pone.0167140.

23. Akter S, Rahman MM, Abe SK, et al. Prevalence of diabetes and prediabetes and their risk factors among Bangladeshi adults: a nationwide survey. *Bull World Health Organ.* 2014;92(3):204-13A. doi: 10.2471/BLT.13.128371.

24. Ke-You G, Da-Wei F. The magnitude and trends of under-and over-nutrition in Asian countries. *Biomed Environ Sci.* 2001;14(1-2):53-60.

25. National Institute of Population Research and Training (NIPORT), Mitra and Associates, ICF International. Bangladesh Demographic and Health Survey 2011. Dhaka, Bangladesh, Calverton, Maryland, USA: NIPORT, Mitra and Associates, and ICF International., 2013.

26. Rahman M, Williams G, Al Mamun A. Hypertension and diabetes prevalence among adults with moderately increased BMI (23· 0–24· 9 kg/m 2): findings from a nationwide survey in Bangladesh. *Public Health Nutr.* 2017:1-8. doi: 10.1017/S1368980016003566.

27. Biswas T, Uddin MJ, Al Mamun A, et al. Increasing prevalence of overweight and obesity in Bangladeshi women of reproductive age: Findings from 2004 to 2014. *PloS One.* 2017;12(7):e0181080. doi: 10.1371/journal.pone.0181080.

28. Hoque ME, Hasan MT, Rahman M, et al. Double burden of underweight and overweight among Bangladeshi adults differs between men and women: evidence from a nationally representative survey. *Public Health Nutr.*2017;20(12):2183-91. doi: 10.1017/S1368980017000957.

29. Biswas T, Garnett SP, Pervin S, et al. The prevalence of underweight, overweight and obesity in Bangladeshi adults: Data from a national survey. *PloS One.* 2017;12(5):e0177395. doi: 10.1371/journal.pone.0177395.

30. Dietz WH. Double-duty solutions for the double burden of malnutrition. *Lancet.* 2017. doi: 10.1016/S0140-6736(17)32479-0.

31. Bhowmik B, Afsana F, Ahmed T, et al. Obesity and associated type 2 diabetes and hypertension in factory workers of Bangladesh. *BMC Res Notes.*2015;8(1):460. doi: 10.1186/s13104-015-1377-4.

32. Pradeepa R. The rising burden of diabetes and hypertension in southeast asian and african regions: need for effective strategies for prevention and control in primary health care settings. *Int J Hypertens.* 2013;2013. doi: 10.1155/2013/409083.

33. Berraho M, El Achhab Y, Benslimane A, et al. Hypertension and type 2 diabetes: a cross-sectional study in Morocco (EPIDIAM Study). *Pan Afr Med J.* 2012;11(1).

34. Hashemizadeh H, Sarvelayati D. Hypertension and Type 2 Diabetes: A Cross-sectional Study in Hospitalized Patients in Quchan, Iran. *Iran J Diabetes Obesity.* 2013;5(1):21-6.

35. Hussain MA, Huxley RR, Al Mamun A. Multimorbidity prevalence and pattern in Indonesian adults: an exploratory study using national survey data. BMJ Open. 2015;5(12):e009810. doi: 10.1136/bmjopen-2015-009810.

36. Howitt C, Hambleton IR, Rose AM, et al. Social distribution of diabetes, hypertension and related risk factors in Barbados: a cross-sectional study. *BMJ Open.* 2015;5(12):e008869. doi: 10.1136/bmjopen-2015-008869.37. Pearson TA. Education and income: double-edged swords in the epidemiologic transition of cardiovascular disease. *Ethn Dis.* 2003;13(2; SUPP/2):S2-158.

38. Agborsangaya CB, Lau D, Lahtinen M, et al. Multimorbidity prevalence and patterns across socioeconomic determinants: a cross-sectional survey. *BMC Public Health*. 2012;12(1):201. doi: 10.1186/1471-2458-12-201.

39. Rahman M, Williams G, Al Mamun A. Gender differences in hypertension awareness, antihypertensive use and blood pressure control in Bangladeshi adults: findings from a national cross-sectional survey. *J Health Popul Nutr.*2017;36(1):23. doi: 10.1186/s41043-017-0101-5.

40. Li G, Hu H, Dong Z, et al. Urban and suburban differences in hypertension trends and self-care: Three population-based cross-sectional studies from 2005-2011. *PloS One.* 2015;10(2):e0117999. doi: 10.1371/journal.pone.0117999.

41. Sola A, Chinyere O, Stephen A, et al. Hypertension prevalence in an urban and rural area of Nigeria. *J Med Sci.* 2013;4:149-54.

42. Dhungana RR, Pandey AR, Bista B, et al. Prevalence and associated factors of hypertension: a community-based cross-sectional study in municipalities of Kathmandu, Nepal. *Int J Hypertens.*2016;2016. doi: 10.1155/2016/1656938.

43. Chowdhury MAB, Uddin MJ, Haque MR, et al. Hypertension among adults in Bangladesh: evidence from a national cross-sectional survey. *BMC Cardiovasc Disord.* 2016;16(1):22. doi: 10.1186/s12872-016-0197-3.

44. Akter S, Rahman MM, Abe SK, et al. Prevalence of diabetes and prediabetes and their risk factors among Bangladeshi adults: a nationwide survey. *Bull World Health Organ.*2014;92(3):204-13A. doi: 10.2471/BLT.13.128371

45. Connolly V, Unwin N, Sherriff P, et al. Diabetes prevalence and socioeconomic status: a population based study showing increased prevalence of type 2 diabetes mellitus in deprived areas. *J Epidemiol Community Health*.2000;54(3):173-7.

46. Glover JD, Hetzel DM, Tennant SK. The socioeconomic gradient and chronic illness and associated risk factors in Australia. *Aust New Zealand Health Policy.* 2004;1(1):8. doi: 10.1186/1743-8462-1-8.

47. Hosseinpoor AR, Bergen N, Mendis S, et al. Socioeconomic inequality in the prevalence of noncommunicable diseases in low-and middle-income countries: results from the World Health Survey. *BMC Public Health.* 2012;12(1):474. doi: 10.1186/s12889-015-2227-y.

48. Van Minh H, Ng N, Juvekar S, et al. Self-reported prevalence of chronic diseases and their relation to selected sociodemographic variables: a study in INDEPTH Asian sites, 2005. *Prev Chronic Dis*.2008;5(3).

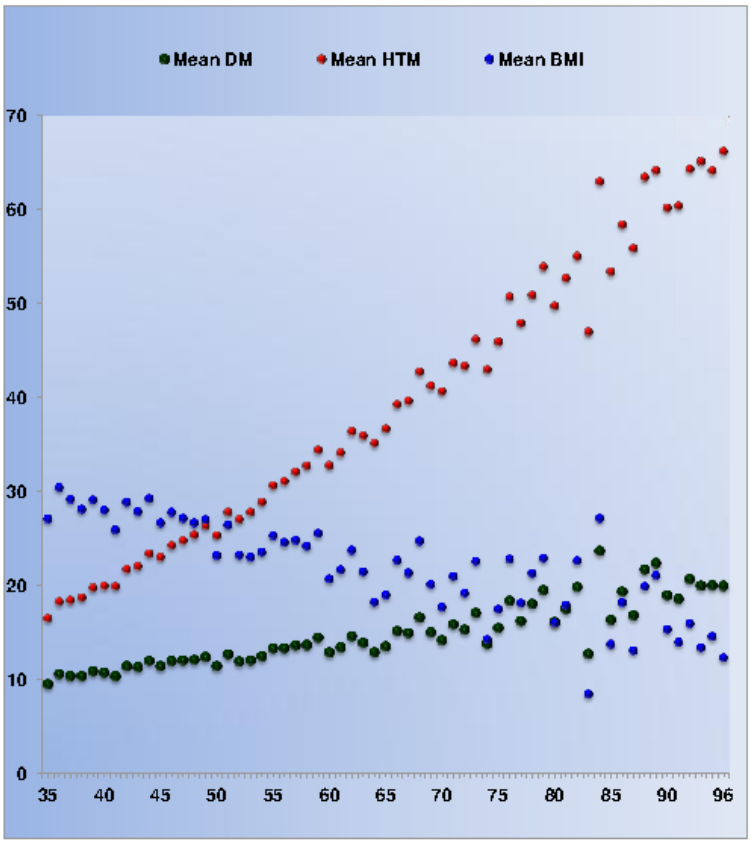
Figures:

Fig 1. Scatter plot between age with blood glucose, systolic blood pressure, diastolic blood pressure and BMI.

Fig 2. Prevalence of diabetes, hypertension, overweight and comorbidity by sex among Bangladeshi adults

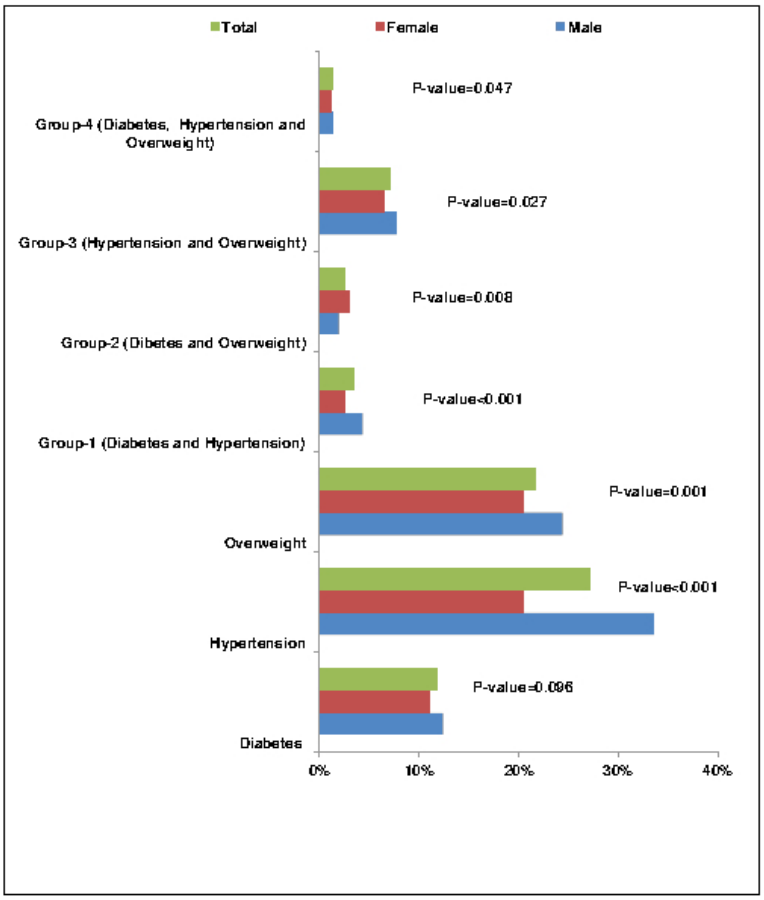
Supplementary Materials:

Supplementary Table 1: Modified stepwise Poisson regression models showing prevalence ratios (PR) and 95% confidence intervals for comorbidities by demographic characteristics among Bangladeshi adults.



Predictive probability of diabetes, hypertension and BMI by age

215x279mm (72 x 72 DPI)



Prevalence of diabetes, hypertension, overweight and co-morbidity by sex among Bangladeshi adults

215x279mm (72 x 72 DPI)

Supplementary Table 1: Modified stepwise Poisson regression models showing prevalence ratios (PR) and 95% confidence intervals for co-morbidities by demographic characteristics among Bangladeshi adults.

	Group-A (Diabetes and hypertension)	Group-B (Diabetes and overweight)	Group-C (Hypertension and overweight)	Group-D (Diabetes, hypertension and overweight)
Model-1 (Wealth index)				
Wealth index				
Richest	3.94 (2.42-6.41)**	9.69 (4.84-19.4) **	6.83 (4.66-10) **	8.67 (3.65-20.56) **
Richer	1.52 (0.88-2.61)	3.39 (1.61-7.16) **	3.78 (2.53-5.64) **	2.44 (0.95-6.31)
Middle	0.9 (0.47-1.71)	1.63 (0.69-3.81)	1.3 (0.81-2.07)	1.17 (0.37-3.7)
Poorer	0.9 (0.47-1.73)	0.81 (0.31-2.16)	1.13 (0.7-1.84)	0.79 (0.24-2.64)
Poorest	Ref	Ref	Ref	Ref
Model-2 (Wealth index + sex)				
Wealth index				
Richest	3.93 (2.42-6.39) **	9.68 (4.84-19.35) **	6.88 (4.7-10.08) **	8.69 (3.68-20.5) **
Richer	1.51 (0.88-2.6)	3.39 (1.61-7.14) **	3.82 (2.56-5.69) **	2.45 (0.96-6.3)
Middle	0.9 (0.47-1.71)	1.62 (0.69-3.8)	1.31 (0.82-2.09)	1.17 (0.37-3.69)
Poorer	0.89 (0.47-1.71)	0.81 (0.31-2.15)	1.16 (0.72-1.89)	0.8 (0.24-2.63)
Poorest	Ref	Ref	Ref	Ref
Sex				
Female	0.85 (0.43-1.66)	0.95 (0.49-1.85)	1.66 (1.22-2.26) **	1.21 (0.53-2.74)
Male	Ref	Ref	Ref	Ref
Model-3 (Wealth index + sex+ age)				
Wealth index				
Richest	4.04 (2.49-6.56) **	9.65 (4.82-19.3) **	6.92 (4.73-10.13) **	8.82 (3.74-20.82) **
Richer	1.51 (0.88-2.59)	3.4 (1.61-7.14) **	3.81 (2.55-5.67) **	2.44 (0.95-6.26)
Middle	0.88 (0.46-1.67)	1.63 (0.7-3.81)	1.3 (0.81-2.07)	1.15 (0.37-3.65)
Poorer	0.86 (0.45-1.64)	0.82 (0.31-2.15)	1.15 (0.71-1.87)	0.78 (0.24-2.57)
Poorest	Ref	Ref	Ref	Ref
Sex				
Female	0.75 (0.39-1.46)	0.97 (0.5-1.88)	1.61 (1.18-2.19) **	1.13 (0.5-2.54)
Male	Ref	Ref	Ref	Ref
Age				
Older	2.34 (1.71-3.2) **	0.88 (0.65-1.2)	1.23 (1.03-1.47) **	1.6 (1.05-2.42) **
Younger	Ref	Ref	Ref	Ref
Model-4 (Wealth index + sex+ age + education)				
Wealth index				
Richest	3.62 (2.16-6.07) **	7.84 (3.74-16.45) **	6.76 (4.55-10.03) **	7.56 (3.11-18.42) **
Richer	1.45 (0.84-2.51)	2.98 (1.37-6.5)	3.77 (2.53-5.63) **	2.24 (0.87-5.8)
Middle	0.87 (0.46-1.64)	1.5 (0.65-3.5)	1.28 (0.81-2.05)	1.1 (0.36-3.36)

Poorer	0.85 (0.45-1.63)	0.78 (0.29-2.09)	1.15 (0.71-1.86)	0.77 (0.23-2.51)
Poorest	Ref	Ref	Ref	Ref
Sex				
Female	0.76 (0.39-1.49)	1.04 (0.53-2.05)	1.62 (1.18-2.22) **	1.19 (0.52-2.71)
Male	Ref	Ref	Ref	Ref
Age				
Older	2.45 (1.79-3.36) **	0.97 (0.7-1.34)	1.25 (1.04-1.51) **	1.72 (1.11-2.65) **
Younger	Ref	Ref	Ref	Ref
Education				
College or higher	1.54 (0.96-2.5)	1.73 (1.06-2.83) **	1.21 (0.91-1.61)	1.59 (0.85-2.97)
Secondary	0.97 (0.62-1.51)	1.22 (0.74-2.01)	0.84 (0.64-1.12)	1.12 (0.59-2.15)
Primary	0.96 (0.64-1.42)	1.35 (0.85-2.14)	1.13 (0.9-1.43)	1.17 (0.65-2.11)
No education, preschool	Ref	Ref	Ref	Ref
Model-5 (Wealth index + sex+ age + education+ occupation)				
Wealth index				
Richest	2.72 (1.6-4.61) **	5.3 (2.54-11.05) **	4.97 (3.37-7.33) **	5.47 (2.32-12.91) **
Richer	1.18 (0.69-2.04)	2.29 (1.06-4.95) **	3.06 (2.06-4.53) **	1.79 (0.71-4.49)
Middle	0.75 (0.4-1.41)	1.24 (0.54-2.85)	1.11 (0.7-1.76)	0.93 (0.31-2.76)
Poorer	0.78 (0.41-1.49)	0.72 (0.27-1.88)	1.06 (0.65-1.7)	0.7 (0.22-2.26)
Poorest	Ref	Ref	Ref	Ref
Sex				
Female	0.67 (0.35-1.31)	0.91 (0.47-1.78)	1.44 (1.06-1.96) **	1.05 (0.47-2.37)
Male	Ref	Ref	Ref	Ref
Age				
Older	2.13 (1.54-2.94) **	0.86 (0.62-1.19)	1.11 (0.91-1.34)	1.54 (1.00-2.38) **
Younger	Ref	Ref	Ref	Ref
Education				
College or higher	1.4 (0.86-2.28)	1.54 (0.94-2.51)	1.09 (0.82-1.45)	1.44 (0.77-2.71)
Secondary	1.05 (0.67-1.64)	1.32 (0.8-2.18)	0.9 (0.68-1.2)	1.22 (0.63-2.35)
Primary	1.03 (0.69-1.53)	1.41 (0.89-2.25)	1.18 (0.93-1.49)	1.24 (0.68-2.26)
No education, preschool	Ref	Ref	Ref	Ref
Occupational				
Non-manual	3.32 (1.97-5.59) **	4.25 (2.27-7.97) **	3.04 (2.19-4.23) **	3.79 (1.67-8.61) **
Manual	Ref	Ref	Ref	Ref
Model-5 (Wealth index + sex+ age + education+ occupation+ place of residence)				
Wealth index				
Richest	2.32 (1.32-4.1) **	4.84 (2.26-10.4) **	4.85 (3.25-7.24) **	3.99 (1.58-10.11) **
Richer	1.12 (0.66-1.91)	2.22 (1.02-4.8)	3.03 (2.04-4.49)	1.59 (0.65-3.92)
Middle	0.74 (0.39-1.38)	1.23 (0.54-2.82)	1.1 (0.69-1.75)	0.9 (0.31-2.64)
Poorer	0.78 (0.41-1.48)	0.71 (0.27-1.88)	1.06 (0.65-1.7)	0.7 (0.22-2.24)

Poorest	Ref	Ref	Ref	Ref
Sex				
Female	0.67 (0.35-1.31)	0.91 (0.47-1.78)	1.44 (1.06-1.96) **	1.05 (0.46-2.36)
Male	Ref	Ref	Ref	Ref
Age				
Older	2.17 (1.58-2.99) **	0.87 (0.62-1.21)	1.11 (0.91-1.35)	1.61 (1.05-2.49) **
Younger	Ref	Ref	Ref	Ref
Education				
College or higher	1.38 (0.85-2.25)	1.53 (0.93-2.5)	1.09 (0.82-1.45)	1.4 (0.74-2.63)
Secondary	1.06 (0.68-1.65)	1.33 (0.8-2.19)	0.91 (0.68-1.2)	1.24 (0.65-2.38)
Primary	1.03 (0.69-1.53)	1.42 (0.89-2.26)	1.18 (0.93-1.5)	1.25 (0.69-2.28)
No education, preschool	Ref	Ref	Ref	Ref
Occupational				
Non-manual	3.27 (1.94-5.52) **	4.22 (2.26-7.9) **	3.04 (2.19-4.22) **	3.69 (1.63-8.36) **
Manual	Ref	Ref	Ref	Ref
Place of residence				
Urban	1.33 (0.9-1.95)	1.17 (0.8-1.72)	1.04 (0.85-1.27)	1.72 (0.99-3.01)
Rural	Ref	Ref	Ref	Ref

BMJ Open

Association between high socioeconomic status with greater prevalence of non-communicable diseases risk factors and comorbidities in Bangladesh: Findings from a nationwide cross-sectional survey

Journal:	*BMJ Open*
Manuscript ID	bmjopen-2018-025538.R2
Article Type:	Research
Date Submitted by the Author:	22-Jan-2019
Complete List of Authors:	Biswas, Tuhin; International Centre for Diarrhoeal Disease Research Bangladesh, Townsend, Nick Islam, Md.saimul; University of Rajshahi, Departmnet of Statistics; Islam, Md. Rajibul ; Health Intervention and Technology Assessment Program (HITAP),Ministry of Public Health, Nonthaburi, Thailand Das Gupta, Rajat; BRAC University James P Grant School of Public Health, Das, Sumon Mamun, Abdullah; University of Queensland, School of Population Health
Primary Subject Heading:	Epidemiology
Secondary Subject Heading:	Public health, Diabetes and endocrinology, Cardiovascular medicine
Keywords:	Overweight, DIABETES & ENDOCRINOLOGY, Hypertension < CARDIOLOGY

Title: Association between high socioeconomic status with greater prevalence of non-communicable diseases risk factors and comorbidities in Bangladesh: Findings from a nationwide cross-sectional survey

Authors:

Tuhin Biswas[1,2*], Nick Townsend[3], Md. Saimul Islam[4],Md. Rajibul Islam[5], Rajat Das Gupta[6,7], Sumon Kumar Das[2], Abdullah Al Mamun[2]

Affiliations:

[1] Universal Health Coverage, Health Systems and Population Studies Division, icddr,b, Mohakhali, Dhaka, Bangladesh

[2]Institute for Social Science Research, The University of Queensland, Long Pocket Precinct, Indooroopilly, Queensland, Australia.

[3] Department for Health, University of Bath, United Kingdom

[4] University Rajshahi, Rajshahi, Bangladesh.

[5] Health Intervention and Technology Assessment Program (HITAP), Ministry of Public Health, Nonthaburi, Thailand.

[6] Centre for Non-Communicable Diseases and Nutrition, BRAC James P Grant School of Public Health, BRAC University, Dhaka, Bangladesh

[7] Centre for Science of Implementation and Scale-Up, BRAC James P Grant School of Public Health, BRAC University, Dhaka, Bangladesh

***Corresponding author:**

Biswas Tuhin

Health Systems and Population Studies Division, icddr,b, Mohakhali, Dhaka, Bangladesh; Institute for Social Science Research, The University of Queensland, Long Pocket Precinct, Indooroopilly, Queensland, Australia.

Email: tuhin_sps04@yahoo.com

ABSTRACT

Objectives: This study aimed to examine the prevalence and distribution in the comorbidity of non-communicable diseases (NCD) among the adult population in Bangladesh by measures of socioeconomic status (SES).

Design: This was a cross-sectional study.

Setting: This study used Bangladesh Demographic and Health Survey (2011) data.

Participants: Total 8,763 individuals aged ≥35 years were included.

Primary and secondary outcome measures: The primary outcome measures were diabetes (DM), hypertension (HTN) and overweight/obesity. The study further assesses factors (in particular socioeconomic status) associated with these comorbidities (diabetes (DM), hypertension (HTN) and overweight/obesity).

Results: Of 8,763 adults**,** 12% had DM, 27% HTN and 22% were overweight/obese (BMI≥23kg/m^2). Just over 1% of the sample had all three conditions, 3% had both DM and HTN, 3% DM and overweight and 7% HTN and overweight. Diabetes, hypertension and overweight were more prevalent those who had higher education, were non-manual workers, were in the richer to richest socioeconomic status and lived in urban settings. Individuals in higher SES groups were also more likely to suffer from comorbidities. In the multivariable analysis, it was found that individual belonging to the richest wealth quintile had the highest odds of having hypertension (Adjusted Odds Ratio (AOR): 1.49, 95% Confidence Interval (CI): 1.29-1.72), diabetes (AOR: 1.63, 95% CI: 1.25-2.14) and obesity (AOR: 4.3, 95% CI: 3.32-5.57).

Conclusions: In contrast to more affluent countries, individuals with NCD risk factors and comorbidities are more common in higher socio-economic status individuals. Public health approaches must consider this social patterning in tackling NCDs in the country.

Key words: Overweight, Diabetes, Hypertension, Non-communicable Disease, socioeconomic status, Bangladesh

STRENGTHS AND LIMITATIONS OF THE STUDY

- The biggest strength of the study is that it utilized a large dataset nationally representative of the Bangladesh population, collected using measures that have been designed and validated through previous data collections in the country.
- Data collection included clinical measures of blood pressure, blood glucose concentration, body weight, and height collected by a health technician.
- The main weakness of the study is that it is cross-sectional in nature, meaning that only associations can be inferred and causality cannot be determined.

INTRODUCTION

According to the Global Burden of Disease report, non-communicable diseases (NCDs) are the leading cause of death worldwide[1-3] and that 80% of this NCD mortality actually occurs in low- and middle-income countries (LMICs)[4-6]. Similarly, the 2014 NCDs global status report showed that of 58 million deaths that occurred globally in 2012, 38 million - almost two thirds - were due to NCDs, with these deaths most due to the four most common NCDs: cardiovascular diseases, cancers, diabetes and chronic lung diseases.[7.] In addition, the report showed that more than 40% of these deaths (16 million) occurred were in individuals under the age of 70 years, often referred to as premature deaths[7]. Deaths at younger ages may be a greater demonstration of its burden, as many consider them preventable. It is alarming, therefore, that the majority of premature deaths (82%) occur in LMICs, with this problem likely to increase if appropriate preventative actions are not taken at a population level.

Like many LMICs, Bangladesh is undergoing rapid urbanization with changing patterns of diseases among the population[8, 9], with some suggesting that the country is at an advanced phase of the third stage of the epidemiologic transition, with deaths from NCDs expected to increase rapidly in the coming years.[10] This increasing mortality from NCDs in the country is supported by high prevalence of the medical risk factors associated with NCDs. A recent WHO STEPS survey in Bangladesh reported that 21% of the population had hypertension, 26% were overweight and 5% had documented diabetes.[11]

These high prevalence figures, raise concerns of comorbidity, in which individuals suffer from more than one of the risk factors at a time, with this thought to be highly predictive of end point diseases, disability and death.[12]. There is evidence of comorbidity risk for factors including

obesity, diabetes and hypertension, predominantly coming from industrialized countries [13-15] and developing nations[16-18]; however evidence on NCD comorbidity scant in Bangladesh. This is important as the patterning of NCDs is not uniform across countries of different income classification, with a higher prevalence of some NCD risk factors, such as diabetes, found in higher socio-economic groups in many studies in LMICs, contradicting those from higher income countries.[19]

With the development of a double burden from both over- and under-nutrition in these LMICs, understanding comorbidity and their correlates is important if we are to develop NCD preventative policies contextualized for these countries. Despite the availability of nationwide survey data in Bangladesh, the prevalence, and in particular the comorbidity of NCD medical risk factors remains unmapped. This understanding of the burden and patterning of NCDs and their risk factors is important if Bangladesh is able to meet the Sustainable Development Goals (SDGs) target of reducing premature death from NCDs by one third by 2030.[20]

This study used 2011 Bangladesh Demography and Health Survey (BDHS) data to estimate the prevalence and pattern of NCD risk factors and comorbidity among the general population aged 35 years and older, as well as determining their socio-demographic patterning and possible predictors of comorbidity .

METHODS

Study design

This study used data from the 2011 Bangladesh Demography and Health Survey (BDHS). The 2011 BDHS is a cross-sectional nationally representative survey that was

conducted between July and December 2011 through the collaboration of the National Institute of Population Research and Training (NIPORT), ICF International (USA), and Mitra and Associates. Participants in the BDHS were selected using probability sampling based on a two-stage cluster sample of households, and stratified by rural and urban areas in the seven administrative regions of Bangladesh. The detailed protocol and methods have been published previously.[21] In brief, 17,500 households were surveyed, of which one in three households were randomly selected for biomarker measurement (blood glucose, blood pressure). All men and women age 35 years and above were eligible for the biomarker measures, with these collected from a final sample of 8,835 individuals (male: 4524, female: 4311). [22] We included 8763 cases in our analytical sample, after excluding cases with missing values.

Measurements of outcomes

A data collection team, including a health technician, measured blood pressure, blood glucose concentration, body weight, and height using standard methods.[21] Diabetes (DM) was defined as a fasting blood glucose level greater than or equal to 7.0 mmol/L or self-reported diabetes medication use.[23] Body mass index (BMI) was calculated as weight (kg)/height (m^2). We used Asian specific BMI cut-offs to define underweight as <18.5 kg/m^2 and overweight and obese (higher BMI) as ≥23kg/m^2.[24] Hypertension was defined as systolic blood pressure (SBP) ≥140 mmHg and diastolic blood pressure (DBP) ≥90 mmHg or self-reported anti-hypertensive medication use during the survey.[25] We then categorized comorbidity into four groups such as respondents having DM and HTN (group A), DM and overweight/obesity(group B), HTN and overweight/obesity (group C) and group D in which individuals had all three conditions (DM, HTN and overweight/obesity).

Socio-demographic factors

We categorized age as older (defined as 56 years and above) and younger (35 to 55 years).[26] Education status was characterized into five levels: 1) no education, 2) preschool, 3) primary, 4) secondary and 5) college or higher. We categorized occupation as manual or non-manual worker and used principle component analysis to determine a wealth index was as described in the BDHS 2011 report.[21] Place of residence (urban and rural) and sex (male and female) were also included as important factors.

Statistical analysis

HTN, DM, overweight/obesity and all possible combinations of the comorbidity conditions were the main outcomes of interest. For analysis purposes, all outcomes were dichotomized into persons with or without the risk factor. Sex, age, education, occupation, wealth index and place of residence were included in analysis as independent variables. We calculated the weighted prevalence of DM, HTN, overweight/obesity through percentage in the sample and used modified Poisson regression （PR) models with robust error variance to calculate prevalence ratios (PR) and 95% confidence interval for DM, HTN and overweight. These analyses were adjusted for cluster and sample weight and were done using IBMSPSS 21 (IBM Corp. Released 2012. IBMSPSS Statistics for Windows, Version 21.0. Armonk, NY: IBM Corp.). We also calculated the power to assess whether the existing sample size is enough for performing the multivariable regression models. The variables sex, age, education, occupation are control variables and not of primary research interest. The variable wealth index is our primary interest to assess the association with the joint estimates of NCDs. We have converted

the log (PR) to calculate the effect size by the formula d= log (prevalence ratio) × (√3/π). The primary research hypothesis was to test the wealth index from poorer to richest groups with the joint estimate of NCDs in the regression equation. We have considered the power .90, level of significance 0.05 , calculated effect size from prevalence ratio and then we get the estimated sample size for each model of each outcomes which covers the existing sample size of our analysis. We have performed the power analysis using G*Power software. The authors followed the guidelines outlined in the Strengthening the Reporting of Observational Studies in Epidemiology (*STROBE*) statement in writing the manuscript (Supplementary File 1).

Ethical consideration and patient involvement

Patients were not involved in the study. BDHS 2011 received ethical approval from ICF Macro Institutional Review Board, Maryland, USA and National Research Ethics Committee of Bangladesh Medical Research Council (BMRC), Dhaka, Bangladesh. Written informed consent was taken from the participants before the survey was completed.

FINDINGS

The study population (n=8763) comprised 51% males, around 56% were 56 years of age or older, 62% reported no education, 25% were in manual employment, and 76% lived in rural locations (Table 1).

Table-1: General characteristics of the study population

Variables	n	%
Sex		

Male	4480	51.13
Female	4283	48.87
Age		
Younger	3603	55.77
Older	2858	44.23
Education		
College or higher	592	6.75
Secondary	1129	12.88
Primary	1634	18.64
No education, preschool	5409	61.72
Occupation		
Manual	2142	24.89
Non-manual	6464	75.11
Wealth index		
Poorest	1696	19.36
Poorer	1671	19.06
Middle	1692	19.31
Richer	1784	20.35
Richest	1921	21.92
Place of residence		
Rural	6623	75.58
Urban	2140	24.42

Among the sample 12% had diabetes, 27% had HTN and 22% were classified as overweight/obesity (BMI≥23kg/m^2). The probability of having diabetes and hypertension increased by increasing age group, whilst the probability of being overweight/obesity was higher in the younger age group (Figure 1). Prevalence of all these conditions were higher amongst males than females. The prevalence of group A (DM and HTN, n=270) and group B (DM and overweight/obesity , n=191) comorbidities was 3%, whilst 7% of the sample had group C comorbidity (HTN and overweight/obesity t, n=513). One percent (1%) of the sample all three conditions (DM, HTN and overweight/obesity =104). Prevalence of all groups of comorbidity was higher in males than females, except for group B (DM and overweight/obesity) (Figure 2). The prevalence of individual conditions and all comorbidities was higher amongst older individuals, those with a 'College or higher' education, 'non-manual' workers, people in the richest quintile for wealth index and those living in urban environments (Table 2).

Variables	Diabetes (%, 95% CI)	Hypertension (%, 95% CI)	Overweight (%, 95% CI)	Group-A (%, 95% CI) (Diabetes and hypertension)	Group-B (%, 95% CI) (Diabetes and overweight/obesity)	Group-C (%, 95% CI) (Hypertension and overweight/obesity)	Group-D (%, 95% CI) (Diabetes, hypertension and overweight/obesity
Age							
Younger	10.2 (9-11.5)	19.2 (17.4-21.1)	24.6 (22.7-26.5)	2.2 (1.7-2.9)	3.5 (2.8-4.4)	8.5 (7.4-9.8)	1.4 (1-2)
Older	14.7 (12.9-16.7)	38.7 (36.3-41.2)	18 (16.2-20)	5 (4.1-6.1)	3.3 (2.5-4.3)	10.1 (8.8-11.5)	2.3 (1.6-3.2)
Education							
Higher	22 (18.7-25.8)	33.1 (29.4-37)	53.9 (49-58.8)	7.7 (5.6-10.6)	8.6 (6.4-11.4)	17.5 (14.5-21)	4.3 (2.8-6.5)
Secondary	13.3 (11.4-15.4)	27.5 (24.9-30.3)	29.7 (26.4-33.2)	4.8 (3.7-6.1)	3.6 (2.6-4.8)	7.8 (6.3-9.8)	1.8 (1.1-2.9)
Primary	11.6 (10.2-13.3)	23.6 (21.4-25.9)	21 (18.6-23.6)	3.2 (2.5-4.3)	2.5 (1.9-3.4)	7.1 (5.8-8.5)	1.2 (0.8-1.8)
No education, preschool	9.5 (8.3-10.8)	28 (26.1-30)	13.3 (11.9-15)	2.5 (1.9-3.1)	1.2 (0.9-1.8)	5.2 (4.4-6.1)	0.8 (0.5-1.3)
Occupation							
Manual	6.8 (5.6-8.2)	14.4 (12.7-16.3)	10.5 (9.2-12.1)	1 (0.6-1.6)	0.8 (0.4-1.3)	2.7 (2-3.5)	0.4 (0.2-0.9)
Non-manual	13.4 (12.3-14.6)	31.5 (29.8-33.1)	27.7 (25.8-29.6)	4.3 (3.7-5)	3.2 (2.6-3.9)	8.8 (7.9-9.8)	1.7 (1.3-2.2)
Wealth index							
Poorest	8.4 (6.9-10.2)	20.6 (18.3-23.1)	6.6 (5.2-8.5)	1.7 (1.1-2.6)	0.6 (0.3-1.4)	2.2 (1.5-3.3)	0.4 (0.1-1.1)

Table-2: Weighted prevalence of individual conditions and comorbidities by characteristics

Poorer	8.1 (6.4-10.2)	22.6 (20-25.4)	10.4 (8.6-12.7)	1.7 (1-2.8)	0.5 (0.2-1.2)	2.9 (2.1-4)	0.3 (0.1-0.9)
Middle	8.2 (6.7-9.9)	24.2 (21.9-26.6)	14.6 (12.3-17.2)	2 (1.3-2.9)	1 (0.5-1.8)	3.4 (2.5-4.7)	0.4 (0.2-1.1)
Richer	11.8 (9.9-14)	28.8 (26.4-31.3)	27.8 (24.7-31.1)	3.5 (2.6-4.7)	2.5 (1.8-3.5)	9.3 (7.9-11)	1.2 (0.7-1.9)
Richest	20.8 (18.6-23.3)	38.6 (36.3-41.1)	47.9 (44.8-51)	8.3 (6.8-10)	8 (6.5-9.8)	17.6 (15.6-19.7)	4.3 (3.2-5.7)
Place of residence							
Urban	16.5 (14.6-18.5)	33.3 (31.1-35.5)	37.4 (34.3-40.7)	6 (4.9-7.3)	5.5 (4.4-6.8)	12.9 (11.3-14.6)	3.1 (2.3-4.2)
Rural	10.3 (9.3-11.3)	25.3 (23.5-27.1)	17.1 (15.6-18.6)	2.7 (2.2-3.3)	1.7 (1.2-2.3)	5.4 (4.7-6.3)	0.8 (0.5-1.3)

192

The prevalence ratio (PR), from modified Poison regression models, of HTN, DM and overweight/obesity was significantly higher among those who had completed higher education, those living in urban areas, non-manual workers and those in the richer to richest socioeconomic status. Although there was no sex disparities for diabetes, HTN and overweight/obesity was higher amongst males. Overweight/obesity was the only condition that was significantly higher among younger participants (Table 3).

Table-3: Modified Poisson regression models showing prevalence ratios (PR) and 95% confidence intervals for diabetes, hypertension and overweight by demographic characteristics among Bangladeshi adults

Variables	Diabetes	Hypertension	Overweight/obesity
	PR (95% CI)	**PR (95% CI)**	**PR (95% CI)**
Sex			
Female	0.89 (0.74-1.08)	0.59 (0.53-0.65) **	0.7 (0.62-0.79) **
Male	Ref	Ref	Ref
Age #			
Older	1.48 (1.26-1.73) **	1.72 (1.56-1.88) **	0.75 (0.67-0.83) **
Younger	Ref	Ref	Ref
Education			
College or higher	1.71 (1.32-2.23) **	1.36 (1.15-1.61) **	2.11 (1.79-2.5) **
Secondary	1.16 (0.92-1.48)	1.13 (0.99-1.28)	1.56 (1.34-1.83) **
Primary	1.21 (0.99-1.48)	0.97 (0.87-1.08)	1.29 (1.12-1.5) **
No education, preschool	Ref	Ref	Ref

Occupation			
Non-manual##	1.54 (1.24-1.91) **	1.46 (1.28-1.68) **	1.62 (1.39-1.90) **
Manual	Ref	Ref	Ref
Wealth index			
Richest	1.63 (1.25-2.14) **	1.49 (1.29-1.72) **	4.3 (3.32-5.57) **
Richer	1.04 (0.79-1.35)	1.24 (1.08-1.42) **	3.07 (2.39-3.95) **
Middle	0.77 (0.58-1.03)	1.05 (0.91-1.21)	1.8 (1.38-2.36) **
Poorer	0.94 (0.71-1.24)	1.01 (0.87-1.16)	1.45 (1.09-1.92) **
Poorest	Ref	Ref	Ref
Place of residence			
Urban	1.1 (0.92-1.32)	1.05 (0.95-1.15)	1.09 (0.98-1.21)
Rural	Ref	Ref	Ref

Younger-(35–55 years and older (56 years or older) [23].

#*Non-manual category included sedentary workers, professionals (e.g., doctors, teachers, etc.), housewives, retired persons, those unable to work and unemployed [24].

**Statistical significance at $p<0.05$

In univariate Poisson regression models, those in the richest quintile of wealth index had the highest PR for all comorbidity groups. These differences remained significant in all models in a stepwise process (**Supplementary File 2**). In final models, once controlling for sex, age, education, occupation and urbanization, those in the richest quintile were 2.3 times as likely to have DM and HTN, 4.8 times as likely to have DM and overweight/obesity, 4.9 times as likely to have HTN and overweight/obesity and 4.0 times as likely to have all three comorbidities, than those in the poorest quintile. In these final models, non-manual workers were also significantly more likely than manual workers to have all comorbidity groups. Sex differences were lost on controlling for other factor for all comorbidities groups, except Group C (HTN and overweight/obesity), for which females were 1.4 times as likely to experience both. Older participants were significantly more likely to have group A comorbidity (DM and HTN） DM and Group D (all comorbidities) (Table 4).

Table-4: Modified stepwise Poisson regression models showing prevalence ratios (PR) and 95% confidence intervals for comorbidities by demographic characteristics among Bangladeshi adults.

Model	Group-A (Diabetes and hypertension)	Group-B (Diabetes and overweight/obesity)	Group-C (Hypertension and overweight/obesity)	Group-D (Diabetes, hypertension and overweight/obesity)
Model-1 (Wealth index)				
Wealth index				
Richest	3.94 (2.42-6.41)**	9.69 (4.84-19.4) **	6.83 (4.66-10) **	8.67 (3.65-20.56) **
Richer	1.52 (0.88-2.61)	3.39 (1.61-7.16) **	3.78 (2.53-5.64) **	2.44 (0.95-6.31)
Middle	0.9 (0.47-1.71)	1.63 (0.69-3.81)	1.3 (0.81-2.07)	1.17 (0.37-3.7)
Poorer	0.9 (0.47-1.73)	0.81 (0.31-2.16)	1.13 (0.7-1.84)	0.79 (0.24-2.64)
Poorest	Ref	Ref	Ref	Ref
Model-6 (Wealth index + sex+ age + education+ occupation+ place of residence)				
Wealth index				
Richest	2.32 (1.32-4.1) **	4.84 (2.26-10.4) **	4.85 (3.25-7.24) **	3.99 (1.58-10.11) **

Richer	1.12 (0.66-1.91)	2.22 (1.02-4.8)	3.03 (2.04-4.49)	1.59 (0.65-3.92)
Middle	0.74 (0.39-1.38)	1.23 (0.54-2.82)	1.1 (0.69-1.75)	0.9 (0.31-2.64)
Poorer	0.78 (0.41-1.48)	0.71 (0.27-1.88)	1.06 (0.65-1.7)	0.7 (0.22-2.24)
Poorest	Ref	Ref	Ref	Ref
Sex				
Female	0.67 (0.35-1.31)	0.91 (0.47-1.78)	1.44 (1.06-1.96) **	1.05 (0.46-2.36)
Male	Ref	Ref	Ref	Ref
Age				
Older	2.17 (1.58-2.99) **	0.87 (0.62-1.21)	1.11 (0.91-1.35)	1.61 (1.05-2.49) **
Younger	Ref	Ref	Ref	Ref
Education				
College or higher	1.38 (0.85-2.25)	1.53 (0.93-2.5)	1.09 (0.82-1.45)	1.4 (0.74-2.63)
Secondary	1.06 (0.68-1.65)	1.33 (0.8-2.19)	0.91 (0.68-1.2)	1.24 (0.65-2.38)
Primary	1.03 (0.69-1.53)	1.42 (0.89-2.26)	1.18 (0.93-1.5)	1.25 (0.69-2.28)
No education, preschool	Ref	Ref	Ref	Ref
Occupational				

Non-manual	3.27 (1.94-5.52) **	4.22 (2.26-7.9) **	3.04 (2.19-4.22) **	3.69 (1.63-8.36) **
Manual	Ref	Ref	Ref	Ref
Place of residence				
Urban	1.33 (0.9-1.95)	1.17 (0.8-1.72)	1.04 (0.85-1.27)	1.72 (0.99-3.01)
Rural	Ref	Ref	Ref	Ref

** Statistical significance at p<0.05

DISCUSSION

This is the first study in Bangladesh that investigated individual and comorbid conditions using a nationally representative sample. We found that within the Bangladesh adult population, aged more than 35 years, the prevalence of diabetes was 12%, hypertension 27% and overweight/obesity 22%. Diabetes, hypertension and overweight/obesity were comparatively higher in males than females. More than 14% of the sample also had more than one condition, with 1.3% exhibiting all three. We also found that individual prevalence and comorbidity were higher in those of a higher socioeconomic status. Once controlling for several confounders, those in the richest quintile of wealth index were significantly more likely than those in the poorest quintile to exhibit comorbidities.

These findings demonstrate an alarming burden of NCDs within Bangladesh, with the rapid growth of overweight in the country becoming a particular public health concern.[27-29] As with many other developing countries, Bangladesh is experiencing a nutritional transition and increases in gross domestic product (GDP), which have been associated with multiple shifts in food intake and reduced physical activity.[30]

Although, to the authors knowledge, this is the first study on the prevalence of NCD risk factor comorbidity in Bangladesh using a nationally representative sample, a previous study had found an association between anthropometric indices such as body mass index (BMI),waist circumference (WC), waist hip ratio (WHR) and cardio metabolic risk indicators (FBG, SBP and DBP).[31] A further study in four geographical regions, including Bangladesh, reported that every standard deviation higher of BMI was associated with 1.65 and 1.60 times higher probability of

diabetes and 1.42 and 1.28 times higher probability of hypertension, for men and women, respectively.[32] Other studies have also found that HTN is a common comorbid condition in DM, and vice versa,[33] whilst there is considerable evidence for an increased prevalence of HTN in diabetic persons from other populations.[34,35]

In the current study, overweight and diabetes risk was greater among young people which is consistent with a similar study conducted in Indonesia.[36] Diabetes, hypertension and overweight/obesity were more prevalent in non-manual labor compared to manual labor, which was similar to findings from a study in Barbados.[37] However, the present study found males were more likely to suffer comorbidities than females, contradicting findings from previous studies.[38,39] We also found that the prevalence of individual conditions (diabetes, hypertension and overweight/obesity) along with the comorbidity of them, was higher in urban areas compared to rural, which is consistent with a number of studies conducted in developing countries, including Bangladesh.[33,40-44]

Within our study we found a higher prevalence of individual conditions and comorbidities in higher socioeconomic groups. These findings conflict with trends reported by previous studies conducted in higher-income countries.[45, 46] However, another multi-country study reported that comorbidity was more prevalent among the poor and less educated in low income countries.[47] However, these findings were based on self-reported diagnosis, which may introduce concerns of report and recall bias. Previous research in INDEPTH Asian sites has reported inverse associations between comorbidity and markers of socioeconomic status.[48]

The main implications of the present study are the increased burden of NCDs within Bangladesh, along with other LMICs, and the patterning of more than one risk factor within

individuals in the population. In contrast to findings from high income countries, prevalence of individual risk factors and comorbidities was higher in higher SES groups. This points to differences between countries in the population level determinants of NCDs and highlights that context specific interventions must be developed to counter them. As a first step, it is important that countries collect and analyse high quality health data to allow them to develop and target interventions.

STRENGTHS AND LIMITATIONS

The main strengths of the study were the large nationally representative sample and the collection of blood pressure, blood glucose concentration, body weight, and height measurements by health technicians follow standard methods, including biomarker analysis, along with validated measures of socio-economic status. The main weakness of the study is the cross-sectional nature, meaning that only associations can be inferred and causality cannot be determined. In addition although clinical measures of diabetes, hypertension and overweight/obesity were taken, no measurements of blood lipids were taken in the survey, meaning that metabolic syndrome could not be investigated. Waist and hip circumference were also not collected, limiting the analysis that could be performed. Finally although the study was reported to be representative, only participants 35 years or older had measured anthropometry and biomarkers meaning that the findings reflect this population of adults in the country.

CONCLUSION

In contrast to more affluent countries, individuals of higher socio-economic status in Bangladesh are more likely to exhibit NCD risk factors and comorbidities than individuals from with lower SES status. It is important that we identify the patterning of these conditions within countries if we are to develop effective public health approaches contextualized to the population. This can be done through improved monitoring and surveillance of NCDs, linked to primary care programmes. Such approaches also need policy and system changes, supported by "political will", societal and community support.

Contributors

TB, NT, SKD & AAM conceptualized the study. TB, NT, SKD, RDG & AAM designed the study and acquired the data. TB, SI & MRI conducted the data analysis. TB, NT, SI, MRI, SKD & AAM interpreted the data. TB, NT & RDG prepared the first draft. TB, NT, SKD & AAM participated in critical revision of the manuscript and contributed to its intellectual improvement. All authors went through the final draft and approved it for submission.

Funding

None.

Acknowledgments

The authors thank MEASURE DHS for permission to use data from the 2011 Bangladesh DHS. The authors are also grateful to Mr. Mehedi Hasan, PhD student, University of Queensland, Australia.

Competing Interests

None declared.

Patient consent

None Declared

Disclaimer

The authors are alone responsible for the integrity and accuracy of data analysis and the writing the manuscript.

Ethics approval

The datasets were obtained from DHS Programme with proper procedure. The study exempt from collecting ethical approval because the survey protocols were reviewed and approved by ICF Macro Institutional Review Board, Maryland, USA and National Research Ethics Committee of Bangladesh Medical Research Council (BMRC), Dhaka, Bangladesh.

Data sharing statement

The dataset of BDHS 2011 is available at the Demographic and Health Surveys Program. Extra data is available which is available on request at http://dhsprogram-com/what-we-do/survey/survey-display-349.cfm.

References:

1. Murray CJ, Vos T, Lozano R, et al. Disability-adjusted life years (DALYs) for 291 diseases and injuries in 21 regions, 1990–2010: a systematic analysis for the Global Burden of Disease Study 2010. *Lancet.* 2013;380(9859):2197-223. doi: 10.1016/S0140-6736(12)61689-4.

2. Lozano R, Naghavi M, Foreman K, et al. Global and regional mortality from 235 causes of death for 20 age groups in 1990 and 2010: a systematic analysis for the Global Burden of Disease Study 2010. *Lancet.* 2013;380(9859):2095-128. doi: 10.1016/S0140-6736(12)61728-0

3. Bennett D, Bisanzio D, Deribew A, et al. Global, regional, and national under-5 mortality, adult mortality, age-specific mortality, and life expectancy, 1970–2016: a systematic analysis for the Global Burden of Disease Study 2016. *Lancet.* 2017;390(10100):1084-1150. doi: 10.1016/s0140-6736(17)31833-0.

4. World Health Organization. Global status report on noncommunicable diseases 2010. Geneva: World Health Organization; 2011. 161 p.

5. Abegunde DO, Mathers CD, Adam T, et al. The burden and costs of chronic diseases in low-income and middle-income countries. *Lancet.* 2007;370(9603):1929-38. doi: 10.1016/S0140-6736(07)61696-1

6. Lee JT, Hamid F, Pati S, et al. Impact of noncommunicable disease multimorbidity on healthcare utilisation and out-of-pocket expenditures in middle-income countries: cross sectional analysis. *PLoS One.* 2015;10(7):e0127199. doi: 10.1371/journal.pone.0127199.

7. World Health Organization. Global status report on noncommunicable diseases 2014. Geneva: World Health Organization; 2015. 280 p.

8. Streatfield PK, Karar ZA. Population challenges for Bangladesh in the coming decades. J Health Popul Nutr. 2008;26(3):261.

9. National Institute of Population Research and Training (NIPORT), Mitra and Associates, ICF International. Bangladesh Urban Health Survey 2013.. Dhaka, Bangladesh, Calverton, Maryland, USA: NIPORT, Mitra and Associates, and ICF International., 2015.

10. Ahsan KZ, Alam MN, Streatfield PK, et al. Has Bangladesh Entered the Fourth Stage of the Epidemiologic Transition?. Proceedings of the International seminar on Mortality: Past, Present and Future; 2017Aug 7-8; the University of Campinas, Brazil.

11. Zaman MM, Bhuiyan MR, Karim MN, et al. Clustering of non-communicable diseases risk factors in Bangladeshi adults: an analysis of STEPS survey 2013. *BMC Public Health.* 2015;15(1):659. doi: 10.1186/s12889-015-1938-4.

12. Hillas G, Perlikos F, Tsiligianni I, et al. Managing comorbidities in COPD. *Int J Chron Obstruct Pulmon Dis*.2015;10:95. doi: 10.2147/COPD.S54473.

13. Roberts KC, Rao DP, Bennett TL, et al. Prevalence and patterns of chronic disease multimorbidity and associated determinants in Canada. *Health Promot Chronic Dis Prev Can.* 2015 ;35(6):87-94.

14. Wang J, Ma JJ, Liu J, et al. Prevalence and Risk Factors of Comorbidities among Hypertensive Patients in China. *Int J Med Sci.* 2017;14(3):201. doi: 10.7150/ijms.16974.

15. Hurst C, Thinkhamrop B. The association between hypertension comorbidity and microvascular complications in type 2 diabetes patients: A nationwide cross-sectional study in Thailand. *Diabetes Metab J.* 2015;39(5):395-404. doi: 10.4093/dmj.2015.39.5.395

19. Allen L, Williams J, Townsend N, et al. Socioeconomic status and non-communicable disease behavioural risk factors in low-income and lower-middle-income countries: a systematic review. *Lancet Glob Health.* 2017;5(3):e277-e89. doi: 10.1016/S2214-109X(17)30058-X.

20. Varghese C. Reducing premature mortality from non-communicable diseases, including for people with severe mental disorders. *World Psychiatry.* 2017;16(1):45-7. doi: 10.1002/wps.20376.

21. National Institute of Population Research and Training (NIPORT), Mitra and Associates, ICF International. Bangladesh Demographic and Health Survey 2011, Preliminary Report. Dhaka, Bangladesh, Calverton, Maryland, USA: NIPORT, Mitra and Associates, and ICF International., 2012.

22. Biswas T, Islam MS, Linton N, et al. Socio-economic inequality of chronic non-communicable diseases in Bangladesh. *PloS One.* 2016;11(11):e0167140. doi: 10.1371/journal.pone.0167140.

23. Akter S, Rahman MM, Abe SK, et al. Prevalence of diabetes and prediabetes and their risk factors among Bangladeshi adults: a nationwide survey. *Bull World Health Organ.* 2014;92(3):204-13A. doi: 10.2471/BLT.13.128371.

24. Ke-You G, Da-Wei F. The magnitude and trends of under-and over-nutrition in Asian countries. *Biomed Environ Sci.* 2001;14(1-2):53-60.

25. National Institute of Population Research and Training (NIPORT), Mitra and Associates, ICF International. Bangladesh Demographic and Health Survey 2011. Dhaka, Bangladesh, Calverton, Maryland, USA: NIPORT, Mitra and Associates, and ICF International., 2013.

26. Rahman M, Williams G, Al Mamun A. Hypertension and diabetes prevalence among adults with moderately increased BMI (23· 0–24· 9 kg/m 2): findings from a nationwide survey in Bangladesh. *Public Health Nutr.* 2017:1-8. doi: 10.1017/S1368980016003566.

27. Biswas T, Uddin MJ, Al Mamun A, et al. Increasing prevalence of overweight and obesity in Bangladeshi women of reproductive age: Findings from 2004 to 2014. *PloS One.* 2017;12(7):e0181080. doi: 10.1371/journal.pone.0181080.

28. Hoque ME, Hasan MT, Rahman M, et al. Double burden of underweight and overweight among Bangladeshi adults differs between men and women: evidence from a nationally representative survey. *Public Health Nutr.*2017;20(12):2183-91. doi: 10.1017/S1368980017000957.

29. Biswas T, Garnett SP, Pervin S, et al. The prevalence of underweight, overweight and obesity in Bangladeshi adults: Data from a national survey. *PloS One.* 2017;12(5):e0177395. doi: 10.1371/journal.pone.0177395.

30. Dietz WH. Double-duty solutions for the double burden of malnutrition. *Lancet.* 2017. doi: 10.1016/S0140-6736(17)32479-0.

31. Bhowmik B, Afsana F, Ahmed T, et al. Obesity and associated type 2 diabetes and hypertension in factory workers of Bangladesh. *BMC Res Notes.*2015;8(1):460. doi: 10.1186/s13104-015-1377-4.

32. Pradeepa R. The rising burden of diabetes and hypertension in southeast asian and african regions: need for effective strategies for prevention and control in primary health care settings. *Int J Hypertens.* 2013;2013. doi: 10.1155/2013/409083.

33. Sola A, Chinyere O, Stephen A, et al. Hypertension prevalence in an urban and rural area of Nigeria. *J Med Sci.* 2013;4:149-54.

34. Berraho M, El Achhab Y, Benslimane A, et al. Hypertension and type 2 diabetes: a cross-sectional study in Morocco (EPIDIAM Study). *Pan Afr Med J.* 2012;11(1).

35. Hashemizadeh H, Sarvelayati D. Hypertension and Type 2 Diabetes: A Cross-sectional Study in Hospitalized Patients in Quchan, Iran. *Iran J Diabetes Obesity.* 2013;5(1):21-6.

36. Hussain MA, Huxley RR, Al Mamun A. Multimorbidity prevalence and pattern in Indonesian adults: an exploratory study using national survey data. BMJ Open. 2015;5(12):e009810. doi: 10.1136/bmjopen-2015-009810.

37. Howitt C, Hambleton IR, Rose AM, et al. Social distribution of diabetes, hypertension and related risk factors in Barbados: a cross-sectional study. *BMJ Open.* 2015;5(12):e008869. doi: 10.1136/bmjopen-2015-008869.

38. Pearson TA. Education and income: double-edged swords in the epidemiologic transition of cardiovascular disease. *Ethn Dis.* 2003;13(2; SUPP/2):S2-158.

39. Agborsangaya CB, Lau D, Lahtinen M, et al. Multimorbidity prevalence and patterns across socioeconomic determinants: a cross-sectional survey. *BMC Public Health*. 2012;12(1):201. doi: 10.1186/1471-2458-12-201.

40. Rahman M, Williams G, Al Mamun A. Gender differences in hypertension awareness, antihypertensive use and blood pressure control in Bangladeshi adults: findings from a national cross-sectional survey. *J Health Popul Nutr.*2017;36(1):23. doi: 10.1186/s41043-017-0101-5.

41. Li G, Hu H, Dong Z, et al. Urban and suburban differences in hypertension trends and self-care: Three population-based cross-sectional studies from 2005-2011. *PloS One.* 2015;10(2):e0117999. doi: 10.1371/journal.pone.0117999.

42. Dhungana RR, Pandey AR, Bista B, et al. Prevalence and associated factors of hypertension: a community-based cross-sectional study in municipalities of Kathmandu, Nepal. *Int J Hypertens.*2016;2016. doi: 10.1155/2016/1656938.

43. Chowdhury MAB, Uddin MJ, Haque MR, et al. Hypertension among adults in Bangladesh: evidence from a national cross-sectional survey. *BMC Cardiovasc Disord.* 2016;16(1):22. doi: 10.1186/s12872-016-0197-3.

44. Akter S, Rahman MM, Abe SK, et al. Prevalence of diabetes and prediabetes and their risk factors among Bangladeshi adults: a nationwide survey. *Bull World Health Organ.*2014;92(3):204-13A. doi: 10.2471/BLT.13.128371

45. Connolly V, Unwin N, Sherriff P, et al. Diabetes prevalence and socioeconomic status: a population based study showing increased prevalence of type 2 diabetes mellitus in deprived areas. *J Epidemiol Community Health*.2000;54(3):173-7.

46. Glover JD, Hetzel DM, Tennant SK. The socioeconomic gradient and chronic illness and associated risk factors in Australia. *Aust New Zealand Health Policy.* 2004;1(1):8. doi: 10.1186/1743-8462-1-8.

47. Hosseinpoor AR, Bergen N, Mendis S, et al. Socioeconomic inequality in the prevalence of noncommunicable diseases in low-and middle-income countries: results from the World Health Survey. *BMC Public Health.* 2012;12(1):474. doi: 10.1186/s12889-015-2227-y.

48. Van Minh H, Ng N, Juvekar S, et al. Self-reported prevalence of chronic diseases and their relation to selected sociodemographic variables: a study in INDEPTH Asian sites, 2005. *Prev Chronic Dis*.2008;5(3).

Figures:

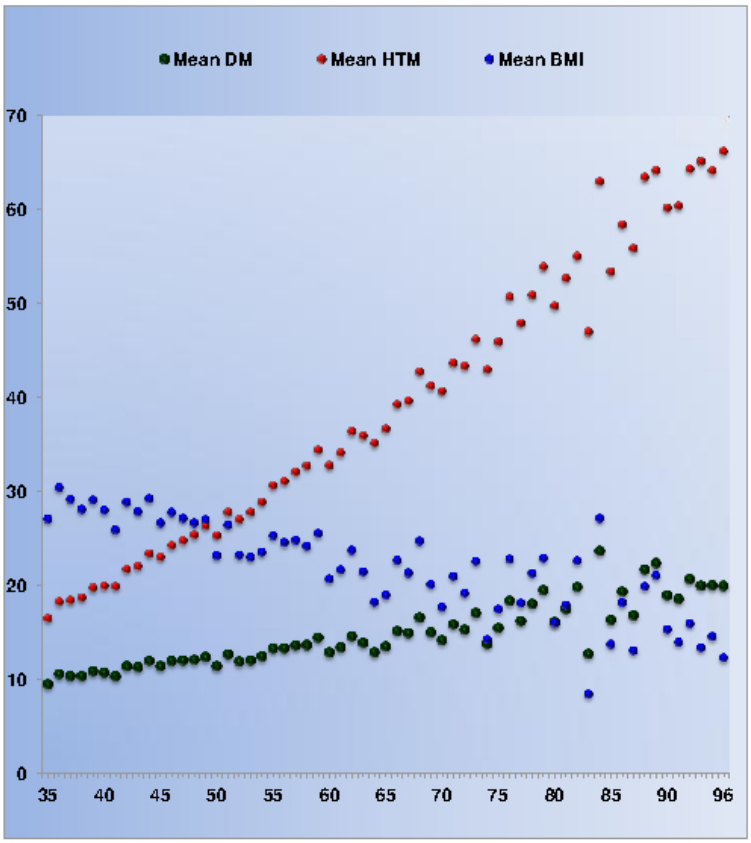
Fig 1. Scatter plot between age with blood glucose, systolic blood pressure, diastolic blood pressure and BMI.

Fig 2. Prevalence of diabetes, hypertension, overweight and comorbidity by sex among Bangladeshi adults

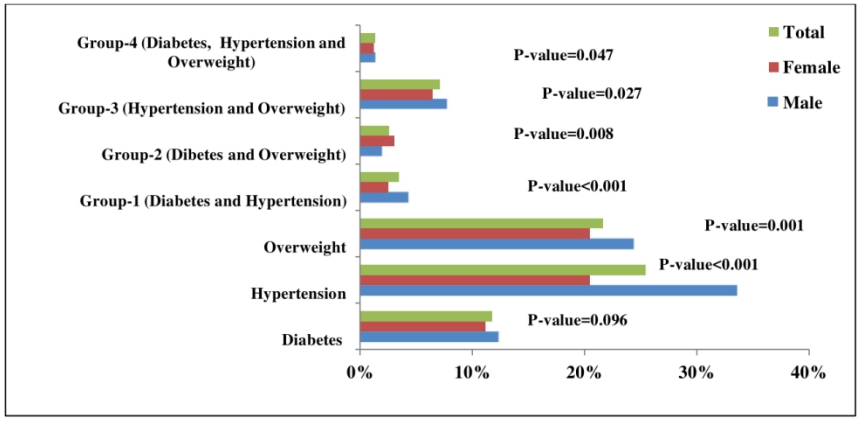
Supplementary Materials:

Supplementary File 1: STROBE Checklist

Supplementary File 2: Modified stepwise Poisson regression models showing prevalence ratios (PR) and 95% confidence intervals for comorbidities by demographic characteristics among Bangladeshi adults.



51x67mm (300 x 300 DPI)



127x62mm (300 x 300 DPI)

STROBE 2007 (v4) Statement—Checklist of items that should be included in reports of *cross-sectional studies*

Title of the study: **Association between high socioeconomic status with greater prevalence of non-communicable diseases risk factors and comorbidities in Bangladesh: Findings from a nationwide cross-sectional survey**

Section/Topic	Item #	Recommendation	Reported on page #
Title and abstract	1	(*a*) Indicate the study's design with a commonly used term in the title or the abstract	1
		(*b*) Provide in the abstract an informative and balanced summary of what was done and what was found	3-4
Introduction			
Background/rationale	2	Explain the scientific background and rationale for the investigation being reported	6-7
Objectives	3	State specific objectives, including any prespecified hypotheses	7
Methods			
Study design	4	Present key elements of study design early in the paper	7-8
Setting	5	Describe the setting, locations, and relevant dates, including periods of recruitment, exposure, follow-up, and data collection	7-8
Participants	6	(*a*) Give the eligibility criteria, and the sources and methods of selection of participants	7-8
Variables	7	Clearly define all outcomes, exposures, predictors, potential confounders, and effect modifiers. Give diagnostic criteria, if applicable	8-9
Data sources/ measurement	8*	For each variable of interest, give sources of data and details of methods of assessment (measurement). Describe comparability of assessment methods if there is more than one group	8-9
Bias	9	Describe any efforts to address potential sources of bias	9
Study size	10	Explain how the study size was arrived at	9
Quantitative variables	11	Explain how quantitative variables were handled in the analyses. If applicable, describe which groupings were chosen and why	9
Statistical methods	12	(*a*) Describe all statistical methods, including those used to control for confounding	9
		(*b*) Describe any methods used to examine subgroups and interactions	Not applicable

		(*c*) Explain how missing data were addressed	Not applicable
		(*d*) If applicable, describe analytical methods taking account of sampling strategy	Not applicable
		(*e*) Describe any sensitivity analyses	Not applicable
Results			
Participants	13*	(a) Report numbers of individuals at each stage of study—eg numbers potentially eligible, examined for eligibility, confirmed eligible, included in the study, completing follow-up, and analysed	10-12
		(b) Give reasons for non-participation at each stage	Not applicable
		(c) Consider use of a flow diagram	Not applicable
Descriptive data	14*	(a) Give characteristics of study participants (eg demographic, clinical, social) and information on exposures and potential confounders	10-12
		(b) Indicate number of participants with missing data for each variable of interest	Not applicable
Outcome data	15*	Report numbers of outcome events or summary measures	11-22
Main results	16	(*a*) Give unadjusted estimates and, if applicable, confounder-adjusted estimates and their precision (eg, 95% confidence interval). Make clear which confounders were adjusted for and why they were included	11-22
		(*b*) Report category boundaries when continuous variables were categorized	Not applicable
		(*c*) If relevant, consider translating estimates of relative risk into absolute risk for a meaningful time period	Not applicable
Other analyses	17	Report other analyses done—eg analyses of subgroups and interactions, and sensitivity analyses	Not applicable
Discussion			
Key results	18	Summarise key results with reference to study objectives	23
Limitations	19	Discuss limitations of the study, taking into account sources of potential bias or imprecision. Discuss both direction and magnitude of any potential bias	25-26
Interpretation	20	Give a cautious overall interpretation of results considering objectives, limitations, multiplicity of analyses, results from similar studies, and other relevant evidence	23-25
Generalisability	21	Discuss the generalisability (external validity) of the study results	23-25
Other information			
Funding	22	Give the source of funding and the role of the funders for the present study and, if applicable, for the original study on which the present article is based	26

*Give information separately for cases and controls in case-control studies and, if applicable, for exposed and unexposed groups in cohort and cross-sectional studies.

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

Table: Modified stepwise Poisson regression models showing prevalence ratios (PR) and 95% confidence intervals for co-morbidities by demographic characteristics among Bangladeshi adults.

	Group-A (Diabetes and hypertension)	Group-B (Diabetes and overweight/obesity)	Group-C (Hypertension and overweight/obesity)	Group-D (Diabetes, hypertension and overweight/obesity)
Model-1 (Wealth index)				
Wealth index				
Richest	3.94 (2.42-6.41)**	9.69 (4.84-19.4) **	6.83 (4.66-10) **	8.67 (3.65-20.56) **
Richer	1.52 (0.88-2.61)	3.39 (1.61-7.16) **	3.78 (2.53-5.64) **	2.44 (0.95-6.31)
Middle	0.9 (0.47-1.71)	1.63 (0.69-3.81)	1.3 (0.81-2.07)	1.17 (0.37-3.7)
Poorer	0.9 (0.47-1.73)	0.81 (0.31-2.16)	1.13 (0.7-1.84)	0.79 (0.24-2.64)
Poorest	Ref	Ref	Ref	Ref
Model-2 (Wealth index + sex)				
Wealth index				
Richest	3.93 (2.42-6.39) **	9.68 (4.84-19.35) **	6.88 (4.7-10.08) **	8.69 (3.68-20.5) **
Richer	1.51 (0.88-2.6)	3.39 (1.61-7.14) **	3.82 (2.56-5.69) **	2.45 (0.96-6.3)
Middle	0.9 (0.47-1.71)	1.62 (0.69-3.8)	1.31 (0.82-2.09)	1.17 (0.37-3.69)
Poorer	0.89 (0.47-1.71)	0.81 (0.31-2.15)	1.16 (0.72-1.89)	0.8 (0.24-2.63)
Poorest	Ref	Ref	Ref	Ref
Sex				
Female	0.85 (0.43-1.66)	0.95 (0.49-1.85)	1.66 (1.22-2.26) **	1.21 (0.53-2.74)
Male	Ref	Ref	Ref	Ref
Model-3 (Wealth index + sex+ age)				
Wealth index				
Richest	4.04 (2.49-6.56) **	9.65 (4.82-19.3) **	6.92 (4.73-10.13) **	8.82 (3.74-20.82) **
Richer	1.51 (0.88-2.59)	3.4 (1.61-7.14) **	3.81 (2.55-5.67) **	2.44 (0.95-6.26)
Middle	0.88 (0.46-1.67)	1.63 (0.7-3.81)	1.3 (0.81-2.07)	1.15 (0.37-3.65)
Poorer	0.86 (0.45-1.64)	0.82 (0.31-2.15)	1.15 (0.71-1.87)	0.78 (0.24-2.57)
Poorest	Ref	Ref	Ref	Ref
Sex				
Female	0.75 (0.39-1.46)	0.97 (0.5-1.88)	1.61 (1.18-2.19) **	1.13 (0.5-2.54)
Male	Ref	Ref	Ref	Ref
Age				
Older	2.34 (1.71-3.2) **	0.88 (0.65-1.2)	1.23 (1.03-1.47) **	1.6 (1.05-2.42) **
Younger	Ref	Ref	Ref	Ref
Model-4 (Wealth index + sex+ age + education)				

Wealth index				
Richest	3.62 (2.16-6.07) **	7.84 (3.74-16.45) **	6.76 (4.55-10.03) **	7.56 (3.11-18.42) **
Richer	1.45 (0.84-2.51)	2.98 (1.37-6.5)	3.77 (2.53-5.63) **	2.24 (0.87-5.8)
Middle	0.87 (0.46-1.64)	1.5 (0.65-3.5)	1.28 (0.81-2.05)	1.1 (0.36-3.36)
Poorer	0.85 (0.45-1.63)	0.78 (0.29-2.09)	1.15 (0.71-1.86)	0.77 (0.23-2.51)
Poorest	Ref	Ref	Ref	Ref
Sex				
Female	0.76 (0.39-1.49)	1.04 (0.53-2.05)	1.62 (1.18-2.22) **	1.19 (0.52-2.71)
Male	Ref	Ref	Ref	Ref
Age				
Older	2.45 (1.79-3.36) **	0.97 (0.7-1.34)	1.25 (1.04-1.51) **	1.72 (1.11-2.65) **
Younger	Ref	Ref	Ref	Ref
Education				
College or higher	1.54 (0.96-2.5)	1.73 (1.06-2.83) **	1.21 (0.91-1.61)	1.59 (0.85-2.97)
Secondary	0.97 (0.62-1.51)	1.22 (0.74-2.01)	0.84 (0.64-1.12)	1.12 (0.59-2.15)
Primary	0.96 (0.64-1.42)	1.35 (0.85-2.14)	1.13 (0.9-1.43)	1.17 (0.65-2.11)
No education, preschool	Ref	Ref	Ref	Ref
Model-5 (Wealth index + sex+ age + education+ occupation)				
Wealth index				
Richest	2.72 (1.6-4.61) **	5.3 (2.54-11.05) **	4.97 (3.37-7.33) **	5.47 (2.32-12.91) **
Richer	1.18 (0.69-2.04)	2.29 (1.06-4.95) **	3.06 (2.06-4.53) **	1.79 (0.71-4.49)
Middle	0.75 (0.4-1.41)	1.24 (0.54-2.85)	1.11 (0.7-1.76)	0.93 (0.31-2.76)
Poorer	0.78 (0.41-1.49)	0.72 (0.27-1.88)	1.06 (0.65-1.7)	0.7 (0.22-2.26)
Poorest	Ref	Ref	Ref	Ref
Sex				
Female	0.67 (0.35-1.31)	0.91 (0.47-1.78)	1.44 (1.06-1.96) **	1.05 (0.47-2.37)
Male	Ref	Ref	Ref	Ref
Age				
Older	2.13 (1.54-2.94) **	0.86 (0.62-1.19)	1.11 (0.91-1.34)	1.54 (1.00-2.38) **
Younger	Ref	Ref	Ref	Ref
Education				
College or higher	1.4 (0.86-2.28)	1.54 (0.94-2.51)	1.09 (0.82-1.45)	1.44 (0.77-2.71)
Secondary	1.05 (0.67-1.64)	1.32 (0.8-2.18)	0.9 (0.68-1.2)	1.22 (0.63-2.35)
Primary	1.03 (0.69-1.53)	1.41 (0.89-2.25)	1.18 (0.93-1.49)	1.24 (0.68-2.26)
No education, preschool	Ref	Ref	Ref	Ref
Occupational				
Non-manual	3.32 (1.97-5.59) **	4.25 (2.27-7.97) **	3.04 (2.19-4.23) **	3.79 (1.67-8.61) **

Manual	Ref	Ref	Ref	Ref
Model-5 (Wealth index + sex+ age + education+ occupation+ place of residence)				
Wealth index				
Richest	2.32 (1.32-4.1) **	4.84 (2.26-10.4) **	4.85 (3.25-7.24) **	3.99 (1.58-10.11) **
Richer	1.12 (0.66-1.91)	2.22 (1.02-4.8)	3.03 (2.04-4.49)	1.59 (0.65-3.92)
Middle	0.74 (0.39-1.38)	1.23 (0.54-2.82)	1.1 (0.69-1.75)	0.9 (0.31-2.64)
Poorer	0.78 (0.41-1.48)	0.71 (0.27-1.88)	1.06 (0.65-1.7)	0.7 (0.22-2.24)
Poorest	Ref	Ref	Ref	Ref
Sex				
Female	0.67 (0.35-1.31)	0.91 (0.47-1.78)	1.44 (1.06-1.96) **	1.05 (0.46-2.36)
Male	Ref	Ref	Ref	Ref
Age				
Older	2.17 (1.58-2.99) **	0.87 (0.62-1.21)	1.11 (0.91-1.35)	1.61 (1.05-2.49) **
Younger	Ref	Ref	Ref	Ref
Education				
College or higher	1.38 (0.85-2.25)	1.53 (0.93-2.5)	1.09 (0.82-1.45)	1.4 (0.74-2.63)
Secondary	1.06 (0.68-1.65)	1.33 (0.8-2.19)	0.91 (0.68-1.2)	1.24 (0.65-2.38)
Primary	1.03 (0.69-1.53)	1.42 (0.89-2.26)	1.18 (0.93-1.5)	1.25 (0.69-2.28)
No education, preschool	Ref	Ref	Ref	Ref
Occupational				
Non-manual	3.27 (1.94-5.52) **	4.22 (2.26-7.9) **	3.04 (2.19-4.22) **	3.69 (1.63-8.36) **
Manual	Ref	Ref	Ref	Ref
Place of residence				
Urban	1.33 (0.9-1.95)	1.17 (0.8-1.72)	1.04 (0.85-1.27)	1.72 (0.99-3.01)
Rural	Ref	Ref	Ref	Ref

BMJ Open

Association between socioeconomic status and prevalence of non-communicable diseases risk factors and comorbidities in Bangladesh: Findings from a nationwide cross-sectional survey

Journal:	*BMJ Open*
Manuscript ID	bmjopen-2018-025538.R3
Article Type:	Research
Date Submitted by the Author:	01-Feb-2019
Complete List of Authors:	Biswas, Tuhin; International Centre for Diarrhoeal Disease Research Bangladesh, Universal Health Coverage, Health Systems and Population Studies Division; The University of Queensland, Institute for Social Science Research Townsend, Nick; University of Bath, Department for Health Islam, Md.saimul; University of Rajshahi, Departmnet of Statistics Islam, Md. Rajibul ; Ministry of Public Health, Health Intervention and Technology Assessment Program (HITAP) Das Gupta, Rajat; BRAC University James P Grant School of Public Health, Das, Sumon ; The University of Queensland, Institute for Social Science Research Mamun, Abdullah; University of Queensland, Institute for Social Science Research
Primary Subject Heading:	Epidemiology
Secondary Subject Heading:	Public health, Diabetes and endocrinology, Cardiovascular medicine
Keywords:	Overweight, DIABETES & ENDOCRINOLOGY, Hypertension < CARDIOLOGY

Title: Association between socioeconomic status and prevalence of non-communicable diseases risk factors and comorbidities in Bangladesh: Findings from a nationwide cross-sectional survey

Authors:

Tuhin Biswas[1,2]*, Nick Townsend[3], Md. Saimul Islam[4],Md. Rajibul Islam[5], Rajat Das Gupta[6,7], Sumon Kumar Das[2], Abdullah Al Mamun[2]

Affiliations:

[1] Universal Health Coverage, Health Systems and Population Studies Division, icddr,b, Mohakhali, Dhaka, Bangladesh

[2]Institute for Social Science Research, The University of Queensland, Long Pocket Precinct, Indooroopilly, Queensland, Australia.

[3] Department for Health, University of Bath, United Kingdom

[4] University Rajshahi, Rajshahi, Bangladesh.

[5] Health Intervention and Technology Assessment Program (HITAP), Ministry of Public Health, Nonthaburi, Thailand.

[6] Centre for Non-Communicable Diseases and Nutrition, BRAC James P Grant School of Public Health, BRAC University, Dhaka, Bangladesh

[7] Centre for Science of Implementation and Scale-Up, BRAC James P Grant School of Public Health, BRAC University, Dhaka, Bangladesh

***Corresponding author:**

Biswas Tuhin

Universal Health Coverage, Health Systems and Population Studies Division, icddr,b, Mohakhali, Dhaka, Bangladesh; Institute for Social Science Research, The University of Queensland, Long Pocket Precinct, Indooroopilly, Queensland, Australia.

Email: tuhin_sps04@yahoo.com

ABSTRACT

Objectives: This study aimed to examine the prevalence and distribution in the comorbidity of non-communicable diseases (NCD) among the adult population in Bangladesh by measures of socioeconomic status (SES).

Design: This was a cross-sectional study.

Setting: This study used Bangladesh Demographic and Health Survey (2011) data.

Participants: Total 8,763 individuals aged ≥35 years were included.

Primary and secondary outcome measures: The primary outcome measures were diabetes (DM), hypertension (HTN) and overweight/obesity. The study further assesses factors (in particular socioeconomic status) associated with these comorbidities (diabetes (DM), hypertension (HTN) and overweight/obesity).

Results: Of 8,763 adults**,** 12% had DM, 27% HTN and 22% were overweight/obese (BMI≥23kg/m^2). Just over 1% of the sample had all three conditions, 3% had both DM and HTN, 3% DM and overweight and 7% HTN and overweight. Diabetes, hypertension and overweight were more prevalent those who had higher education, were non-manual workers, were in the richer to richest socioeconomic status and lived in urban settings. Individuals in higher SES groups were also more likely to suffer from comorbidities. In the multivariable analysis, it was found that individual belonging to the richest wealth quintile had the highest odds of having hypertension (Adjusted Odds Ratio (AOR): 1.49, 95% Confidence Interval (CI): 1.29-1.72), diabetes (AOR: 1.63, 95% CI: 1.25-2.14) and obesity (AOR: 4.3, 95% CI: 3.32-5.57).

Conclusions: In contrast to more affluent countries, individuals with NCD risk factors and comorbidities are more common in higher socio-economic status individuals. Public health approaches must consider this social patterning in tackling NCDs in the country.

Key words: Overweight, Diabetes, Hypertension, Non-communicable Disease, socioeconomic status, Bangladesh

STRENGTHS AND LIMITATIONS OF THE STUDY

- The biggest strength of the study is that it utilized a large dataset nationally representative of the Bangladesh population, collected using measures that have been designed and validated through previous data collections in the country.
- Data collection included clinical measures of blood pressure, blood glucose concentration, body weight, and height collected by a health technician.
- The main weakness of the study is that it is cross-sectional in nature, meaning that only associations can be inferred and causality cannot be determined.

INTRODUCTION

According to the Global Burden of Disease report, non-communicable diseases (NCDs) are the leading cause of death worldwide[1-3] and that 80% of this NCD mortality actually occurs in low- and middle-income countries (LMICs)[4-6]. Similarly, the 2014 NCDs global status report showed that of 58 million deaths that occurred globally in 2012, 38 million - almost two thirds - were due to NCDs, with these deaths most due to the four most common NCDs: cardiovascular diseases, cancers, diabetes and chronic lung diseases.[7.] In addition, the report showed that more than 40% of these deaths (16 million) occurred were in individuals under the age of 70 years, often referred to as premature deaths[7]. Deaths at younger ages may be a greater demonstration of its burden, as many consider them preventable. It is alarming, therefore, that the majority of premature deaths (82%) occur in LMICs, with this problem likely to increase if appropriate preventative actions are not taken at a population level.

Like many LMICs, Bangladesh is undergoing rapid urbanization with changing patterns of diseases among the population[8, 9], with some suggesting that the country is at an advanced phase of the third stage of the epidemiologic transition, with deaths from NCDs expected to increase rapidly in the coming years.[10] This increasing mortality from NCDs in the country is supported by high prevalence of the medical risk factors associated with NCDs. A recent WHO STEPS survey in Bangladesh reported that 21% of the population had hypertension, 26% were overweight and 5% had documented diabetes.[11]

These high prevalence figures, raise concerns of comorbidity, in which individuals suffer from more than one of the risk factors at a time, with this thought to be highly predictive of end point diseases, disability and death.[12]. There is evidence of comorbidity risk for factors including

obesity, diabetes and hypertension, predominantly coming from industrialized countries [13-15] and developing nations[16-18]; however evidence on NCD comorbidity scant in Bangladesh. This is important as the patterning of NCDs is not uniform across countries of different income classification, with a higher prevalence of some NCD risk factors, such as diabetes, found in higher socio-economic groups in many studies in LMICs, contradicting those from higher income countries.[19]

With the development of a double burden from both over- and under-nutrition in these LMICs, understanding comorbidity and their correlates is important if we are to develop NCD preventative policies contextualized for these countries. Despite the availability of nationwide survey data in Bangladesh, the prevalence, and in particular the comorbidity of NCD medical risk factors remains unmapped. This understanding of the burden and patterning of NCDs and their risk factors is important if Bangladesh is able to meet the Sustainable Development Goals (SDGs) target of reducing premature death from NCDs by one third by 2030.[20]

This study used 2011 Bangladesh Demography and Health Survey (BDHS) data to estimate the prevalence and pattern of NCD risk factors and comorbidity among the general population aged 35 years and older, as well as determining their socio-demographic patterning and possible predictors of comorbidity .

METHODS

Study design

This study used data from the 2011 Bangladesh Demography and Health Survey (BDHS). The 2011 BDHS is a cross-sectional nationally representative survey that was

conducted between July and December 2011 through the collaboration of the National Institute of Population Research and Training (NIPORT), ICF International (USA), and Mitra and Associates. Participants in the BDHS were selected using probability sampling based on a two-stage cluster sample of households, and stratified by rural and urban areas in the seven administrative regions of Bangladesh. The detailed protocol and methods have been published previously.[21] In brief, 17,500 households were surveyed, of which one in three households were randomly selected for biomarker measurement (blood glucose, blood pressure). All men and women age 35 years and above were eligible for the biomarker measures, with these collected from a final sample of 8,835 individuals (male: 4524, female: 4311). [22] We included 8763 cases in our analytical sample, after excluding cases with missing values.

Measurements of outcomes

A data collection team, including a health technician, measured blood pressure, blood glucose concentration, body weight, and height using standard methods.[21] Diabetes (DM) was defined as a fasting blood glucose level greater than or equal to 7.0 mmol/L or self-reported diabetes medication use.[23] Body mass index (BMI) was calculated as weight (kg)/height (m^2). We used Asian specific BMI cut-offs to define underweight as <18.5 kg/m^2 and overweight and obese (higher BMI) as ≥23kg/m^2.[24] Hypertension was defined as systolic blood pressure (SBP) ≥140 mmHg and diastolic blood pressure (DBP) ≥90 mmHg or self-reported anti-hypertensive medication use during the survey.[25] We then categorized comorbidity into four groups such as respondents having DM and HTN (group A), DM and overweight/obesity(group B), HTN and overweight/obesity (group C) and group D in which individuals had all three conditions (DM, HTN and overweight/obesity).

Socio-demographic factors

We categorized age as older (defined as 56 years and above) and younger (35 to 55 years).[26] Education status was characterized into five levels: 1) no education, 2) preschool, 3) primary, 4) secondary and 5) college or higher. We categorized occupation as manual or non-manual worker and used principle component analysis to determine a wealth index was as described in the BDHS 2011 report.[21] Place of residence (urban and rural) and sex (male and female) were also included as important factors.

Statistical analysis

HTN, DM, overweight/obesity and all possible combinations of the comorbidity conditions were the main outcomes of interest. For analysis purposes, all outcomes were dichotomized into persons with or without the risk factor. Sex, age, education, occupation, wealth index and place of residence were included in analysis as independent variables. We calculated the weighted prevalence of DM, HTN, overweight/obesity through percentage in the sample and used modified Poisson regression （PR) models with robust error variance to calculate prevalence ratios (PR) and 95% confidence interval for DM, HTN and overweight. These analyses were adjusted for cluster and sample weight and were done using IBMSPSS 21 (IBM Corp. Released 2012. IBMSPSS Statistics for Windows, Version 21.0. Armonk, NY: IBM Corp.). We also calculated the power to assess whether the existing sample size is enough for performing the multivariable regression models. The variables sex, age, education, occupation are control variables and not of primary research interest. The variable wealth index is our primary interest to assess the association with the joint estimates of NCDs. We have converted

the log (PR) to calculate the effect size by the formula d= log (prevalence ratio) × (√3/π). The primary research hypothesis was to test the wealth index from poorer to richest groups with the joint estimate of NCDs in the regression equation. We have considered the power .90, level of significance 0.05 , calculated effect size from prevalence ratio and then we get the estimated sample size for each model of each outcomes which covers the existing sample size of our analysis. We have performed the power analysis using G*Power software. The authors followed the guidelines outlined in the Strengthening the Reporting of Observational Studies in Epidemiology (*STROBE*) statement in writing the manuscript (Supplementary File 1).

Ethical consideration and patient involvement

Patients were not involved in the study. BDHS 2011 received ethical approval from ICF Macro Institutional Review Board, Maryland, USA and National Research Ethics Committee of Bangladesh Medical Research Council (BMRC), Dhaka, Bangladesh. Written informed consent was taken from the participants before the survey was completed.

FINDINGS

The study population (n=8763) comprised 51% males, around 56% were 56 years of age or older, 62% reported no education, 25% were in manual employment, and 76% lived in rural locations (Table 1).

Table-1: General characteristics of the study population

Variables	n	%
Sex		

Male	4480	51.13
Female	4283	48.87
Age		
Younger	3603	55.77
Older	2858	44.23
Education		
College or higher	592	6.75
Secondary	1129	12.88
Primary	1634	18.64
No education, preschool	5409	61.72
Occupation		
Manual	2142	24.89
Non-manual	6464	75.11
Wealth index		
Poorest	1696	19.36
Poorer	1671	19.06
Middle	1692	19.31
Richer	1784	20.35
Richest	1921	21.92
Place of residence		
Rural	6623	75.58
Urban	2140	24.42

Among the sample 12% had diabetes, 27% had HTN and 22% were classified as overweight/obesity (BMI≥23kg/m^2). The probability of having diabetes and hypertension increased by increasing age group, whilst the probability of being overweight/obesity was higher in the younger age group (Figure 1). Prevalence of all these conditions were higher amongst males than females. The prevalence of group A (DM and HTN, n=270) and group B (DM and overweight/obesity , n=191) comorbidities was 3%, whilst 7% of the sample had group C comorbidity (HTN and overweight/obesity t, n=513). One percent (1%) of the sample all three conditions (DM, HTN and overweight/obesity =104). Prevalence of all groups of comorbidity was higher in males than females, except for group B (DM and overweight/obesity) (Figure 2). The prevalence of individual conditions and all comorbidities was higher amongst older individuals, those with a 'College or higher' education, 'non-manual' workers, people in the richest quintile for wealth index and those living in urban environments (Table 2).

Variables	Diabetes (%, 95% CI)	Hypertension (%, 95% CI)	Overweight (%, 95% CI)	Group-A (%, 95% CI) (Diabetes and hypertension)	Group-B (%, 95% CI) (Diabetes and overweight/obesity)	Group-C (%, 95% CI) (Hypertension and overweight/obesity)	Group-D (%, 95% CI) (Diabetes, hypertension and overweight/obesity
Age							
Younger	10.2 (9-11.5)	19.2 (17.4-21.1)	24.6 (22.7-26.5)	2.2 (1.7-2.9)	3.5 (2.8-4.4)	8.5 (7.4-9.8)	1.4 (1-2)
Older	14.7 (12.9-16.7)	38.7 (36.3-41.2)	18 (16.2-20)	5 (4.1-6.1)	3.3 (2.5-4.3)	10.1 (8.8-11.5)	2.3 (1.6-3.2)
Education							
Higher	22 (18.7-25.8)	33.1 (29.4-37)	53.9 (49-58.8)	7.7 (5.6-10.6)	8.6 (6.4-11.4)	17.5 (14.5-21)	4.3 (2.8-6.5)
Secondary	13.3 (11.4-15.4)	27.5 (24.9-30.3)	29.7 (26.4-33.2)	4.8 (3.7-6.1)	3.6 (2.6-4.8)	7.8 (6.3-9.8)	1.8 (1.1-2.9)
Primary	11.6 (10.2-13.3)	23.6 (21.4-25.9)	21 (18.6-23.6)	3.2 (2.5-4.3)	2.5 (1.9-3.4)	7.1 (5.8-8.5)	1.2 (0.8-1.8)
No education, preschool	9.5 (8.3-10.8)	28 (26.1-30)	13.3 (11.9-15)	2.5 (1.9-3.1)	1.2 (0.9-1.8)	5.2 (4.4-6.1)	0.8 (0.5-1.3)
Occupation							
Manual	6.8 (5.6-8.2)	14.4 (12.7-16.3)	10.5 (9.2-12.1)	1 (0.6-1.6)	0.8 (0.4-1.3)	2.7 (2-3.5)	0.4 (0.2-0.9)
Non-manual	13.4 (12.3-14.6)	31.5 (29.8-33.1)	27.7 (25.8-29.6)	4.3 (3.7-5)	3.2 (2.6-3.9)	8.8 (7.9-9.8)	1.7 (1.3-2.2)
Wealth index							
Poorest	8.4 (6.9-10.2)	20.6 (18.3-23.1)	6.6 (5.2-8.5)	1.7 (1.1-2.6)	0.6 (0.3-1.4)	2.2 (1.5-3.3)	0.4 (0.1-1.1)

Table-2: Weighted prevalence of individual conditions and comorbidities by characteristics

Poorer	8.1 (6.4-10.2)	22.6 (20-25.4)	10.4 (8.6-12.7)	1.7 (1-2.8)	0.5 (0.2-1.2)	2.9 (2.1-4)	0.3 (0.1-0.9)
Middle	8.2 (6.7-9.9)	24.2 (21.9-26.6)	14.6 (12.3-17.2)	2 (1.3-2.9)	1 (0.5-1.8)	3.4 (2.5-4.7)	0.4 (0.2-1.1)
Richer	11.8 (9.9-14)	28.8 (26.4-31.3)	27.8 (24.7-31.1)	3.5 (2.6-4.7)	2.5 (1.8-3.5)	9.3 (7.9-11)	1.2 (0.7-1.9)
Richest	20.8 (18.6-23.3)	38.6 (36.3-41.1)	47.9 (44.8-51)	8.3 (6.8-10)	8 (6.5-9.8)	17.6 (15.6-19.7)	4.3 (3.2-5.7)
Place of residence							
Urban	16.5 (14.6-18.5)	33.3 (31.1-35.5)	37.4 (34.3-40.7)	6 (4.9-7.3)	5.5 (4.4-6.8)	12.9 (11.3-14.6)	3.1 (2.3-4.2)
Rural	10.3 (9.3-11.3)	25.3 (23.5-27.1)	17.1 (15.6-18.6)	2.7 (2.2-3.3)	1.7 (1.2-2.3)	5.4 (4.7-6.3)	0.8 (0.5-1.3)

192

The prevalence ratio (PR), from modified Poison regression models, of HTN, DM and overweight/obesity was significantly higher among those who had completed higher education, those living in urban areas, non-manual workers and those in the richer to richest socioeconomic status. Although there was no sex disparities for diabetes, HTN and overweight/obesity was higher amongst males. Overweight/obesity was the only condition that was significantly higher among younger participants (Table 3).

Table-3: Modified Poisson regression models showing prevalence ratios (PR) and 95% confidence intervals for diabetes, hypertension and overweight by demographic characteristics among Bangladeshi adults

Variables	Diabetes	Hypertension	Overweight/obesity
	PR (95% CI)	**PR (95% CI)**	**PR (95% CI)**
Sex			
Female	0.89 (0.74-1.08)	0.59 (0.53-0.65) **	0.7 (0.62-0.79) **
Male	Ref	Ref	Ref
Age #			
Older	1.48 (1.26-1.73) **	1.72 (1.56-1.88) **	0.75 (0.67-0.83) **
Younger	Ref	Ref	Ref
Education			
College or higher	1.71 (1.32-2.23) **	1.36 (1.15-1.61) **	2.11 (1.79-2.5) **
Secondary	1.16 (0.92-1.48)	1.13 (0.99-1.28)	1.56 (1.34-1.83) **
Primary	1.21 (0.99-1.48)	0.97 (0.87-1.08)	1.29 (1.12-1.5) **
No education, preschool	Ref	Ref	Ref

Occupation			
Non-manual##	1.54 (1.24-1.91) **	1.46 (1.28-1.68) **	1.62 (1.39-1.90) **
Manual	Ref	Ref	Ref
Wealth index			
Richest	1.63 (1.25-2.14) **	1.49 (1.29-1.72) **	4.3 (3.32-5.57) **
Richer	1.04 (0.79-1.35)	1.24 (1.08-1.42) **	3.07 (2.39-3.95) **
Middle	0.77 (0.58-1.03)	1.05 (0.91-1.21)	1.8 (1.38-2.36) **
Poorer	0.94 (0.71-1.24)	1.01 (0.87-1.16)	1.45 (1.09-1.92) **
Poorest	Ref	Ref	Ref
Place of residence			
Urban	1.1 (0.92-1.32)	1.05 (0.95-1.15)	1.09 (0.98-1.21)
Rural	Ref	Ref	Ref

Younger-(35–55 years and older (56 years or older) [23].

#*Non-manual category included sedentary workers, professionals (e.g., doctors, teachers, etc.), housewives, retired persons, those unable to work and unemployed [24].

**Statistical significance at $p<0.05$

In univariate Poisson regression models, those in the richest quintile of wealth index had the highest PR for all comorbidity groups. These differences remained significant in all models in a stepwise process (**Supplementary File 2**). In final models, once controlling for sex, age, education, occupation and urbanization, those in the richest quintile were 2.3 times as likely to have DM and HTN, 4.8 times as likely to have DM and overweight/obesity, 4.9 times as likely to have HTN and overweight/obesity and 4.0 times as likely to have all three comorbidities, than those in the poorest quintile. In these final models, non-manual workers were also significantly more likely than manual workers to have all comorbidity groups. Sex differences were lost on controlling for other factor for all comorbidities groups, except Group C (HTN and overweight/obesity), for which females were 1.4 times as likely to experience both. Older participants were significantly more likely to have group A comorbidity (DM and HTN） DM and Group D (all comorbidities) (Table 4).

Table-4: Modified stepwise Poisson regression models showing prevalence ratios (PR) and 95% confidence intervals for comorbidities by demographic characteristics among Bangladeshi adults.

Model	Group-A (Diabetes and hypertension)	Group-B (Diabetes and overweight/obesity)	Group-C (Hypertension and overweight/obesity)	Group-D (Diabetes, hypertension and overweight/obesity)
Model-1 (Wealth index)				
Wealth index				
Richest	3.94 (2.42-6.41)**	9.69 (4.84-19.4) **	6.83 (4.66-10) **	8.67 (3.65-20.56) **
Richer	1.52 (0.88-2.61)	3.39 (1.61-7.16) **	3.78 (2.53-5.64) **	2.44 (0.95-6.31)
Middle	0.9 (0.47-1.71)	1.63 (0.69-3.81)	1.3 (0.81-2.07)	1.17 (0.37-3.7)
Poorer	0.9 (0.47-1.73)	0.81 (0.31-2.16)	1.13 (0.7-1.84)	0.79 (0.24-2.64)
Poorest	Ref	Ref	Ref	Ref
Model-6 (Wealth index + sex+ age + education+ occupation+ place of residence)				
Wealth index				
Richest	2.32 (1.32-4.1) **	4.84 (2.26-10.4) **	4.85 (3.25-7.24) **	3.99 (1.58-10.11) **

Richer	1.12 (0.66-1.91)	2.22 (1.02-4.8)	3.03 (2.04-4.49)	1.59 (0.65-3.92)
Middle	0.74 (0.39-1.38)	1.23 (0.54-2.82)	1.1 (0.69-1.75)	0.9 (0.31-2.64)
Poorer	0.78 (0.41-1.48)	0.71 (0.27-1.88)	1.06 (0.65-1.7)	0.7 (0.22-2.24)
Poorest	Ref	Ref	Ref	Ref
Sex				
Female	0.67 (0.35-1.31)	0.91 (0.47-1.78)	1.44 (1.06-1.96) **	1.05 (0.46-2.36)
Male	Ref	Ref	Ref	Ref
Age				
Older	2.17 (1.58-2.99) **	0.87 (0.62-1.21)	1.11 (0.91-1.35)	1.61 (1.05-2.49) **
Younger	Ref	Ref	Ref	Ref
Education				
College or higher	1.38 (0.85-2.25)	1.53 (0.93-2.5)	1.09 (0.82-1.45)	1.4 (0.74-2.63)
Secondary	1.06 (0.68-1.65)	1.33 (0.8-2.19)	0.91 (0.68-1.2)	1.24 (0.65-2.38)
Primary	1.03 (0.69-1.53)	1.42 (0.89-2.26)	1.18 (0.93-1.5)	1.25 (0.69-2.28)
No education, preschool	Ref	Ref	Ref	Ref
Occupational				

Non-manual	3.27 (1.94-5.52) **	4.22 (2.26-7.9) **	3.04 (2.19-4.22) **	3.69 (1.63-8.36) **
Manual	Ref	Ref	Ref	Ref
Place of residence				
Urban	1.33 (0.9-1.95)	1.17 (0.8-1.72)	1.04 (0.85-1.27)	1.72 (0.99-3.01)
Rural	Ref	Ref	Ref	Ref

** Statistical significance at p<0.05

DISCUSSION

This is the first study in Bangladesh that investigated individual and comorbid conditions using a nationally representative sample. We found that within the Bangladesh adult population, aged more than 35 years, the prevalence of diabetes was 12%, hypertension 27% and overweight/obesity 22%. Diabetes, hypertension and overweight/obesity were comparatively higher in males than females. More than 14% of the sample also had more than one condition, with 1.3% exhibiting all three. We also found that individual prevalence and comorbidity were higher in those of a higher socioeconomic status. Once controlling for several confounders, those in the richest quintile of wealth index were significantly more likely than those in the poorest quintile to exhibit comorbidities.

These findings demonstrate an alarming burden of NCDs within Bangladesh, with the rapid growth of overweight in the country becoming a particular public health concern.[27-29] As with many other developing countries, Bangladesh is experiencing a nutritional transition and increases in gross domestic product (GDP), which have been associated with multiple shifts in food intake and reduced physical activity.[30]

Although, to the authors knowledge, this is the first study on the prevalence of NCD risk factor comorbidity in Bangladesh using a nationally representative sample, a previous study had found an association between anthropometric indices such as body mass index (BMI),waist circumference (WC), waist hip ratio (WHR) and cardio metabolic risk indicators (FBG, SBP and DBP).[31] A further study in four geographical regions, including Bangladesh, reported that every standard deviation higher of BMI was associated with 1.65 and 1.60 times higher probability of

diabetes and 1.42 and 1.28 times higher probability of hypertension, for men and women, respectively.[32] Other studies have also found that HTN is a common comorbid condition in DM, and vice versa,[33] whilst there is considerable evidence for an increased prevalence of HTN in diabetic persons from other populations.[34,35]

In the current study, overweight and diabetes risk was greater among young people which is consistent with a similar study conducted in Indonesia.[36] Diabetes, hypertension and overweight/obesity were more prevalent in non-manual labor compared to manual labor, which was similar to findings from a study in Barbados.[37] However, the present study found males were more likely to suffer comorbidities than females, contradicting findings from previous studies.[38,39] We also found that the prevalence of individual conditions (diabetes, hypertension and overweight/obesity) along with the comorbidity of them, was higher in urban areas compared to rural, which is consistent with a number of studies conducted in developing countries, including Bangladesh.[33,40-44]

Within our study we found a higher prevalence of individual conditions and comorbidities in higher socioeconomic groups. These findings conflict with trends reported by previous studies conducted in higher-income countries.[45, 46] However, another multi-country study reported that comorbidity was more prevalent among the poor and less educated in low income countries.[47] However, these findings were based on self-reported diagnosis, which may introduce concerns of report and recall bias. Previous research in INDEPTH Asian sites has reported inverse associations between comorbidity and markers of socioeconomic status.[48]

The main implications of the present study are the increased burden of NCDs within Bangladesh, along with other LMICs, and the patterning of more than one risk factor within

individuals in the population. In contrast to findings from high income countries, prevalence of individual risk factors and comorbidities was higher in higher SES groups. This points to differences between countries in the population level determinants of NCDs and highlights that context specific interventions must be developed to counter them. As a first step, it is important that countries collect and analyse high quality health data to allow them to develop and target interventions.

STRENGTHS AND LIMITATIONS

The main strengths of the study were the large nationally representative sample and the collection of blood pressure, blood glucose concentration, body weight, and height measurements by health technicians follow standard methods, including biomarker analysis, along with validated measures of socio-economic status. The main weakness of the study is the cross-sectional nature, meaning that only associations can be inferred and causality cannot be determined. In addition although clinical measures of diabetes, hypertension and overweight/obesity were taken, no measurements of blood lipids were taken in the survey, meaning that metabolic syndrome could not be investigated. Waist and hip circumference were also not collected, limiting the analysis that could be performed. Finally although the study was reported to be representative, only participants 35 years or older had measured anthropometry and biomarkers meaning that the findings reflect this population of adults in the country.

CONCLUSION

In contrast to more affluent countries, individuals of higher socio-economic status in Bangladesh are more likely to exhibit NCD risk factors and comorbidities than individuals from with lower SES status. It is important that we identify the patterning of these conditions within countries if we are to develop effective public health approaches contextualized to the population. This can be done through improved monitoring and surveillance of NCDs, linked to primary care programmes. Such approaches also need policy and system changes, supported by "political will", societal and community support.

Contributors

TB, NT, SKD & AAM conceptualized the study. TB, NT, SKD, RDG & AAM designed the study and acquired the data. TB, SI & MRI conducted the data analysis. TB, NT, SI, MRI, SKD & AAM interpreted the data. TB, NT & RDG prepared the first draft. TB, NT, SKD & AAM participated in critical revision of the manuscript and contributed to its intellectual improvement. All authors went through the final draft and approved it for submission.

Funding

None.

Acknowledgments

The authors thank MEASURE DHS for permission to use data from the 2011 Bangladesh DHS. The authors are also grateful to Mr. Mehedi Hasan, PhD student, University of Queensland, Australia.

Competing Interests

None declared.

Patient consent

None Declared

Disclaimer

The authors are alone responsible for the integrity and accuracy of data analysis and the writing the manuscript.

Ethics approval

The datasets were obtained from DHS Programme with proper procedure. The study exempt from collecting ethical approval because the survey protocols were reviewed and approved by ICF Macro Institutional Review Board, Maryland, USA and National Research Ethics Committee of Bangladesh Medical Research Council (BMRC), Dhaka, Bangladesh.

Data sharing statement

The dataset of BDHS 2011 is available at the Demographic and Health Surveys Program. Extra data is available which is available on request at http://dhsprogram-com/what-we-do/survey/survey-display-349.cfm.

References:

1. Murray CJ, Vos T, Lozano R, et al. Disability-adjusted life years (DALYs) for 291 diseases and injuries in 21 regions, 1990–2010: a systematic analysis for the Global Burden of Disease Study 2010. *Lancet.* 2013;380(9859):2197-223. doi: 10.1016/S0140-6736(12)61689-4.

2. Lozano R, Naghavi M, Foreman K, et al. Global and regional mortality from 235 causes of death for 20 age groups in 1990 and 2010: a systematic analysis for the Global Burden of Disease Study 2010. *Lancet.* 2013;380(9859):2095-128. doi: 10.1016/S0140-6736(12)61728-0

3. Bennett D, Bisanzio D, Deribew A, et al. Global, regional, and national under-5 mortality, adult mortality, age-specific mortality, and life expectancy, 1970–2016: a systematic analysis for the Global Burden of Disease Study 2016. *Lancet.* 2017;390(10100):1084-1150. doi: 10.1016/s0140-6736(17)31833-0.

4. World Health Organization. Global status report on noncommunicable diseases 2010. Geneva: World Health Organization; 2011. 161 p.

5. Abegunde DO, Mathers CD, Adam T, et al. The burden and costs of chronic diseases in low-income and middle-income countries. *Lancet.* 2007;370(9603):1929-38. doi: 10.1016/S0140-6736(07)61696-1

6. Lee JT, Hamid F, Pati S, et al. Impact of noncommunicable disease multimorbidity on healthcare utilisation and out-of-pocket expenditures in middle-income countries: cross sectional analysis. *PLoS One.* 2015;10(7):e0127199. doi: 10.1371/journal.pone.0127199.

7. World Health Organization. Global status report on noncommunicable diseases 2014. Geneva: World Health Organization; 2015. 280 p.

8. Streatfield PK, Karar ZA. Population challenges for Bangladesh in the coming decades. J Health Popul Nutr. 2008;26(3):261.

9. National Institute of Population Research and Training (NIPORT), Mitra and Associates, ICF International. Bangladesh Urban Health Survey 2013.. Dhaka, Bangladesh, Calverton, Maryland, USA: NIPORT, Mitra and Associates, and ICF International., 2015.

10. Ahsan KZ, Alam MN, Streatfield PK, et al. Has Bangladesh Entered the Fourth Stage of the Epidemiologic Transition?. Proceedings of the International seminar on Mortality: Past, Present and Future; 2017Aug 7-8; the University of Campinas, Brazil.

11. Zaman MM, Bhuiyan MR, Karim MN, et al. Clustering of non-communicable diseases risk factors in Bangladeshi adults: an analysis of STEPS survey 2013. *BMC Public Health.* 2015;15(1):659. doi: 10.1186/s12889-015-1938-4.

12. Hillas G, Perlikos F, Tsiligianni I, et al. Managing comorbidities in COPD. *Int J Chron Obstruct Pulmon Dis*.2015;10:95. doi: 10.2147/COPD.S54473.

13. Roberts KC, Rao DP, Bennett TL, et al. Prevalence and patterns of chronic disease multimorbidity and associated determinants in Canada. *Health Promot Chronic Dis Prev Can.* 2015 ;35(6):87-94.

14. Wang J, Ma JJ, Liu J, et al. Prevalence and Risk Factors of Comorbidities among Hypertensive Patients in China. *Int J Med Sci.* 2017;14(3):201. doi: 10.7150/ijms.16974.

15. Hurst C, Thinkhamrop B. The association between hypertension comorbidity and microvascular complications in type 2 diabetes patients: A nationwide cross-sectional study in Thailand. *Diabetes Metab J.* 2015;39(5):395-404. doi: 10.4093/dmj.2015.39.5.395

19. Allen L, Williams J, Townsend N, et al. Socioeconomic status and non-communicable disease behavioural risk factors in low-income and lower-middle-income countries: a systematic review. *Lancet Glob Health.* 2017;5(3):e277-e89. doi: 10.1016/S2214-109X(17)30058-X.

20. Varghese C. Reducing premature mortality from non-communicable diseases, including for people with severe mental disorders. *World Psychiatry.* 2017;16(1):45-7. doi: 10.1002/wps.20376.

21. National Institute of Population Research and Training (NIPORT), Mitra and Associates, ICF International. Bangladesh Demographic and Health Survey 2011, Preliminary Report. Dhaka, Bangladesh, Calverton, Maryland, USA: NIPORT, Mitra and Associates, and ICF International., 2012.

22. Biswas T, Islam MS, Linton N, et al. Socio-economic inequality of chronic non-communicable diseases in Bangladesh. *PloS One.* 2016;11(11):e0167140. doi: 10.1371/journal.pone.0167140.

23. Akter S, Rahman MM, Abe SK, et al. Prevalence of diabetes and prediabetes and their risk factors among Bangladeshi adults: a nationwide survey. *Bull World Health Organ.* 2014;92(3):204-13A. doi: 10.2471/BLT.13.128371.

24. Ke-You G, Da-Wei F. The magnitude and trends of under-and over-nutrition in Asian countries. *Biomed Environ Sci.* 2001;14(1-2):53-60.

25. National Institute of Population Research and Training (NIPORT), Mitra and Associates, ICF International. Bangladesh Demographic and Health Survey 2011. Dhaka, Bangladesh, Calverton, Maryland, USA: NIPORT, Mitra and Associates, and ICF International., 2013.

26. Rahman M, Williams G, Al Mamun A. Hypertension and diabetes prevalence among adults with moderately increased BMI (23· 0–24· 9 kg/m 2): findings from a nationwide survey in Bangladesh. *Public Health Nutr.* 2017:1-8. doi: 10.1017/S1368980016003566.

27. Biswas T, Uddin MJ, Al Mamun A, et al. Increasing prevalence of overweight and obesity in Bangladeshi women of reproductive age: Findings from 2004 to 2014. *PloS One.* 2017;12(7):e0181080. doi: 10.1371/journal.pone.0181080.

28. Hoque ME, Hasan MT, Rahman M, et al. Double burden of underweight and overweight among Bangladeshi adults differs between men and women: evidence from a nationally representative survey. *Public Health Nutr.*2017;20(12):2183-91. doi: 10.1017/S1368980017000957.

29. Biswas T, Garnett SP, Pervin S, et al. The prevalence of underweight, overweight and obesity in Bangladeshi adults: Data from a national survey. *PloS One.* 2017;12(5):e0177395. doi: 10.1371/journal.pone.0177395.

30. Dietz WH. Double-duty solutions for the double burden of malnutrition. *Lancet.* 2017. doi: 10.1016/S0140-6736(17)32479-0.

31. Bhowmik B, Afsana F, Ahmed T, et al. Obesity and associated type 2 diabetes and hypertension in factory workers of Bangladesh. *BMC Res Notes.*2015;8(1):460. doi: 10.1186/s13104-015-1377-4.

32. Pradeepa R. The rising burden of diabetes and hypertension in southeast asian and african regions: need for effective strategies for prevention and control in primary health care settings. *Int J Hypertens.* 2013;2013. doi: 10.1155/2013/409083.

33. Sola A, Chinyere O, Stephen A, et al. Hypertension prevalence in an urban and rural area of Nigeria. *J Med Sci.* 2013;4:149-54.

34. Berraho M, El Achhab Y, Benslimane A, et al. Hypertension and type 2 diabetes: a cross-sectional study in Morocco (EPIDIAM Study). *Pan Afr Med J.* 2012;11(1).

35. Hashemizadeh H, Sarvelayati D. Hypertension and Type 2 Diabetes: A Cross-sectional Study in Hospitalized Patients in Quchan, Iran. *Iran J Diabetes Obesity.* 2013;5(1):21-6.

36. Hussain MA, Huxley RR, Al Mamun A. Multimorbidity prevalence and pattern in Indonesian adults: an exploratory study using national survey data. BMJ Open. 2015;5(12):e009810. doi: 10.1136/bmjopen-2015-009810.

37. Howitt C, Hambleton IR, Rose AM, et al. Social distribution of diabetes, hypertension and related risk factors in Barbados: a cross-sectional study. *BMJ Open.* 2015;5(12):e008869. doi: 10.1136/bmjopen-2015-008869.

38. Pearson TA. Education and income: double-edged swords in the epidemiologic transition of cardiovascular disease. *Ethn Dis.* 2003;13(2; SUPP/2):S2-158.

39. Agborsangaya CB, Lau D, Lahtinen M, et al. Multimorbidity prevalence and patterns across socioeconomic determinants: a cross-sectional survey. *BMC Public Health*. 2012;12(1):201. doi: 10.1186/1471-2458-12-201.

40. Rahman M, Williams G, Al Mamun A. Gender differences in hypertension awareness, antihypertensive use and blood pressure control in Bangladeshi adults: findings from a national cross-sectional survey. *J Health Popul Nutr.*2017;36(1):23. doi: 10.1186/s41043-017-0101-5.

41. Li G, Hu H, Dong Z, et al. Urban and suburban differences in hypertension trends and self-care: Three population-based cross-sectional studies from 2005-2011. *PloS One.* 2015;10(2):e0117999. doi: 10.1371/journal.pone.0117999.

42. Dhungana RR, Pandey AR, Bista B, et al. Prevalence and associated factors of hypertension: a community-based cross-sectional study in municipalities of Kathmandu, Nepal. *Int J Hypertens.*2016;2016. doi: 10.1155/2016/1656938.

43. Chowdhury MAB, Uddin MJ, Haque MR, et al. Hypertension among adults in Bangladesh: evidence from a national cross-sectional survey. *BMC Cardiovasc Disord.* 2016;16(1):22. doi: 10.1186/s12872-016-0197-3.

44. Akter S, Rahman MM, Abe SK, et al. Prevalence of diabetes and prediabetes and their risk factors among Bangladeshi adults: a nationwide survey. *Bull World Health Organ.*2014;92(3):204-13A. doi: 10.2471/BLT.13.128371

45. Connolly V, Unwin N, Sherriff P, et al. Diabetes prevalence and socioeconomic status: a population based study showing increased prevalence of type 2 diabetes mellitus in deprived areas. *J Epidemiol Community Health*.2000;54(3):173-7.

46. Glover JD, Hetzel DM, Tennant SK. The socioeconomic gradient and chronic illness and associated risk factors in Australia. *Aust New Zealand Health Policy.* 2004;1(1):8. doi: 10.1186/1743-8462-1-8.

47. Hosseinpoor AR, Bergen N, Mendis S, et al. Socioeconomic inequality in the prevalence of noncommunicable diseases in low-and middle-income countries: results from the World Health Survey. *BMC Public Health.* 2012;12(1):474. doi: 10.1186/s12889-015-2227-y.

48. Van Minh H, Ng N, Juvekar S, et al. Self-reported prevalence of chronic diseases and their relation to selected sociodemographic variables: a study in INDEPTH Asian sites, 2005. *Prev Chronic Dis*.2008;5(3).

Figures:

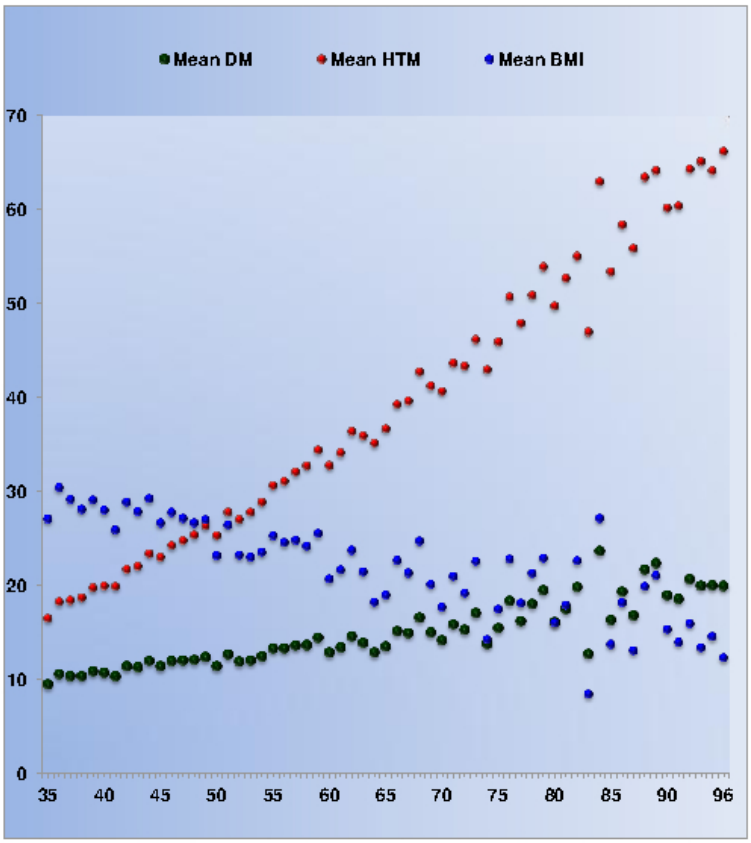
Fig 1. Scatter plot between age with blood glucose, systolic blood pressure, diastolic blood pressure and BMI.

Fig 2. Prevalence of diabetes, hypertension, overweight and comorbidity by sex among Bangladeshi adults

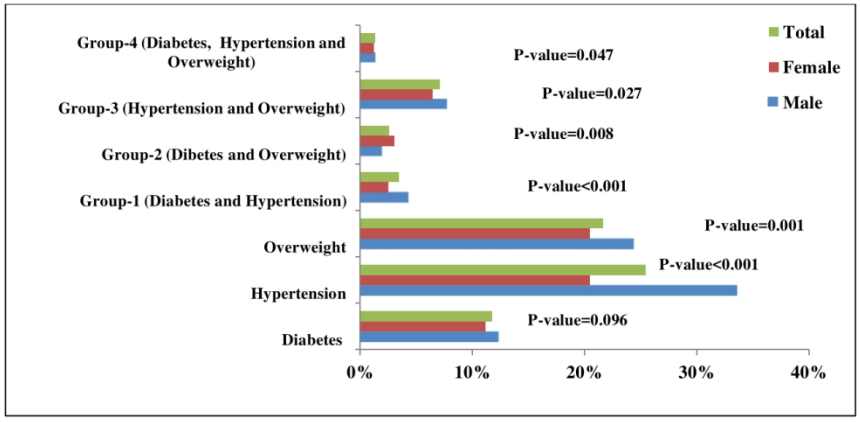
Supplementary Materials:

Supplementary File 1: STROBE Checklist

Supplementary File 2: Modified stepwise Poisson regression models showing prevalence ratios (PR) and 95% confidence intervals for comorbidities by demographic characteristics among Bangladeshi adults.



51x67mm (300 x 300 DPI)



127x62mm (300 x 300 DPI)

STROBE 2007 (v4) Statement—Checklist of items that should be included in reports of *cross-sectional studies*

Title of the study: **Association between high socioeconomic status with greater prevalence of non-communicable diseases risk factors and comorbidities in Bangladesh: Findings from a nationwide cross-sectional survey**

Section/Topic	Item #	Recommendation	Reported on page #
Title and abstract	1	(*a*) Indicate the study's design with a commonly used term in the title or the abstract	1
		(*b*) Provide in the abstract an informative and balanced summary of what was done and what was found	3-4
Introduction			
Background/rationale	2	Explain the scientific background and rationale for the investigation being reported	6-7
Objectives	3	State specific objectives, including any prespecified hypotheses	7
Methods			
Study design	4	Present key elements of study design early in the paper	7-8
Setting	5	Describe the setting, locations, and relevant dates, including periods of recruitment, exposure, follow-up, and data collection	7-8
Participants	6	(*a*) Give the eligibility criteria, and the sources and methods of selection of participants	7-8
Variables	7	Clearly define all outcomes, exposures, predictors, potential confounders, and effect modifiers. Give diagnostic criteria, if applicable	8-9
Data sources/ measurement	8*	For each variable of interest, give sources of data and details of methods of assessment (measurement). Describe comparability of assessment methods if there is more than one group	8-9
Bias	9	Describe any efforts to address potential sources of bias	9
Study size	10	Explain how the study size was arrived at	9
Quantitative variables	11	Explain how quantitative variables were handled in the analyses. If applicable, describe which groupings were chosen and why	9
Statistical methods	12	(*a*) Describe all statistical methods, including those used to control for confounding	9
		(*b*) Describe any methods used to examine subgroups and interactions	Not applicable

		(*c*) Explain how missing data were addressed	Not applicable
		(*d*) If applicable, describe analytical methods taking account of sampling strategy	Not applicable
		(*e*) Describe any sensitivity analyses	Not applicable
Results			
Participants	13*	(a) Report numbers of individuals at each stage of study—eg numbers potentially eligible, examined for eligibility, confirmed eligible, included in the study, completing follow-up, and analysed	10-12
		(b) Give reasons for non-participation at each stage	Not applicable
		(c) Consider use of a flow diagram	Not applicable
Descriptive data	14*	(a) Give characteristics of study participants (eg demographic, clinical, social) and information on exposures and potential confounders	10-12
		(b) Indicate number of participants with missing data for each variable of interest	Not applicable
Outcome data	15*	Report numbers of outcome events or summary measures	11-22
Main results	16	(*a*) Give unadjusted estimates and, if applicable, confounder-adjusted estimates and their precision (eg, 95% confidence interval). Make clear which confounders were adjusted for and why they were included	11-22
		(*b*) Report category boundaries when continuous variables were categorized	Not applicable
		(*c*) If relevant, consider translating estimates of relative risk into absolute risk for a meaningful time period	Not applicable
Other analyses	17	Report other analyses done—eg analyses of subgroups and interactions, and sensitivity analyses	Not applicable
Discussion			
Key results	18	Summarise key results with reference to study objectives	23
Limitations	19	Discuss limitations of the study, taking into account sources of potential bias or imprecision. Discuss both direction and magnitude of any potential bias	25-26
Interpretation	20	Give a cautious overall interpretation of results considering objectives, limitations, multiplicity of analyses, results from similar studies, and other relevant evidence	23-25
Generalisability	21	Discuss the generalisability (external validity) of the study results	23-25
Other information			
Funding	22	Give the source of funding and the role of the funders for the present study and, if applicable, for the original study on which the present article is based	26

*Give information separately for cases and controls in case-control studies and, if applicable, for exposed and unexposed groups in cohort and cross-sectional studies.

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

Table: Modified stepwise Poisson regression models showing prevalence ratios (PR) and 95% confidence intervals for co-morbidities by demographic characteristics among Bangladeshi adults.

	Group-A (Diabetes and hypertension)	Group-B (Diabetes and overweight/obesity)	Group-C (Hypertension and overweight/obesity)	Group-D (Diabetes, hypertension and overweight/obesity)
Model-1 (Wealth index)				
Wealth index				
Richest	3.94 (2.42-6.41)**	9.69 (4.84-19.4) **	6.83 (4.66-10) **	8.67 (3.65-20.56) **
Richer	1.52 (0.88-2.61)	3.39 (1.61-7.16) **	3.78 (2.53-5.64) **	2.44 (0.95-6.31)
Middle	0.9 (0.47-1.71)	1.63 (0.69-3.81)	1.3 (0.81-2.07)	1.17 (0.37-3.7)
Poorer	0.9 (0.47-1.73)	0.81 (0.31-2.16)	1.13 (0.7-1.84)	0.79 (0.24-2.64)
Poorest	Ref	Ref	Ref	Ref
Model-2 (Wealth index + sex)				
Wealth index				
Richest	3.93 (2.42-6.39) **	9.68 (4.84-19.35) **	6.88 (4.7-10.08) **	8.69 (3.68-20.5) **
Richer	1.51 (0.88-2.6)	3.39 (1.61-7.14) **	3.82 (2.56-5.69) **	2.45 (0.96-6.3)
Middle	0.9 (0.47-1.71)	1.62 (0.69-3.8)	1.31 (0.82-2.09)	1.17 (0.37-3.69)
Poorer	0.89 (0.47-1.71)	0.81 (0.31-2.15)	1.16 (0.72-1.89)	0.8 (0.24-2.63)
Poorest	Ref	Ref	Ref	Ref
Sex				
Female	0.85 (0.43-1.66)	0.95 (0.49-1.85)	1.66 (1.22-2.26) **	1.21 (0.53-2.74)
Male	Ref	Ref	Ref	Ref
Model-3 (Wealth index + sex+ age)				
Wealth index				
Richest	4.04 (2.49-6.56) **	9.65 (4.82-19.3) **	6.92 (4.73-10.13) **	8.82 (3.74-20.82) **
Richer	1.51 (0.88-2.59)	3.4 (1.61-7.14) **	3.81 (2.55-5.67) **	2.44 (0.95-6.26)
Middle	0.88 (0.46-1.67)	1.63 (0.7-3.81)	1.3 (0.81-2.07)	1.15 (0.37-3.65)
Poorer	0.86 (0.45-1.64)	0.82 (0.31-2.15)	1.15 (0.71-1.87)	0.78 (0.24-2.57)
Poorest	Ref	Ref	Ref	Ref
Sex				
Female	0.75 (0.39-1.46)	0.97 (0.5-1.88)	1.61 (1.18-2.19) **	1.13 (0.5-2.54)
Male	Ref	Ref	Ref	Ref
Age				
Older	2.34 (1.71-3.2) **	0.88 (0.65-1.2)	1.23 (1.03-1.47) **	1.6 (1.05-2.42) **
Younger	Ref	Ref	Ref	Ref
Model-4 (Wealth index + sex+ age + education)				

Wealth index				
Richest	3.62 (2.16-6.07) **	7.84 (3.74-16.45) **	6.76 (4.55-10.03) **	7.56 (3.11-18.42) **
Richer	1.45 (0.84-2.51)	2.98 (1.37-6.5)	3.77 (2.53-5.63) **	2.24 (0.87-5.8)
Middle	0.87 (0.46-1.64)	1.5 (0.65-3.5)	1.28 (0.81-2.05)	1.1 (0.36-3.36)
Poorer	0.85 (0.45-1.63)	0.78 (0.29-2.09)	1.15 (0.71-1.86)	0.77 (0.23-2.51)
Poorest	Ref	Ref	Ref	Ref
Sex				
Female	0.76 (0.39-1.49)	1.04 (0.53-2.05)	1.62 (1.18-2.22) **	1.19 (0.52-2.71)
Male	Ref	Ref	Ref	Ref
Age				
Older	2.45 (1.79-3.36) **	0.97 (0.7-1.34)	1.25 (1.04-1.51) **	1.72 (1.11-2.65) **
Younger	Ref	Ref	Ref	Ref
Education				
College or higher	1.54 (0.96-2.5)	1.73 (1.06-2.83) **	1.21 (0.91-1.61)	1.59 (0.85-2.97)
Secondary	0.97 (0.62-1.51)	1.22 (0.74-2.01)	0.84 (0.64-1.12)	1.12 (0.59-2.15)
Primary	0.96 (0.64-1.42)	1.35 (0.85-2.14)	1.13 (0.9-1.43)	1.17 (0.65-2.11)
No education, preschool	Ref	Ref	Ref	Ref
Model-5 (Wealth index + sex+ age + education+ occupation)				
Wealth index				
Richest	2.72 (1.6-4.61) **	5.3 (2.54-11.05) **	4.97 (3.37-7.33) **	5.47 (2.32-12.91) **
Richer	1.18 (0.69-2.04)	2.29 (1.06-4.95) **	3.06 (2.06-4.53) **	1.79 (0.71-4.49)
Middle	0.75 (0.4-1.41)	1.24 (0.54-2.85)	1.11 (0.7-1.76)	0.93 (0.31-2.76)
Poorer	0.78 (0.41-1.49)	0.72 (0.27-1.88)	1.06 (0.65-1.7)	0.7 (0.22-2.26)
Poorest	Ref	Ref	Ref	Ref
Sex				
Female	0.67 (0.35-1.31)	0.91 (0.47-1.78)	1.44 (1.06-1.96) **	1.05 (0.47-2.37)
Male	Ref	Ref	Ref	Ref
Age				
Older	2.13 (1.54-2.94) **	0.86 (0.62-1.19)	1.11 (0.91-1.34)	1.54 (1.00-2.38) **
Younger	Ref	Ref	Ref	Ref
Education				
College or higher	1.4 (0.86-2.28)	1.54 (0.94-2.51)	1.09 (0.82-1.45)	1.44 (0.77-2.71)
Secondary	1.05 (0.67-1.64)	1.32 (0.8-2.18)	0.9 (0.68-1.2)	1.22 (0.63-2.35)
Primary	1.03 (0.69-1.53)	1.41 (0.89-2.25)	1.18 (0.93-1.49)	1.24 (0.68-2.26)
No education, preschool	Ref	Ref	Ref	Ref
Occupational				
Non-manual	3.32 (1.97-5.59) **	4.25 (2.27-7.97) **	3.04 (2.19-4.23) **	3.79 (1.67-8.61) **

Manual	Ref	Ref	Ref	Ref
Model-5 (Wealth index + sex+ age + education+ occupation+ place of residence)				
Wealth index				
Richest	2.32 (1.32-4.1) **	4.84 (2.26-10.4) **	4.85 (3.25-7.24) **	3.99 (1.58-10.11) **
Richer	1.12 (0.66-1.91)	2.22 (1.02-4.8)	3.03 (2.04-4.49)	1.59 (0.65-3.92)
Middle	0.74 (0.39-1.38)	1.23 (0.54-2.82)	1.1 (0.69-1.75)	0.9 (0.31-2.64)
Poorer	0.78 (0.41-1.48)	0.71 (0.27-1.88)	1.06 (0.65-1.7)	0.7 (0.22-2.24)
Poorest	Ref	Ref	Ref	Ref
Sex				
Female	0.67 (0.35-1.31)	0.91 (0.47-1.78)	1.44 (1.06-1.96) **	1.05 (0.46-2.36)
Male	Ref	Ref	Ref	Ref
Age				
Older	2.17 (1.58-2.99) **	0.87 (0.62-1.21)	1.11 (0.91-1.35)	1.61 (1.05-2.49) **
Younger	Ref	Ref	Ref	Ref
Education				
College or higher	1.38 (0.85-2.25)	1.53 (0.93-2.5)	1.09 (0.82-1.45)	1.4 (0.74-2.63)
Secondary	1.06 (0.68-1.65)	1.33 (0.8-2.19)	0.91 (0.68-1.2)	1.24 (0.65-2.38)
Primary	1.03 (0.69-1.53)	1.42 (0.89-2.26)	1.18 (0.93-1.5)	1.25 (0.69-2.28)
No education, preschool	Ref	Ref	Ref	Ref
Occupational				
Non-manual	3.27 (1.94-5.52) **	4.22 (2.26-7.9) **	3.04 (2.19-4.22) **	3.69 (1.63-8.36) **
Manual	Ref	Ref	Ref	Ref
Place of residence				
Urban	1.33 (0.9-1.95)	1.17 (0.8-1.72)	1.04 (0.85-1.27)	1.72 (0.99-3.01)
Rural	Ref	Ref	Ref	Ref