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

Journal:	<i>BMJ Open</i>
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, Department 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

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Manuscripts

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3 **1 Title: High socioeconomic status associated with greater prevalence of NCD**
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6 **2 risk factors and co-morbidities in Bangladesh. Findings from a nationwide**
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9 **3 survey**
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3 30 **ABSTRACT**
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6 31 **Objectives:** This study aimed to find out prevalence and distribution patterns of co-morbidity of
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8 32 non-communicable diseases (NCD) among the adult population in Bangladesh by measures of
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11 33 socio-economic status..
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17 35 **Design:** This was a cross-sectional study.
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25 37 **Setting:** This study used Bangladesh Demographic and Health Survey (2011) data.
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31 39 **Participants:** Total 8,763 individual aged ≥ 35 years were included.
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39 41 **Primary and secondary outcome measures:** The primary outcome was diabetes (DM),
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41 42 hypertension (HTN) and overweight/obesity. The study further assesses factors associated with
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43 43 co-morbidities, in particular socio-economic status.
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50 45 **Results:** Of 8,763 adults, 12% had diabetes (DM), 27% hypertension (HTN) and 22% were
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52 46 overweight ($BMI \geq 23 \text{ kg/m}^2$). Just over 1% of the sample had all three conditions, 3% had both
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54 47 DM and HTN, 3% DM and overweight and 7% HTN and overweight. Diabetes, hypertension
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3 48 and overweight was more prevalent amongst those who had higher education, were non-manual
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5 49 workers, were in the richer to richest socioeconomic status and lived in urban settings.
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8 50 Individuals in higher socio-economic status groups were also more likely to suffer from co-
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10 51 morbidity.
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16 53 **Conclusions:** In contrast to more affluent countries, individual NCD risk factors and co-
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18 54 morbidities are more common in higher socio-economic status individuals. Public health
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21 55 approaches must consider this social patterning in tackling NCDs in the country.
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28 57 **Key words:** Obesity, Overweight, Noncommunicable Disease, Bangladesh
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58 STRENGTHS AND LIMITATIONS OF THE STUDY

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

64 INTRODUCTION

65 According to the Global Burden of Disease report, Non-communicable diseases (NCDs)
66 are the leading cause of death¹⁻³ with 80% of NCD mortality occurring in low- and middle-
67 income countries (LMICs).⁴⁻⁶ The NCDs global status report (2014) showed that of 58 million
68 deaths that occurred globally in 2012, 38 million - almost two thirds - were due to NCDs,
69 comprising mainly cardiovascular diseases, cancers, diabetes and chronic lung diseases.⁷ More
70 than 40% of these deaths (16 million) were in individuals under the age of 70 years, often
71 referred to as premature deaths. Deaths at these younger ages may be a greater demonstration of
72 its burden, as many consider them preventable. It is alarming, therefore, that the majority of
73 premature deaths (82%) occur in LMICs, with this problem likely to increase if the appropriate
74 interventions are not implemented.

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

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

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3 86 ¹³⁻¹⁵ with evidence on NCD co-morbidity scant in less affluent countries, including Bangladesh.
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5 87 This is important as the patterning of NCDs is not uniform across countries of different income
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7 88 classification, with a higher prevalence of some NCD risk factors, such as diabetes, found in
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9 89 higher socio-economic groups in many studies in LMICs, contradicting those from higher
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11 90 income countries.¹⁶
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15 91 With the rapid transition of under nutrition to over-nutrition in these LMICs,
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17 92 understanding co-morbidity and their correlates are important to develop NCD policy for
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19 93 individual countries. Despite the availability of nationwide survey, data in Bangladesh, the
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21 94 prevalence, and in particular the co-morbidity of NCD medical risk factors remains unmapped.
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23 95 This understanding of the burden and patterning of NCDs and their risk factors is important if
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25 96 Bangladesh is able to meet the Sustainable Development Goals (SDGs) target of reducing
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27 97 premature death from NCDs by one third by 2030.¹⁷
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32 98 This study used 2011 Bangladesh Demography and Health Survey (BDHS) data to
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34 99 estimate the prevalence and pattern of NCD risk factors and co-morbidity among the general
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36 100 population aged 35 years and older, as well as determining their socio-demographic patterning
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38 101 and possible predictors of co-morbidity.
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104 **METHODS**

105 **study design**

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

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3 108 conducted between July and December 2011 through the collaboration of the National Institute
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5 109 of Population Research and Training (NIPORT), ICF International (USA), and Mitra and
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7 110 Associates. Participants in the BDHS were selected using probability sampling based on a two-
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9 111 stage cluster sample of households, and stratified by rural and urban areas in the seven
10
11 112 administrative regions of Bangladesh. The detailed protocol and methods have been published
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13 113 previously.¹⁸ In brief, 17,500 households were surveyed, of which one in three households were
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15 114 randomly selected for biomarker measurement. All men and women age 35 years and above
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17 115 were eligible for the biomarker test and total biomarker measures were collected from 8,835
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19 116 individuals (male: 4524, female: 4311) who were eligible and were available during the time of
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21 117 data collection.¹⁹ In our analysis, we included a sample 8763 cases after excluding missing
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23 118 values.
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32 **measurements of outcome**

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34 121 A data collection team including a health technician measured blood pressure, blood
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36 122 glucose concentration, body weight, and height using standard methods.¹⁸ Diabetes (DM) was
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38 123 defined as fasting blood glucose level greater than or equal to 7.0 mmol/L or self-reported
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40 124 diabetes medication use.²⁰ Body mass index (BMI) was calculated as weight (kg)/height (m²).
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42 125 Using Asian specific BMI cut-offs underweight was defined as <18.5 kg/m², overweight (higher
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44 126 BMI) as ≥23kg/m².²¹ Hypertension (HTN) was defined as systolic blood pressure (SBP) ≥140
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46 127 mmHg and diastolic blood pressure (DBP) ≥90 mmHg or self-reported anti-hypertensive
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48 128 medication use during the survey.²² We categorized the co-morbidity into four group such as
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50 129 respondents having DM and HTN (group A), DM and overweight (group B), HTN and
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3 130 overweight(group C) and group D in which individuals had all three conditions (DM, HTN and
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5 131 overweight).

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10 133 **socio-demographic factors**

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12 134 We categorized age as older (defined as 56 years and above) and younger (35 to 55
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14 135 years) [23]. Education status was characterized by no education, preschool, primary, secondary
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16 136 and College or higher. Occupation was categorized manual and non-manual worker.²⁴. Wealth
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18 137 index was determine using principle component analysis using presence of household assets and
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20 138 overall method was describe in detail in the BDHS 2011 report. Place of residence (urban and
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22 139 rural) and sex (male and female) were also considered socio-demographic factors.

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31 142 **statistical analysis**

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33 143 HTN, DM, overweight and all possible combinations of the co-morbidity conditions
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35 144 were the main outcomes interest. For analysis purposes, all outcomes were made dichotomous
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37 145 (persons with/without risk factor).Sex, age, education, occupation, wealth index and place of
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39 146 residence were included in analysis as independent variables. The prevalence of DM, HTN,
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41 147 overweight and co-morbidity are shown in percentages. Using modified Poisson regression
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43 148 (PR) models with robust error variance; we calculated the prevalence ratio (PR) and 95%
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45 149 confidence interval for DM, HTN and overweight/obesity all analyses were adjusted for cluster
46
47 150 and sample weight. The analysis was done using IBMSPSS 21. The authors followed the
48
49 151 Strengthening the Reporting of Observational Studies in Epidemiology (STROBE) Statement in
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51 152 writing this manuscript (supplementary file 1).

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154 **ethical consideration**

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

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160 **patient involvement**

161 Patients were not involved in the study.

162

163 **FINDINGS**

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

167 **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

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

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3 171 figure-1. According to that probability of having diabetes and hypertension increasing by
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5 172 increasing age group. But probability having higher BMI is higher in younger age group
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8 173 compare to older age group. Prevalence of all these conditions were higher amongst males than
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10 174 females. The prevalence of group-1 (DM and HTN) and group 2 co-morbidities was 3%, 7% of
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12 175 the sample had group-3 co-morbidity (HTN and overweight), were as 1% had all three
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14 176 conditions (DM, HTN and overweight). Prevalence of all group of co-morbid condition was also
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17 177 higher in male compare to female except for group 2 (DM and overweight) (Figure 2).
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23 179 The prevalence of individual conditions and all co-morbidities was higher amongst
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25 180 older individuals, those with a 'College or higher' education, 'non-manual' workers, people in
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28 181 the richest quintile for wealth index and those living in urban environments (Table 2).
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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							

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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

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3 186 The prevalence ratio, from modified Poisson regression models, of HTN, DM and
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5 187 overweight was significantly higher among those who completed higher education, those living
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7 188 in the urban areas, non-manual workers and richer to richest socioeconomic status. Although
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9 189 there was no sex disparities for diabetes, HTN and overweight was higher in males. The PR of
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11 190 overweight was the only condition which was significantly higher among younger participants
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14 191 (Table 3).
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192 **Table-3: Modified Poisson regression models showing prevalence ratios (PR) and 95% confidence intervals for diabetes,**
 193 **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

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

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

198 **Statistical significance at $p < 0.05$

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3 199 In univariate Poisson regression models those in the richest quintile of wealth index had the
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5 200 highest prevalence ratio of all co-morbidity groups. These differences remained significant in all
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8 201 models in a stepwise process (Supplementary Table 1). In final models once controlling for sex,
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10 202 age, education, occupation and level of urbanisation, with those in the richest quintile 2.3 times
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12 203 as likely to have DM and HTN, 4.8 times as likely to have DM and overweight, 4.9 times as
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14 204 likely to have HTN and overweight and 4.0 times as likely to have all three co-morbidities than
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17 205 those in the poorest quintile. In these final models non-manual workers were also significantly
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19 206 more likely than manual workers to have all co-morbidity groups. Sex differences were lost,
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21 207 except for HTN and overweight in which females were 1.4 times as likely to experience both and
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24 208 older participants were significantly more likely to have DM and HTN and all co-morbidities
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26 209 (Table 4).
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210 **Table-4: Modified stepwise Poisson regression models showing prevalence ratios (PR) and 95% confidence intervals for co-**
 211 **morbidities by demographic characteristics among Bangladeshi adults.**

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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)				
<i>Wealth index</i>				
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)				
<i>Wealth index</i>				
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
<i>Place of residence</i>				
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

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214 ** Statistical significance at $p < 0.05$

215 DISCUSSION

216
217 This is the first study in Bangladesh that investigated individual and co-morbid
218 condition using nationally representative sample. We found that within the Bangladesh adult
219 population, aged more than 35 years, the prevalence of diabetes was 12%, hypertension 27% and
220 22% were overweight. Diabetes, hypertension and overweight comparatively higher in male
221 compare to female. More than 14% of the sample also had more than one condition, with 1.3%
222 exhibiting all three. It was also reported that individual prevalence and co-morbidity were higher
223 in high socio-economic status, and once controlling for several confounders those in the richest
224 quintile of wealth index were significantly more likely than those in poorest quintile to exhibit
225 co-morbidities.

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

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3 238 data including Bangladesh reported that Every standard deviation higher of BMI was associated
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5 239 with 1.65 and 1.60 times higher probability of diabetes and 1.42 and 1.28 times higher
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8 240 probability of hypertension.³⁹
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11 241 This paper is the first to study Non-communicable diseases (NCDs) risk factor co-
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13 242 morbidities within a Bangladesh population. It uses a national representative dataset, the 2011
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15 243 Bangladesh Demography and Health Survey (BDHS), resulting in a national representative
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18 244 sample with good power for statistical analysis.
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21 245 Although, to the authors knowledge this is the first study on the prevalence of NCD
22
23 246 risk factor co-morbidity in Bangladesh, a previous study had observed the association between
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25
26 247 anthropometric indices such as body mass index (BMI), waist circumference (WC) and waist
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29 248 hip ratio (WHR) and cardio metabolic risk indicators (FBG, SBP and DBP).⁴⁰ A further study in
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31 249 four geographical regions, including Bangladesh, reported that every standard deviation higher
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33 250 of BMI was associated with 1.65 and 1.60 times higher probability of diabetes and 1.42 and 1.28
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36 251 times higher probability of hypertension, for men and women, respectively.³⁹ Other studies have
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38 252 also found that HTN is a common co-morbid condition in DM, and vice versa,⁴¹ whilst there is
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41 253 considerable evidence for an increased prevalence of HTN in diabetic persons from other
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43 254 populations.^{42, 43}
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46 255 Our study reported individual condition and co-morbidities higher in high socio-
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48 256 economic group. These findings conflict with trends reported by previous studies conducted in
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50 257 higher-income countries.^{44, 45} However, another multicounty study in low income country (LIMs)
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53 258 reported the co-morbidity was more prevalent among the poor and less educated.⁴⁶ But one of the
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55 259 limitations of that study was self-reported diagnosis, which may introduce biases. Previous
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3 260 research in INDEPTH Asian sites has reported inverse associations between co-morbidity and
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5 261 markers of socioeconomic status.⁴⁷
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11 263 The main implications of the this study are the increased burden of NCDs within
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14 264 Bangladesh, along with other LMICs and the patterning of more than one risk factors within
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16 265 individuals in the population. In contrast to findings from high income countries prevalence of
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18 266 individual risk factors and co-morbidities was higher in higher SES groups. This points to
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20 267 differences between countries in the population level determinants of NCDs and highlights that
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22 268 context specific interventions must be developed to counter them. As a first step, it is important
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24 269 that countries collect and analyse high quality health data to allow them to develop and target
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26 270 interventions.
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32 33 34 272 **STRENGTHS AND LIMITATIONS**

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37 273 Measurements were taken by health technicians, WHO measured blood pressure, blood
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39 274 glucose concentration, body weight, and height using standard methods including biomarker
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41 275 analysis and validated measures of socio-economic status collected. The main weakness of the
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43 276 study is the cross-sectional nature meaning that only associations can be inferred and causality
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45 277 cannot be determined. In addition although clinical measures of the diabetes, hypertension and
46
47 278 overweight were taken, no measurements of blood lipids were taken in the survey, meaning that
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49 279 metabolic syndrome could not be investigated. Waist circumference and hip circumference were
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51 280 also not collected, limiting the analysis that could be performed. Finally although the study was
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3 281 reported to be representative, only participants 35 years or older had measured anthropometry
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5 282 and biomarkers.
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10 11 12 284 **CONCLUSION** 13 14

15 285 Several socio-demographic factors associated with DM, HTN, overweight and co-morbid
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18 286 condition. There is an urgent need to improve monitoring and management of NCDs through
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20 287 primary care linked programmes. Policy and system changes are essential to reduce risk in
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22 288 population. At the same time for prevention and control of NCDs needs “political will” societal
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25 289 and community support.
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31 291 **Contributors** 32 33

34 292 TB, NT, SKD & AAM conceptualized the study. TB, NT, SKD, RDG & AAM designed the
35
36 293 study and acquired the data. TB, SI & MRI conducted the data analysis. TB, NT, SI, MRI, SKD
37
38 294 & AAM interpreted the data. TB, NT & RDG prepared the first draft. TB, NT, SKD & AAM
39
40 295 participated in critical revision of the manuscript and contributed to its intellectual improvement.
41
42
43 296 All authors went through the final draft and approved it for submission.
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50 298 **Funding** 51 52

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56 301 **Acknowledgments**
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9 302 The authors thank MEASURE DHS for permission to use data from the 2011
10
11 303 Bangladesh DHS. The authors are also grateful to Mr. Mehedi Hasan, PhD student, University of
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13 304 Queensland, Australia.
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16 305 **Competing Interests**
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19 306 None declared.
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26 308 **Patient consent**
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29 309 None Declared
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35 311 **Disclaimer**
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38 312 The authors are alone responsible for the integrity and accuracy of data analysis and the writing
39
40 313 the manuscript.
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45 315 **Ethics approval**
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47

48 316 The datasets were obtained from DHS Programme with proper procedure. The study exempt
49
50 317 from collecting ethical approval because the survey protocols were reviewed and approved by
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52 318 ICF Macro Institutional Review Board, Maryland, USA and National Research Ethics
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54 319 Committee of Bangladesh Medical Research Council (BMRC), Dhaka, Bangladesh.
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7 321 **Data sharing statement**8
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10 322 The dataset of BDHS 2011 is available at the Demographic and Health Surveys Program. Extra11
12
13 323 data is available which is available on request at <http://dhsprogram-com/what-we->14
15 324 [do/survey/survey-display-349.cfm](http://dhsprogram-com/what-we-do/survey/survey-display-349.cfm).16
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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.

- 1
2
3 350 9. National Institute of Population Research and Training (NIPORT), Mitra and Associates,
4
5 351 ICF International. Bangladesh Urban Health Survey 2013.. Dhaka, Bangladesh, Calverton,
6
7 352 Maryland, USA: NIPORT, Mitra and Associates, and ICF International., 2015.
8
9
10 353 10. Ahsan KZ, Alam MN, Streatfield PK, et al. Has Bangladesh Entered the Fourth Stage of
11
12 354 the Epidemiologic Transition?. Proceedings of the International seminar on Mortality: Past,
13
14 355 Present and Future; 2017Aug 7-8; the University of Campinas, Brazil.
15
16
17 356 11. Zaman MM, Bhuiyan MR, Karim MN, et al. Clustering of non-communicable diseases
18
19 357 risk factors in Bangladeshi adults: an analysis of STEPS survey 2013. *BMC Public Health*.
20
21 358 2015;15(1):659. doi: 10.1186/s12889-015-1938-4.
22
23
24 359 12. Hillas G, Perlikos F, Tsiligianni I, et al. Managing comorbidities in COPD. *Int J Chron*
25
26 360 *Obstruct Pulmon Dis*.2015;10:95. doi: 10.2147/COPD.S54473.
27
28
29 361 13. Shukla A, Kumar K, Singh A. Association between obesity and selected morbidities: a
30
31 362 study of BRICS countries. *PloS One*. 2014;9(4):e94433. doi: 10.1371/journal.pone.0094433.
32
33 363 14. Wang J, Ma JJ, Liu J, et al. Prevalence and Risk Factors of Comorbidities among
34
35 364 Hypertensive Patients in China. *Int J Med Sci*. 2017;14(3):201. doi: 10.7150/ijms.16974.
36
37
38 365 15. Bosu WK. The prevalence, awareness, and control of hypertension among workers in
39
40 366 West Africa: a systematic review. *Glob Health Action*. 2015;8(1):26227. doi:
41
42 367 10.3402/gha.v8.26227.
43
44
45 368 16. Allen L, Williams J, Townsend N, et al. Socioeconomic status and non-communicable
46
47 369 disease behavioural risk factors in low-income and lower-middle-income countries: a systematic
48
49 370 review. *Lancet Glob Health*. 2017;5(3):e277-e89. doi: 10.1016/S2214-109X(17)30058-X.
50
51
52
53
54
55
56
57

- 1
2
3 371 17. Varghese C. Reducing premature mortality from non-communicable diseases, including
4
5 372 for people with severe mental disorders. *World Psychiatry*. 2017;16(1):45-7. doi:
6
7 373 10.1002/wps.20376.
8
9
10 374 18. National Institute of Population Research and Training (NIPORT), Mitra and Associates,
11
12 375 ICF International. Bangladesh Demographic and Health Survey 2011, Preliminary Report.
13
14 376 Dhaka, Bangladesh, Calverton, Maryland, USA: NIPORT, Mitra and Associates, and ICF
15
16 377 International., 2012.
17
18
19 378 19. Biswas T, Islam MS, Linton N, et al. Socio-economic inequality of chronic non-
20
21 379 communicable diseases in Bangladesh. *PloS One*. 2016;11(11):e0167140. doi:
22
23 380 10.1371/journal.pone.0167140.
24
25
26 381 20. Akter S, Rahman MM, Abe SK, et al. Prevalence of diabetes and prediabetes and their
27
28 382 risk factors among Bangladeshi adults: a nationwide survey. *Bull World Health Organ*.
29
30 383 2014;92(3):204-13A. doi: 10.2471/BLT.13.128371.
31
32
33 384 21. Ke-You G, Da-Wei F. The magnitude and trends of under-and over-nutrition in Asian
34
35 385 countries. *Biomed Environ Sci*. 2001;14(1-2):53-60.
36
37
38 386 22. National Institute of Population Research and Training (NIPORT), Mitra and Associates,
39
40 387 ICF International. Bangladesh Demographic and Health Survey 2011. Dhaka, Bangladesh,
41
42 388 Calverton, Maryland, USA: NIPORT, Mitra and Associates, and ICF International., 2013.
43
44
45 389 23. Rahman M, Williams G, Al Mamun A. Hypertension and diabetes prevalence among
46
47 390 adults with moderately increased BMI (23· 0–24· 9 kg/m²): findings from a nationwide survey
48
49 391 in Bangladesh. *Public Health Nutr*. 2017:1-8. doi: 10.1017/S1368980016003566.
50
51
52
53
54
55
56
57

- 1
2
3 392 24. Alam DS, Chowdhury MA, Siddiquee AT, et al. Prevalence and determinants of chronic
4
5 393 obstructive pulmonary disease (COPD) in Bangladesh. *COPD*. 2015;12(6):658-67. doi:
6
7 394 10.3109/15412555.2015.1041101.
8
9
10 395 25. Hussain MA, Huxley RR, Al Mamun A. Multimorbidity prevalence and pattern in
11
12 396 Indonesian adults: an exploratory study using national survey data. *BMJ Open*.
13
14 397 2015;5(12):e009810. doi: 10.1136/bmjopen-2015-009810.
15
16
17 398 26. Howitt C, Hambleton IR, Rose AM, et al. Social distribution of diabetes, hypertension
18
19 399 and related risk factors in Barbados: a cross-sectional study. *BMJ Open*. 2015;5(12):e008869.
20
21 400 doi: 10.1136/bmjopen-2015-008869.
22
23
24 401 27. Pearson TA. Education and income: double-edged swords in the epidemiologic transition
25
26 402 of cardiovascular disease. *Ethn Dis*. 2003;13(2; SUPP/2):S2-158.
27
28
29 403 28. Agborsangaya CB, Lau D, Lahtinen M, et al. Multimorbidity prevalence and patterns
30
31 404 across socioeconomic determinants: a cross-sectional survey. *BMC Public Health*.
32
33 405 2012;12(1):201. doi: 10.1186/1471-2458-12-201.
34
35
36 406 29. Rahman M, Williams G, Al Mamun A. Gender differences in hypertension awareness,
37
38 407 antihypertensive use and blood pressure control in Bangladeshi adults: findings from a national
39
40 408 cross-sectional survey. *J Health Popul Nutr*. 2017;36(1):23. doi: 10.1186/s41043-017-0101-5.
41
42
43 409 30. Li G, Hu H, Dong Z, et al. Urban and suburban differences in hypertension trends and
44
45 410 self-care: Three population-based cross-sectional studies from 2005-2011. *PloS One*.
46
47 411 2015;10(2):e0117999. doi: 10.1371/journal.pone.0117999.
48
49
50 412 31. Sola A, Chinyere O, Stephen A, et al. Hypertension prevalence in an urban and rural area
51
52 413 of Nigeria. *J Med Sci*. 2013;4:149-54.
53
54
55
56
57

- 1
2
3 414 32. Dhungana RR, Pandey AR, Bista B, et al. Prevalence and associated factors of
4
5 415 hypertension: a community-based cross-sectional study in municipalities of Kathmandu, Nepal.
6
7 416 *Int J Hypertens*.2016;2016. doi: 10.1155/2016/1656938.
8
9
10 417 33. Chowdhury MAB, Uddin MJ, Haque MR, et al. Hypertension among adults in
11
12 418 Bangladesh: evidence from a national cross-sectional survey. *BMC Cardiovasc Disord*.
13
14 419 2016;16(1):22. doi: 10.1186/s12872-016-0197-3.
15
16
17 420 34. Akter S, Rahman MM, Abe SK, et al. Prevalence of diabetes and prediabetes and their
18
19 421 risk factors among Bangladeshi adults: a nationwide survey. *Bull World Health*
20
21 422 *Organ*.2014;92(3):204-13A. doi: 10.2471/BLT.13.128371
22
23
24 423 35. Biswas T, Uddin MJ, Al Mamun A, et al. Increasing prevalence of overweight and
25
26 424 obesity in Bangladeshi women of reproductive age: Findings from 2004 to 2014. *PloS One*.
27
28 425 2017;12(7):e0181080. doi: 10.1371/journal.pone.0181080.
29
30
31 426 36. Hoque ME, Hasan MT, Rahman M, et al. Double burden of underweight and overweight
32
33 427 among Bangladeshi adults differs between men and women: evidence from a nationally
34
35 428 representative survey. *Public Health Nutr*.2017;20(12):2183-91. doi:
36
37 429 10.1017/S1368980017000957.
38
39
40 430 37. Biswas T, Garnett SP, Pervin S, et al. The prevalence of underweight, overweight and
41
42 431 obesity in Bangladeshi adults: Data from a national survey. *PloS One*. 2017;12(5):e0177395. doi:
43
44 432 10.1371/journal.pone.0177395.
45
46
47 433 38. Dietz WH. Double-duty solutions for the double burden of malnutrition. *Lancet*. 2017.
48
49 434 doi: 10.1016/S0140-6736(17)32479-0.
50
51
52
53
54
55
56
57

- 1
2
3 435 39. Patel SA, Ali MK, Alam D, et al. Obesity and its relation with diabetes and hypertension:
4
5 436 a cross-sectional study across 4 geographical regions. *Glob Heart*.2016;11(1):71-9. e4. doi:
6
7 437 10.1016/j.ghheart.2016.01.003.
8
9
10 438 40. Bhowmik B, Afsana F, Ahmed T, et al. Obesity and associated type 2 diabetes and
11
12 439 hypertension in factory workers of Bangladesh. *BMC Res Notes*.2015;8(1):460. doi:
13
14 440 10.1186/s13104-015-1377-4.
15
16
17 441 41. Pradeepa R. The rising burden of diabetes and hypertension in southeast asian and african
18
19 442 regions: need for effective strategies for prevention and control in primary health care settings.
20
21 443 *Int J Hypertens*. 2013;2013. doi: 10.1155/2013/409083.
22
23
24 444 42. Berraho M, El Achhab Y, Benslimane A, et al. Hypertension and type 2 diabetes: a cross-
25
26 445 sectional study in Morocco (EPIDIAM Study). *Pan Afr Med J*. 2012;11(1).
27
28
29 446 43. Hashemizadeh H, Sarvelayati D. Hypertension and Type 2 Diabetes: A Cross-sectional
30
31 447 Study in Hospitalized Patients in Quchan, Iran. *Iran J Diabetes Obesity*. 2013;5(1):21-6.
32
33
34 448 44. Connolly V, Unwin N, Sherriff P, et al. Diabetes prevalence and socioeconomic status: a
35
36 449 population based study showing increased prevalence of type 2 diabetes mellitus in deprived
37
38 450 areas. *J Epidemiol Community Health*.2000;54(3):173-7.
39
40
41 451 45. Glover JD, Hetzel DM, Tennant SK. The socioeconomic gradient and chronic illness and
42
43 452 associated risk factors in Australia. *Aust New Zealand Health Policy*. 2004;1(1):8. doi:
44
45 453 10.1186/1743-8462-1-8.
46
47
48 454 46. Hosseinpoor AR, Bergen N, Mendis S, et al. Socioeconomic inequality in the prevalence
49
50 455 of noncommunicable diseases in low-and middle-income countries: results from the World
51
52 456 Health Survey. *BMC Public Health*. 2012;12(1):474. doi: 10.1186/s12889-015-2227-y.
53
54
55
56
57

1
2
3 457 47. Van Minh H, Ng N, Juvekar S, et al. Self-reported prevalence of chronic diseases and
4
5 458 their relation to selected sociodemographic variables: a study in INDEPTH Asian sites, 2005.
6
7 459 *Prev Chronic Dis.*2008;5(3).
8
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For peer review only

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3 **460 Figures:**
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6 **461 Fig 1. Predictive probability of diabetes, hypertension and BMI by age**
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8 **462 Fig 2. Prevalence of diabetes, hypertension, overweight and co-morbidity by sex among**
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10 **463 Bangladeshi adults**
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17 **465 Supplementary Materials:**
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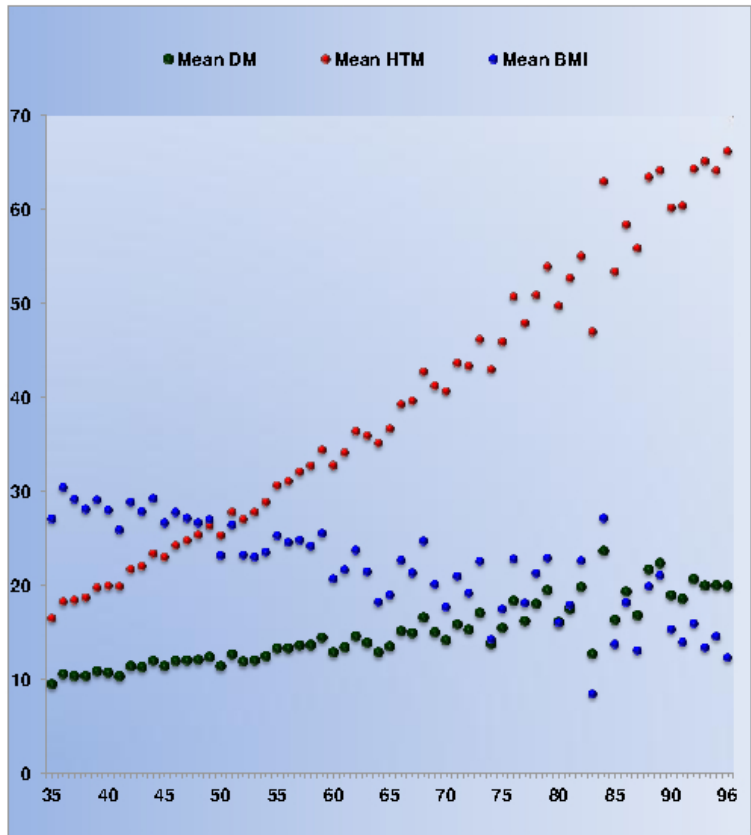
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20 **466 Supplementary File 1: STROBE Checklist**
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23 **467 Supplementary File 2: Supplementary Table 1: Modified stepwise Poisson regression models**
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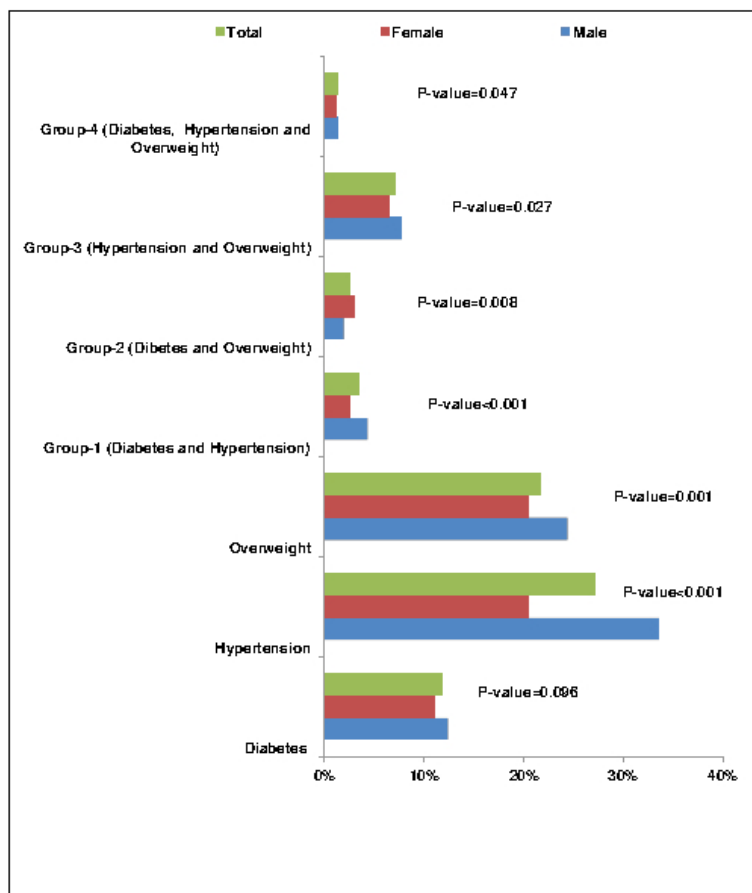
25 **468 showing prevalence ratios (PR) and 95% confidence intervals for co-morbidities by demographic**
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27 **469 characteristics among Bangladeshi adults.**
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Predictive probability of diabetes, hypertension 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)				
<i>Wealth index</i>				
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)				
<i>Wealth index</i>				
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
<i>Sex</i>				
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)				
<i>Wealth index</i>				
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
<i>Sex</i>				
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
<i>Age</i>				
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)				
<i>Wealth index</i>				
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

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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.

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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.

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BMJ Open

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

Journal:	<i>BMJ Open</i>
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, Department 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

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Manuscripts

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3 1 **Title: High socioeconomic status is associated with greater prevalence of NCD**
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6 2 **risk factors and comorbidities in Bangladesh. Findings from a nationwide**
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29 ABSTRACT

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

33 **Design:** This was a cross-sectional study.

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

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

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

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

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

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3 49 **Key words:** Overweight, Diabetes, Hypertension, Non-communicable Disease, socioeconomic
4 50 status, Bangladesh
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51 STRENGTHS AND LIMITATIONS OF THE STUDY

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

59

60 INTRODUCTION

61 According to the Global Burden of Disease report, non-communicable diseases (NCDs)
62 are the leading cause of death worldwide¹⁻³ and that 80% of this NCD mortality actually occurs in
63 low- and middle-income countries (LMICs)⁴⁻⁶. Similarly, the 2014 NCDs global status report
64 showed that of 58 million deaths that occurred globally in 2012, 38 million - almost two thirds -
65 were due to NCDs, with these deaths most due to the four most common NCDs: cardiovascular
66 diseases, cancers, diabetes and chronic lung diseases.⁷ In addition, the report showed that more
67 than 40% of these deaths (16 million) occurred were in individuals under the age of 70 years, often
68 referred to as premature deaths⁷. Deaths at younger ages may be a greater demonstration of its
69 burden, as many consider them preventable. It is alarming, therefore, that the majority of premature
70 deaths (82%) occur in LMICs, with this problem likely to increase if appropriate preventative
71 actions are not taken at a population level.

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

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

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3 82 obesity, diabetes and hypertension, predominantly coming from industrialized countries¹³⁻¹⁵ and
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5 83 developing nations¹⁶⁻¹⁸; however evidence on NCD comorbidity scant in Bangladesh. This is
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8 84 important as the patterning of NCDs is not uniform across countries of different income
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10 85 classification, with a higher prevalence of some NCD risk factors, such as diabetes, found in higher
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12 86 socio-economic groups in many studies in LMICs, contradicting those from higher income
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15 87 countries.¹⁹
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18 88 With the development of a double burden from both over- and under-nutrition in these
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20 89 LMICs, understanding comorbidity and their correlates is important if we are to develop NCD
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22 90 preventative policies contextualized for these countries. Despite the availability of nationwide
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24 91 survey data in Bangladesh, the prevalence, and in particular the comorbidity of NCD medical risk
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26 92 factors remains unmapped. This understanding of the burden and patterning of NCDs and their
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28 93 risk factors is important if Bangladesh is able to meet the Sustainable Development Goals (SDGs)
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30 94 target of reducing premature death from NCDs by one third by 2030.²⁰
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35 95 This study used 2011 Bangladesh Demography and Health Survey (BDHS) data to estimate
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37 96 the prevalence and pattern of NCD risk factors and comorbidity among the general population
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39 97 aged 35 years and older, as well as determining their socio-demographic patterning and possible
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41 98 predictors of comorbidity .
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48 100 **METHODS**

50 101 **Study design**

53 102 This study used data from the 2011 Bangladesh Demography and Health Survey (BDHS).
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56 103 The 2011 BDHS is a cross-sectional nationally representative survey that was conducted between
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3 104 July and December 2011 through the collaboration of the National Institute of Population Research
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5 105 and Training (NIPORT), ICF International (USA), and Mitra and Associates. Participants in the
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7 106 BDHS were selected using probability sampling based on a two-stage cluster sample of
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10 107 households, and stratified by rural and urban areas in the seven administrative regions of
11
12 108 Bangladesh. The detailed protocol and methods have been published previously.²¹ In brief, 17,500
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15 109 households were surveyed, of which one in three households were randomly selected for
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17 110 biomarker measurement (blood glucose, blood pressure). All men and women age 35 years and
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19 111 above were eligible for the biomarker measures, with these collected from a final sample of 8,835
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21 112 individuals (male: 4524, female: 4311).²² We included 8763 cases in our analytical sample, after
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24 113 excluding cases with missing values.
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29 115 **Measurements of outcomes**

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32 116 A data collection team, including a health technician, measured blood pressure, blood
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34 117 glucose concentration, body weight, and height using standard methods.²¹ Diabetes (DM) was
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36 118 defined as a fasting blood glucose level greater than or equal to 7.0 mmol/L or self-reported
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38 119 diabetes medication use.²³ Body mass index (BMI) was calculated as weight (kg)/height (m²). We
39
40 120 used Asian specific BMI cut-offs to define underweight as <18.5 kg/m² and overweight and obese
41
42 121 (higher BMI) as ≥23kg/m².²⁴ Hypertension was defined as systolic blood pressure (SBP) ≥140
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45 122 mmHg and diastolic blood pressure (DBP) ≥90 mmHg or self-reported anti-hypertensive
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47 123 medication use during the survey.²⁵ We then categorized comorbidity into four groups such as
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49 124 respondents having DM and HTN (group A), DM and overweight (group B), HTN and overweight
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51 125 (group C) and group D in which individuals had all three conditions (DM, HTN and overweight).
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127 **Socio-demographic factors**

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

135 **Statistical analysis**

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

146 **Ethical consideration and patient involvement**

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

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3 149 Bangladesh Medical Research Council (BMRC), Dhaka, Bangladesh. Written informed consent
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5 150 was taken from the participants before the survey was completed.
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8 151 **FINDINGS**

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10 152 The study population (n=8763) comprised 51% males, around 56% were 56 years of age
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12 153 or older, 62% reported no education, 25% were in manual employment, and 76% lived in rural
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14 154 locations (Table 1).
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18 155 **Table-1: General characteristics of the study population**
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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

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157 Among the sample 12% had diabetes, 27% had HTN and 22% were classified as overweight
 158 (BMI \geq 23kg/m²). The probability of having diabetes and hypertension increased by increasing age
 159 group, whilst the probability of being overweight was higher in the younger age group (Figure 1).
 160 Prevalence of all these conditions were higher amongst males than females. The prevalence of
 161 group A (DM and HTN, n=270) and group B (DM and overweight, n=191) comorbidities was
 162 3%, whilst 7% of the sample had group C comorbidity (HTN and overweight, n=513). One percent
 163 (1%) of the sample all three conditions (DM, HTN and overweight=104). Prevalence of all groups
 164 of comorbidity was higher in males than females, except for group B (DM and overweight) (Figure
 165 2). The prevalence of individual conditions and all comorbidities was higher amongst older
 166 individuals, those with a 'College or higher' education, 'non-manual' workers, people in the richest
 167 quintile for wealth index and those living in urban environments (Table 2).

168

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**

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3	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)
4								
5	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)
6								
7	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)
8								
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)
10								
11	Place of residence							
12								
13								
14	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)
15								
16	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)
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3 171 The prevalence ratio (PR), from modified Poisson regression models, of HTN, DM and
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5 172 overweight was significantly higher among those who had completed higher education, those
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7 173 living in urban areas, non-manual workers and those in the richer to richest socioeconomic status.
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9 174 Although there was no sex disparities for diabetes, HTN and overweight was higher amongst
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11 175 males. Overweight was the only condition that was significantly higher among younger
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13 176 participants (Table 3).
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177 **Table-3: Modified Poisson regression models showing prevalence ratios (PR) and 95% confidence intervals for diabetes,**
 178 **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

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

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

183 **Statistical significance at $p < 0.05$

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3 184 In univariate Poisson regression models, those in the richest quintile of wealth index had the
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5 185 highest PR for all comorbidity groups. These differences remained significant in all models in a
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8 186 stepwise process (**Supplementary Table 1**). In final models, once controlling for sex, age,
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10 187 education, occupation and urbanization, those in the richest quintile were 2.3 times as likely to
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12 188 have DM and HTN, 4.8 times as likely to have DM and overweight, 4.9 times as likely to have
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14 189 HTN and overweight and 4.0 times as likely to have all three comorbidities, than those in the
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16
17 190 poorest quintile. In these final models, non-manual workers were also significantly more likely
18
19 191 than manual workers to have all comorbidity groups. Sex differences were lost on controlling for
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21 192 other factor for all comorbidities groups, except Group C (HTN and overweight), for which
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24 193 females were 1.4 times as likely to experience both. Older participants were significantly more
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26 194 likely to have group A comorbidity (DM and HTN) DM and Group D (all comorbidities) (Table
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29 195 4).

196 **Table-4: Modified stepwise Poisson regression models showing prevalence ratios (PR) and 95% confidence intervals for**
 197 **comorbidities by demographic characteristics among Bangladeshi adults.**
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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)				
<i>Wealth index</i>				
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)				
<i>Wealth index</i>				
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
<i>Place of residence</i>				
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

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200 ** Statistical significance at $p < 0.05$

201 **DISCUSSION**

202
203 This is the first study in Bangladesh that investigated individual and comorbid conditions
204 using a nationally representative sample. We found that within the Bangladesh adult population,
205 aged more than 35 years, the prevalence of diabetes was 12%, hypertension 27% and overweight
206 22%. Diabetes, hypertension and overweight were comparatively higher in males than females.
207 More than 14% of the sample also had more than one condition, with 1.3% exhibiting all three.
208 We also found that individual prevalence and comorbidity were higher in those of a higher
209 socioeconomic status. Once controlling for several confounders, those in the richest quintile of
210 wealth index were significantly more likely than those in the poorest quintile to exhibit
211 comorbidities.

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

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

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3 223 diabetes and 1.42 and 1.28 times higher probability of hypertension, for men and women,
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5 224 respectively.³² Other studies have also found that HTN is a common comorbid condition in DM,
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8 225 and vice versa,⁴¹ whilst there is considerable evidence for an increased prevalence of HTN in
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10 226 diabetic persons from other populations.^{33, 34}

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13 227 In the current study, overweight and diabetes risk was greater among young people
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15 228 which is consistent with a similar study conducted in Indonesia.³⁵ Diabetes, hypertension and
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18 229 overweight were more prevalent in non-manual labor compared to manual labor, which was
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20 230 similar to findings from a study in Barbados.³⁶ However, the present study found males were more
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22 231 likely to suffer comorbidities than females, contradicting findings from previous studies.^{37,38} We
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24 232 also found that the prevalence of individual conditions (diabetes, hypertension and overweight)
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27 233 along with the comorbidity of them, was higher in urban areas compared to rural, which is
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29 234 consistent with a number of studies conducted in developing countries, including Bangladesh.³⁹⁻⁴⁴

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32 235 Within our study we found a higher prevalence of individual conditions and comorbidities
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34 236 in higher socioeconomic groups. These findings conflict with trends reported by previous studies
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37 237 conducted in higher-income countries.^{45, 46} However, another multi-country study reported that
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39 238 comorbidity was more prevalent among the poor and less educated in low income countries.⁴⁷
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41 239 However, these findings were based on self-reported diagnosis, which may introduce concerns of
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43 240 report and recall bias. Previous research in INDEPTH Asian sites has reported inverse associations
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46 241 between comorbidity and markers of socioeconomic status.⁴⁸

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49 242 The main implications of the present study are the increased burden of NCDs within
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51 243 Bangladesh, along with other LMICs, and the patterning of more than one risk factor within
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54 244 individuals in the population. In contrast to findings from high income countries, prevalence of

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3 245 individual risk factors and comorbidities was higher in higher SES groups. This points to
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5 246 differences between countries in the population level determinants of NCDs and highlights that
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7 247 context specific interventions must be developed to counter them. As a first step, it is important
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9 248 that countries collect and analyse high quality health data to allow them to develop and target
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11 249 interventions.
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19 251 **STRENGTHS AND LIMITATIONS**

22 252 The main strengths of the study were the large nationally representative sample and the
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24 253 collection of blood pressure, blood glucose concentration, body weight, and height measurements
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26 254 by health technicians follow standard methods, including biomarker analysis, along with validated
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28 255 measures of socio-economic status. The main weakness of the study is the cross-sectional nature,
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30 256 meaning that only associations can be inferred and causality cannot be determined. In addition
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32 257 although clinical measures of diabetes, hypertension and overweight were taken, no measurements
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34 258 of blood lipids were taken in the survey, meaning that metabolic syndrome could not be
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36 259 investigated. Waist and hip circumference were also not collected, limiting the analysis that could
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38 260 be performed. Finally although the study was reported to be representative, only participants 35
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40 261 years or older had measured anthropometry and biomarkers meaning that the findings reflect this
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42 262 population of adults in the country.
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51 264 **CONCLUSION**

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3 265 In contrast to more affluent countries, individuals of higher socio-economic status in
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5 266 Bangladesh are more likely to exhibit NCD risk factors and comorbidities than individuals from
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8 267 with lower SES status. It is important that we identify the patterning of these conditions within
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10 268 countries if we are to develop effective public health approaches contextualized to the population.
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12 269 This can be done through improved monitoring and surveillance of NCDs, linked to primary care
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14 270 programmes. Such approaches also need policy and system changes, supported by “political will”,
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16 271 societal and community support.
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22 273 **Contributors**

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25 274 TB, NT, SKD & AAM conceptualized the study. TB, NT, SKD, RDG & AAM designed the study
26
27 and acquired the data. TB, SI & MRI conducted the data analysis. TB, NT, SI, MRI, SKD & AAM
28 275 interpreted the data. TB, NT & RDG prepared the first draft. TB, NT, SKD & AAM participated
29
30 276 in critical revision of the manuscript and contributed to its intellectual improvement. All authors
31
32 277 went through the final draft and approved it for submission.
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41 280 **Funding**

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50 283 **Acknowledgments**

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3 284 The authors thank MEASURE DHS for permission to use data from the 2011
4
5 285 Bangladesh DHS. The authors are also grateful to Mr. Mehedi Hasan, PhD student, University of
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7
8 286 Queensland, Australia.
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11 287 **Competing Interests**
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14 288 None declared.
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20 290 **Patient consent**
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29 293 **Disclaimer**
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31 294 The authors are alone responsible for the integrity and accuracy of data analysis and the writing
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33 295 the manuscript.
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39 297 **Ethics approval**
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42 298 The datasets were obtained from DHS Programme with proper procedure. The study exempt from
43
44 299 collecting ethical approval because the survey protocols were reviewed and approved by ICF
45
46 300 Macro Institutional Review Board, Maryland, USA and National Research Ethics Committee of
47
48 301 Bangladesh Medical Research Council (BMRC), Dhaka, Bangladesh.
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3 303 **Data sharing statement**
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6 304 The dataset of BDHS 2011 is available at the Demographic and Health Surveys Program. Extra
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9 305 data is available which is available on request at [http://dhsprogram-com/what-we-](http://dhsprogram-com/what-we-do/survey/survey-display-349.cfm)
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11 306 [do/survey/survey-display-349.cfm](http://dhsprogram-com/what-we-do/survey/survey-display-349.cfm).
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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.

- 1
2
3 332 9. National Institute of Population Research and Training (NIPORT), Mitra and Associates,
4
5 333 ICF International. Bangladesh Urban Health Survey 2013.. Dhaka, Bangladesh, Calverton,
6
7 334 Maryland, USA: NIPORT, Mitra and Associates, and ICF International., 2015.
8
9
10 335 10. Ahsan KZ, Alam MN, Streatfield PK, et al. Has Bangladesh Entered the Fourth Stage of
11
12 336 the Epidemiologic Transition?. Proceedings of the International seminar on Mortality: Past,
13
14 337 Present and Future; 2017Aug 7-8; the University of Campinas, Brazil.
15
16
17 338 11. Zaman MM, Bhuiyan MR, Karim MN, et al. Clustering of non-communicable diseases risk
18
19 339 factors in Bangladeshi adults: an analysis of STEPS survey 2013. *BMC Public Health*.
20
21 340 2015;15(1):659. doi: 10.1186/s12889-015-1938-4.
22
23
24 341 12. Hillas G, Perlikos F, Tsiligianni I, et al. Managing comorbidities in COPD. *Int J Chron*
25
26 342 *Obstruct Pulmon Dis*.2015;10:95. doi: 10.2147/COPD.S54473.
27
28
29 343 13. Roberts KC, Rao DP, Bennett TL, et al. Prevalence and patterns of chronic disease
30
31 344 multimorbidity and associated determinants in Canada. *Health Promot Chronic Dis Prev*
32
33 345 *Can*. 2015 ;35(6):87-94.
34
35
36 346 14. Wang J, Ma JJ, Liu J, et al. Prevalence and Risk Factors of Comorbidities among
37
38 347 Hypertensive Patients in China. *Int J Med Sci*. 2017;14(3):201. doi: 10.7150/ijms.16974.
39
40
41 348 15. Hurst C, Thinkhamrop B. The association between hypertension comorbidity and
42
43 349 microvascular complications in type 2 diabetes patients: A nationwide cross-sectional study in
44
45 350 Thailand. *Diabetes Metab J*. 2015;39(5):395-404. doi: 10.4093/dmj.2015.39.5.395
46
47
48 351 19. Allen L, Williams J, Townsend N, et al. Socioeconomic status and non-communicable
49
50 352 disease behavioural risk factors in low-income and lower-middle-income countries: a systematic
51
52 353 review. *Lancet Glob Health*. 2017;5(3):e277-e89. doi: 10.1016/S2214-109X(17)30058-X.
53
54
55
56
57

- 1
2
3 354 20. Varghese C. Reducing premature mortality from non-communicable diseases, including
4
5 355 for people with severe mental disorders. *World Psychiatry*. 2017;16(1):45-7. doi:
6
7 356 10.1002/wps.20376.
8
9
10 357 21. National Institute of Population Research and Training (NIPORT), Mitra and Associates,
11
12 358 ICF International. Bangladesh Demographic and Health Survey 2011, Preliminary Report. Dhaka,
13
14 359 Bangladesh, Calverton, Maryland, USA: NIPORT, Mitra and Associates, and ICF International.,
15
16 360 2012.
17
18
19 361 22. Biswas T, Islam MS, Linton N, et al. Socio-economic inequality of chronic non-
20
21 362 communicable diseases in Bangladesh. *PloS One*. 2016;11(11):e0167140. doi:
22
23 363 10.1371/journal.pone.0167140.
24
25
26 364 23. Akter S, Rahman MM, Abe SK, et al. Prevalence of diabetes and prediabetes and their risk
27
28 365 factors among Bangladeshi adults: a nationwide survey. *Bull World Health Organ*.
29
30 366 2014;92(3):204-13A. doi: 10.2471/BLT.13.128371.
31
32
33 367 24. Ke-You G, Da-Wei F. The magnitude and trends of under-and over-nutrition in Asian
34
35 368 countries. *Biomed Environ Sci*. 2001;14(1-2):53-60.
36
37
38 369 25. National Institute of Population Research and Training (NIPORT), Mitra and Associates,
39
40 370 ICF International. Bangladesh Demographic and Health Survey 2011. Dhaka, Bangladesh,
41
42 371 Calverton, Maryland, USA: NIPORT, Mitra and Associates, and ICF International., 2013.
43
44
45 372 26. Rahman M, Williams G, Al Mamun A. Hypertension and diabetes prevalence among adults
46
47 373 with moderately increased BMI (23· 0–24· 9 kg/m²): findings from a nationwide survey in
48
49 374 Bangladesh. *Public Health Nutr*. 2017:1-8. doi: 10.1017/S1368980016003566.
50
51
52
53
54
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56
57

- 1
2
3 375 27. Biswas T, Uddin MJ, Al Mamun A, et al. Increasing prevalence of overweight and obesity
4
5 376 in Bangladeshi women of reproductive age: Findings from 2004 to 2014. *PloS One*.
6
7 377 2017;12(7):e0181080. doi: 10.1371/journal.pone.0181080.
8
9
10 378 28. Hoque ME, Hasan MT, Rahman M, et al. Double burden of underweight and overweight
11
12 379 among Bangladeshi adults differs between men and women: evidence from a nationally
13
14 380 representative survey. *Public Health Nutr.*2017;20(12):2183-91. doi:
15
16 381 10.1017/S1368980017000957.
17
18
19 382 29. Biswas T, Garnett SP, Pervin S, et al. The prevalence of underweight, overweight and
20
21 383 obesity in Bangladeshi adults: Data from a national survey. *PloS One*. 2017;12(5):e0177395. doi:
22
23 384 10.1371/journal.pone.0177395.
24
25
26 385 30. Dietz WH. Double-duty solutions for the double burden of malnutrition. *Lancet*. 2017. doi:
27
28 386 10.1016/S0140-6736(17)32479-0.
29
30
31 387 31. Bhowmik B, Afsana F, Ahmed T, et al. Obesity and associated type 2 diabetes and
32
33 388 hypertension in factory workers of Bangladesh. *BMC Res Notes*.2015;8(1):460. doi:
34
35 389 10.1186/s13104-015-1377-4.
36
37
38 390 32. Pradeepa R. The rising burden of diabetes and hypertension in southeast asian and african
39
40 391 regions: need for effective strategies for prevention and control in primary health care settings. *Int*
41
42 392 *J Hypertens*. 2013;2013. doi: 10.1155/2013/409083.
43
44
45 393 33. Berraho M, El Achhab Y, Benslimane A, et al. Hypertension and type 2 diabetes: a cross-
46
47 394 sectional study in Morocco (EPIDIAM Study). *Pan Afr Med J*. 2012;11(1).
48
49 395 34. Hashemizadeh H, Sarvelayati D. Hypertension and Type 2 Diabetes: A Cross-sectional
50
51 396 Study in Hospitalized Patients in Quchan, Iran. *Iran J Diabetes Obesity*. 2013;5(1):21-6.
52
53
54
55
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- 1
2
3 397 35. Hussain MA, Huxley RR, Al Mamun A. Multimorbidity prevalence and pattern in
4
5 398 Indonesian adults: an exploratory study using national survey data. *BMJ Open*.
6
7 399 2015;5(12):e009810. doi: 10.1136/bmjopen-2015-009810.
8
9
10 400 36. Howitt C, Hambleton IR, Rose AM, et al. Social distribution of diabetes, hypertension and
11
12 401 related risk factors in Barbados: a cross-sectional study. *BMJ Open*. 2015;5(12):e008869. doi:
13
14 402 10.1136/bmjopen-2015-008869.37. Pearson TA. Education and income: double-edged swords in
15
16 403 the epidemiologic transition of cardiovascular disease. *Ethn Dis*. 2003;13(2; SUPP/2):S2-158.
17
18
19 404 38. Agborsangaya CB, Lau D, Lahtinen M, et al. Multimorbidity prevalence and patterns
20
21 405 across socioeconomic determinants: a cross-sectional survey. *BMC Public Health*.
22
23 406 2012;12(1):201. doi: 10.1186/1471-2458-12-201.
24
25
26 407 39. Rahman M, Williams G, Al Mamun A. Gender differences in hypertension awareness,
27
28 408 antihypertensive use and blood pressure control in Bangladeshi adults: findings from a national
29
30 409 cross-sectional survey. *J Health Popul Nutr*.2017;36(1):23. doi: 10.1186/s41043-017-0101-5.
31
32
33 410 40. Li G, Hu H, Dong Z, et al. Urban and suburban differences in hypertension trends and self-
34
35 411 care: Three population-based cross-sectional studies from 2005-2011. *PloS One*.
36
37 412 2015;10(2):e0117999. doi: 10.1371/journal.pone.0117999.
38
39
40 413 41. Sola A, Chinyere O, Stephen A, et al. Hypertension prevalence in an urban and rural area
41
42 414 of Nigeria. *J Med Sci*. 2013;4:149-54.
43
44
45 415 42. Dhungana RR, Pandey AR, Bista B, et al. Prevalence and associated factors of
46
47 416 hypertension: a community-based cross-sectional study in municipalities of Kathmandu, Nepal.
48
49 417 *Int J Hypertens*.2016;2016. doi: 10.1155/2016/1656938.
50
51
52
53
54
55
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2
3 418 43. Chowdhury MAB, Uddin MJ, Haque MR, et al. Hypertension among adults in Bangladesh:
4
5 419 evidence from a national cross-sectional survey. *BMC Cardiovasc Disord.* 2016;16(1):22. doi:
6
7 420 10.1186/s12872-016-0197-3.
8
9
10 421 44. Akter S, Rahman MM, Abe SK, et al. Prevalence of diabetes and prediabetes and their risk
11
12 422 factors among Bangladeshi adults: a nationwide survey. *Bull World Health*
13
14 423 *Organ.*2014;92(3):204-13A. doi: 10.2471/BLT.13.128371
15
16
17 424 45. Connolly V, Unwin N, Sherriff P, et al. Diabetes prevalence and socioeconomic status: a
18
19 425 population based study showing increased prevalence of type 2 diabetes mellitus in deprived areas.
20
21 426 *J Epidemiol Community Health.*2000;54(3):173-7.
22
23
24 427 46. Glover JD, Hetzel DM, Tennant SK. The socioeconomic gradient and chronic illness and
25
26 428 associated risk factors in Australia. *Aust New Zealand Health Policy.* 2004;1(1):8. doi:
27
28 429 10.1186/1743-8462-1-8.
29
30
31 430 47. Hosseinpoor AR, Bergen N, Mendis S, et al. Socioeconomic inequality in the prevalence
32
33 431 of noncommunicable diseases in low-and middle-income countries: results from the World Health
34
35 432 Survey. *BMC Public Health.* 2012;12(1):474. doi: 10.1186/s12889-015-2227-y.
36
37
38 433 48. Van Minh H, Ng N, Juvekar S, et al. Self-reported prevalence of chronic diseases and their
39
40 434 relation to selected sociodemographic variables: a study in INDEPTH Asian sites, 2005. *Prev*
41
42 435 *Chronic Dis.*2008;5(3).
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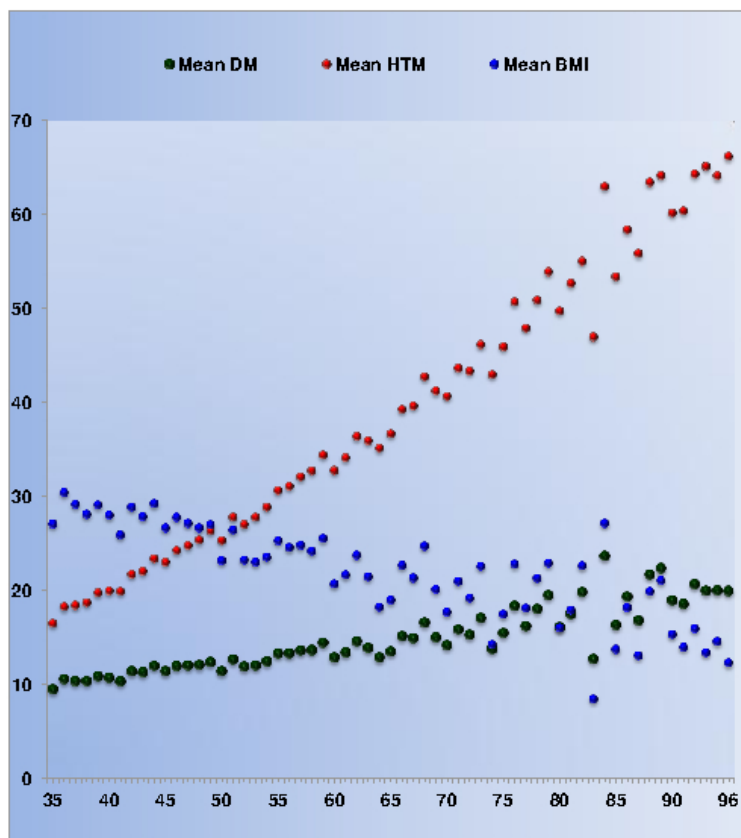
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6 **437 Fig 1.** Scatter plot between age with blood glucose, systolic blood pressure, diastolic blood
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8 **438** pressure and BMI.
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10 **439 Fig 2.** Prevalence of diabetes, hypertension, overweight and comorbidity by sex among
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12 **440 Bangladeshi adults**
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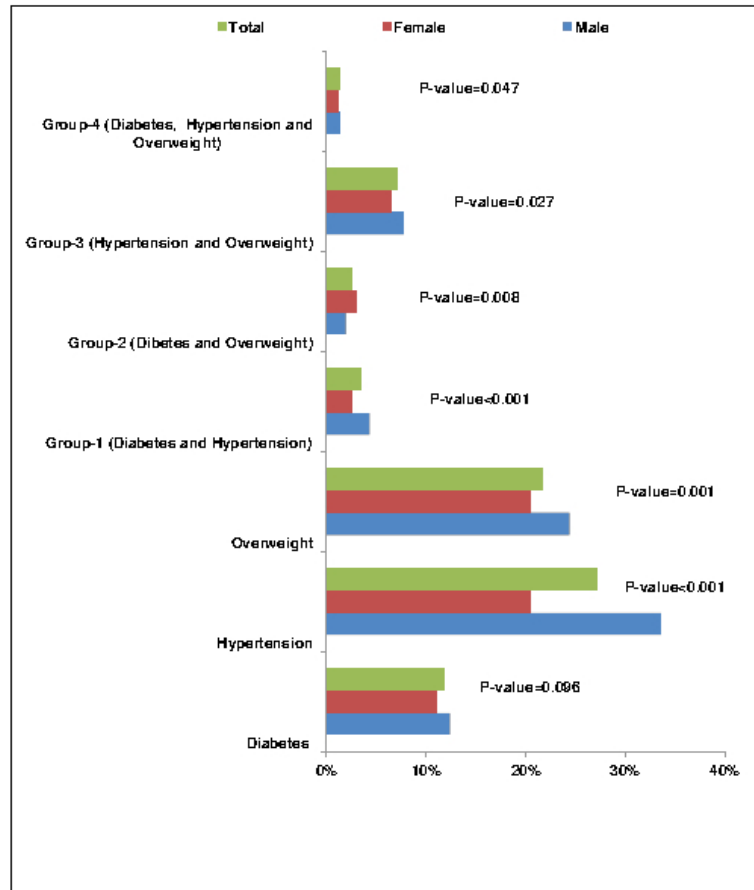
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22 **443** Supplementary Table 1: Modified stepwise Poisson regression models showing prevalence ratios
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24 **444** (PR) and 95% confidence intervals for comorbidities by demographic characteristics among
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26 **445** Bangladeshi adults.
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Predictive probability of diabetes, hypertension and BMI by age

215x279mm (72 x 72 DPI)

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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)				
<i>Wealth index</i>				
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)				
<i>Wealth index</i>				
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
<i>Sex</i>				
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)				
<i>Wealth index</i>				
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
<i>Sex</i>				
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
<i>Age</i>				
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)				
<i>Wealth index</i>				
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

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For peer review only

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:	<i>BMJ Open</i>
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, Department 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

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30 ABSTRACT

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

34 **Design:** This was a cross-sectional study.

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

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

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

41 **Results:** Of 8,763 adults, 12% had DM, 27% HTN and 22% were overweight/obese
42 ($\text{BMI} \geq 23 \text{ kg/m}^2$). Just over 1% of the sample had all three conditions, 3% had both DM and
43 HTN, 3% DM and overweight and 7% HTN and overweight. Diabetes, hypertension and
44 overweight were more prevalent those who had higher education, were non-manual workers,
45 were in the richer to richest socioeconomic status and lived in urban settings. Individuals in
46 higher SES groups were also more likely to suffer from comorbidities. In the multivariable
47 analysis, it was found that individual belonging to the richest wealth quintile had the highest
48 odds of having hypertension (Adjusted Odds Ratio (AOR): 1.49, 95% Confidence Interval (CI):
49 1.29-1.72), diabetes (AOR: 1.63, 95% CI: 1.25-2.14) and obesity (AOR: 4.3, 95% CI: 3.32-
50 5.57).

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7 52 **Conclusions:** In contrast to more affluent countries, individuals with NCD risk factors and
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9 53 comorbidities are more common in higher socio-economic status individuals. Public health
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11 54 approaches must consider this social patterning in tackling NCDs in the country.
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18 56 **Key words:** Overweight, Diabetes, Hypertension, Non-communicable Disease, socioeconomic
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58 STRENGTHS AND LIMITATIONS OF THE STUDY

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

66

67 INTRODUCTION

68 According to the Global Burden of Disease report, non-communicable diseases (NCDs)
69 are the leading cause of death worldwide¹⁻³ and that 80% of this NCD mortality actually occurs
70 in low- and middle-income countries (LMICs)⁴⁻⁶. Similarly, the 2014 NCDs global status report
71 showed that of 58 million deaths that occurred globally in 2012, 38 million - almost two thirds -
72 were due to NCDs, with these deaths most due to the four most common NCDs: cardiovascular
73 diseases, cancers, diabetes and chronic lung diseases.⁷ In addition, the report showed that more
74 than 40% of these deaths (16 million) occurred were in individuals under the age of 70 years,
75 often referred to as premature deaths⁷. Deaths at younger ages may be a greater demonstration of
76 its burden, as many consider them preventable. It is alarming, therefore, that the majority of
77 premature deaths (82%) occur in LMICs, with this problem likely to increase if appropriate
78 preventative actions are not taken at a population level.

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

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

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3 89 obesity, diabetes and hypertension, predominantly coming from industrialized countries¹³⁻¹⁵ and
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5 90 developing nations¹⁶⁻¹⁸; however evidence on NCD comorbidity scant in Bangladesh. This is
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8 91 important as the patterning of NCDs is not uniform across countries of different income
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10 92 classification, with a higher prevalence of some NCD risk factors, such as diabetes, found in
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12 93 higher socio-economic groups in many studies in LMICs, contradicting those from higher
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15 94 income countries.¹⁹

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18 95 With the development of a double burden from both over- and under-nutrition in these
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20 96 LMICs, understanding comorbidity and their correlates is important if we are to develop NCD
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22 97 preventative policies contextualized for these countries. Despite the availability of nationwide
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25 98 survey data in Bangladesh, the prevalence, and in particular the comorbidity of NCD medical
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27 99 risk factors remains unmapped. This understanding of the burden and patterning of NCDs and
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29 100 their risk factors is important if Bangladesh is able to meet the Sustainable Development Goals
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31 101 (SDGs) target of reducing premature death from NCDs by one third by 2030.²⁰

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35 102 This study used 2011 Bangladesh Demography and Health Survey (BDHS) data to
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37 103 estimate the prevalence and pattern of NCD risk factors and comorbidity among the general
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39 104 population aged 35 years and older, as well as determining their socio-demographic patterning
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42 105 and possible predictors of comorbidity .

43 44 45 106 46 47 107 **METHODS**

48 49 50 108 **Study design**

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53 109 This study used data from the 2011 Bangladesh Demography and Health Survey
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56 110 (BDHS). The 2011 BDHS is a cross-sectional nationally representative survey that was

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3 111 conducted between July and December 2011 through the collaboration of the National Institute
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5 112 of Population Research and Training (NIPORT), ICF International (USA), and Mitra and
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7 113 Associates. Participants in the BDHS were selected using probability sampling based on a two-
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9 114 stage cluster sample of households, and stratified by rural and urban areas in the seven
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11 115 administrative regions of Bangladesh. The detailed protocol and methods have been published
12
13 116 previously.²¹ In brief, 17,500 households were surveyed, of which one in three households were
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15 117 randomly selected for biomarker measurement (blood glucose, blood pressure). All men and
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17 118 women age 35 years and above were eligible for the biomarker measures, with these collected
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19 119 from a final sample of 8,835 individuals (male: 4524, female: 4311).²² We included 8763 cases
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24 120 in our analytical sample, after excluding cases with missing values.
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122 **Measurements of outcomes**

123 A data collection team, including a health technician, measured blood pressure, blood
124 glucose concentration, body weight, and height using standard methods.²¹ Diabetes (DM) was
125 defined as a fasting blood glucose level greater than or equal to 7.0 mmol/L or self-reported
126 diabetes medication use.²³ Body mass index (BMI) was calculated as weight (kg)/height (m²).
127 We used Asian specific BMI cut-offs to define underweight as <18.5 kg/m² and overweight and
128 obese (higher BMI) as ≥ 23 kg/m².²⁴ Hypertension was defined as systolic blood pressure (SBP)
129 ≥ 140 mmHg and diastolic blood pressure (DBP) ≥ 90 mmHg or self-reported anti-hypertensive
130 medication use during the survey.²⁵ We then categorized comorbidity into four groups such as
131 respondents having DM and HTN (group A), DM and overweight/obesity (group B), HTN and
132 overweight/obesity (group C) and group D in which individuals had all three conditions (DM,
133 HTN and overweight/obesity).

134

135 **Socio-demographic factors**

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

142

143 **Statistical analysis**

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

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3 157 the log (PR) to calculate the effect size by the formula $d = \log(\text{prevalence ratio}) \times (\sqrt{3/\pi})$. The
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5 158 primary research hypothesis was to test the wealth index from poorer to richest groups with the
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7 159 joint estimate of NCDs in the regression equation. We have considered the power .90, level of
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9 160 significance 0.05 , calculated effect size from prevalence ratio and then we get the estimated
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11 161 sample size for each model of each outcomes which covers the existing sample size of our
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13 162 analysis. We have performed the power analysis using G*Power software. The authors followed
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15 163 the guidelines outlined in the Strengthening the Reporting of Observational Studies in
16
17 164 Epidemiology (*STROBE*) statement in writing the manuscript (Supplementary File 1).
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166 Ethical consideration and patient involvement

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27 167 Patients were not involved in the study. BDHS 2011 received ethical approval from ICF
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29 168 Macro Institutional Review Board, Maryland, USA and National Research Ethics Committee of
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31 169 Bangladesh Medical Research Council (BMRC), Dhaka, Bangladesh. Written informed consent
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33 170 was taken from the participants before the survey was completed.
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171 FINDINGS

38
39 172 The study population (n=8763) comprised 51% males, around 56% were 56 years of age
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41 173 or older, 62% reported no education, 25% were in manual employment, and 76% lived in rural
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43 174 locations (Table 1).
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175 **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

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6 177 Among the sample 12% had diabetes, 27% had HTN and 22% were classified as
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8 178 overweight/obesity ($BMI \geq 23 \text{ kg/m}^2$). The probability of having diabetes and hypertension
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10 179 increased by increasing age group, whilst the probability of being overweight/obesity was higher
11
12 180 in the younger age group (Figure 1). Prevalence of all these conditions were higher amongst
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14 181 males than females. The prevalence of group A (DM and HTN, $n=270$) and group B (DM and
15
16 182 overweight/obesity, $n=191$) comorbidities was 3%, whilst 7% of the sample had group C
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18 183 comorbidity (HTN and overweight/obesity, $n=513$). One percent (1%) of the sample all three
19
20 184 conditions (DM, HTN and overweight/obesity =104). Prevalence of all groups of comorbidity
21
22 185 was higher in males than females, except for group B (DM and overweight/obesity) (Figure 2).
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24 186 The prevalence of individual conditions and all comorbidities was higher amongst older
25
26 187 individuals, those with a 'College or higher' education, 'non-manual' workers, people in the
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28 188 richest quintile for wealth index and those living in urban environments (Table 2).
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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)

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

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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)

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3 193 The prevalence ratio (PR), from modified Poisson regression models, of HTN, DM and
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5 194 overweight/obesity was significantly higher among those who had completed higher education,
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8 195 those living in urban areas, non-manual workers and those in the richer to richest socioeconomic
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10 196 status. Although there was no sex disparities for diabetes, HTN and overweight/obesity was
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12 197 higher amongst males. Overweight/obesity was the only condition that was significantly higher
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15 198 among younger participants (Table 3).
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199 **Table-3: Modified Poisson regression models showing prevalence ratios (PR) and 95% confidence intervals for diabetes,**
 200 **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

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

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

205 **Statistical significance at p<0.05

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3 206 In univariate Poisson regression models, those in the richest quintile of wealth index had the
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5 207 highest PR for all comorbidity groups. These differences remained significant in all models in a
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8 208 stepwise process (**Supplementary File 2**). In final models, once controlling for sex, age,
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10 209 education, occupation and urbanization, those in the richest quintile were 2.3 times as likely to
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12 210 have DM and HTN, 4.8 times as likely to have DM and overweight/obesity, 4.9 times as likely to
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14 211 have HTN and overweight/obesity and 4.0 times as likely to have all three comorbidities, than
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16 212 those in the poorest quintile. In these final models, non-manual workers were also significantly
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18 213 more likely than manual workers to have all comorbidity groups. Sex differences were lost on
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20 214 controlling for other factor for all comorbidities groups, except Group C (HTN and
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22 215 overweight/obesity), for which females were 1.4 times as likely to experience both. Older
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24 216 participants were significantly more likely to have group A comorbidity (DM and HTN) DM
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29 217 and Group D (all comorbidities) (Table 4).
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218 **Table-4: Modified stepwise Poisson regression models showing prevalence ratios (PR) and 95% confidence intervals for**
 219 **comorbidities by demographic characteristics among Bangladeshi adults.**

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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)				
<i>Wealth index</i>				
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)				
<i>Wealth index</i>				
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
<i>Place of residence</i>				
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

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222 ** Statistical significance at p<0.05

For peer review only

223 DISCUSSION

224
225 This is the first study in Bangladesh that investigated individual and comorbid
226 conditions using a nationally representative sample. We found that within the Bangladesh adult
227 population, aged more than 35 years, the prevalence of diabetes was 12%, hypertension 27%
228 and overweight/obesity 22%. Diabetes, hypertension and overweight/obesity were comparatively
229 higher in males than females. More than 14% of the sample also had more than one condition,
230 with 1.3% exhibiting all three. We also found that individual prevalence and comorbidity were
231 higher in those of a higher socioeconomic status. Once controlling for several confounders, those
232 in the richest quintile of wealth index were significantly more likely than those in the poorest
233 quintile to exhibit comorbidities.

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

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

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3 245 diabetes and 1.42 and 1.28 times higher probability of hypertension, for men and women,
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5 246 respectively.³² Other studies have also found that HTN is a common comorbid condition in DM,
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7 247 and vice versa,³³ whilst there is considerable evidence for an increased prevalence of HTN in
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9 248 diabetic persons from other populations.^{34,35}
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13 249 In the current study, overweight and diabetes risk was greater among young
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15 250 people which is consistent with a similar study conducted in Indonesia.³⁶ Diabetes, hypertension
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17 251 and overweight/obesity were more prevalent in non-manual labor compared to manual labor,
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19 252 which was similar to findings from a study in Barbados.³⁷ However, the present study found
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21 253 males were more likely to suffer comorbidities than females, contradicting findings from
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23 254 previous studies.^{38,39} We also found that the prevalence of individual conditions (diabetes,
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25 255 hypertension and overweight/obesity) along with the comorbidity of them, was higher in urban
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27 256 areas compared to rural, which is consistent with a number of studies conducted in developing
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29 257 countries, including Bangladesh.^{33,40-44}
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35 258 Within our study we found a higher prevalence of individual conditions and
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37 259 comorbidities in higher socioeconomic groups. These findings conflict with trends reported by
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39 260 previous studies conducted in higher-income countries.^{45, 46} However, another multi-country
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41 261 study reported that comorbidity was more prevalent among the poor and less educated in low
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43 262 income countries.⁴⁷ However, these findings were based on self-reported diagnosis, which may
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45 263 introduce concerns of report and recall bias. Previous research in INDEPTH Asian sites has
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47 264 reported inverse associations between comorbidity and markers of socioeconomic status.⁴⁸
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51 265 The main implications of the present study are the increased burden of NCDs within
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53 266 Bangladesh, along with other LMICs, and the patterning of more than one risk factor within
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3 267 individuals in the population. In contrast to findings from high income countries, prevalence of
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5 268 individual risk factors and comorbidities was higher in higher SES groups. This points to
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7 269 differences between countries in the population level determinants of NCDs and highlights that
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10 270 context specific interventions must be developed to counter them. As a first step, it is important
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12 271 that countries collect and analyse high quality health data to allow them to develop and target
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15 272 interventions.
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21 274 **STRENGTHS AND LIMITATIONS**

24 275 The main strengths of the study were the large nationally representative sample and the
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26 276 collection of blood pressure, blood glucose concentration, body weight, and height
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28 277 measurements by health technicians follow standard methods, including biomarker analysis,
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31 278 along with validated measures of socio-economic status. The main weakness of the study is the
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33 279 cross-sectional nature, meaning that only associations can be inferred and causality cannot be
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36 280 determined. In addition although clinical measures of diabetes, hypertension and
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38 281 overweight/obesity were taken, no measurements of blood lipids were taken in the survey,
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40 282 meaning that metabolic syndrome could not be investigated. Waist and hip circumference were
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42 283 also not collected, limiting the analysis that could be performed. Finally although the study was
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45 284 reported to be representative, only participants 35 years or older had measured anthropometry
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47 285 and biomarkers meaning that the findings reflect this population of adults in the country.
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53 287 **CONCLUSION**

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3 288 In contrast to more affluent countries, individuals of higher socio-economic status in
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5 289 Bangladesh are more likely to exhibit NCD risk factors and comorbidities than individuals from
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8 290 with lower SES status. It is important that we identify the patterning of these conditions within
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10 291 countries if we are to develop effective public health approaches contextualized to the
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12 292 population. This can be done through improved monitoring and surveillance of NCDs, linked to
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14 293 primary care programmes. Such approaches also need policy and system changes, supported by
15
16 294 “political will”, societal and community support.
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22 296 **Contributors**

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25 297 TB, NT, SKD & AAM conceptualized the study. TB, NT, SKD, RDG & AAM designed the
26
27 298 study and acquired the data. TB, SI & MRI conducted the data analysis. TB, NT, SI, MRI, SKD
28
29 299 & AAM interpreted the data. TB, NT & RDG prepared the first draft. TB, NT, SKD & AAM
30
31 300 participated in critical revision of the manuscript and contributed to its intellectual improvement.
32
33 301 All authors went through the final draft and approved it for submission.
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38 302

41 303 **Funding**

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44 304 None.
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50 306 **Acknowledgments**

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3 307 The authors thank MEASURE DHS for permission to use data from the 2011
4
5 308 Bangladesh DHS. The authors are also grateful to Mr. Mehedi Hasan, PhD student, University of
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8 309 Queensland, Australia.
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11 310 **Competing Interests**
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14 311 None declared.
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20 313 **Patient consent**
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23 314 None Declared
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29 316 **Disclaimer**
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31 317 The authors are alone responsible for the integrity and accuracy of data analysis and the writing
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33 318 the manuscript.
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39 320 **Ethics approval**
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42 321 The datasets were obtained from DHS Programme with proper procedure. The study exempt
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44 322 from collecting ethical approval because the survey protocols were reviewed and approved by
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46 323 ICF Macro Institutional Review Board, Maryland, USA and National Research Ethics
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48 324 Committee of Bangladesh Medical Research Council (BMRC), Dhaka, Bangladesh.
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3 326 **Data sharing statement**
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6 327 The dataset of BDHS 2011 is available at the Demographic and Health Surveys Program. Extra
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9 328 data is available which is available on request at [http://dhsprogram-com/what-we-](http://dhsprogram-com/what-we-do/survey/survey-display-349.cfm)
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11 329 [do/survey/survey-display-349.cfm](http://dhsprogram-com/what-we-do/survey/survey-display-349.cfm).
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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.

- 1
2
3 355 9. National Institute of Population Research and Training (NIPORT), Mitra and Associates,
4
5 356 ICF International. Bangladesh Urban Health Survey 2013.. Dhaka, Bangladesh, Calverton,
6
7 357 Maryland, USA: NIPORT, Mitra and Associates, and ICF International., 2015.
8
9
10 358 10. Ahsan KZ, Alam MN, Streatfield PK, et al. Has Bangladesh Entered the Fourth Stage of
11
12 359 the Epidemiologic Transition?. Proceedings of the International seminar on Mortality: Past,
13
14 360 Present and Future; 2017Aug 7-8; the University of Campinas, Brazil.
15
16
17 361 11. Zaman MM, Bhuiyan MR, Karim MN, et al. Clustering of non-communicable diseases
18
19 362 risk factors in Bangladeshi adults: an analysis of STEPS survey 2013. *BMC Public Health*.
20
21 363 2015;15(1):659. doi: 10.1186/s12889-015-1938-4.
22
23
24 364 12. Hillas G, Perlikos F, Tsiligianni I, et al. Managing comorbidities in COPD. *Int J Chron*
25
26 365 *Obstruct Pulmon Dis*.2015;10:95. doi: 10.2147/COPD.S54473.
27
28
29 366 13. Roberts KC, Rao DP, Bennett TL, et al. Prevalence and patterns of chronic disease
30
31 367 multimorbidity and associated determinants in Canada. *Health Promot Chronic Dis Prev*
32
33 368 *Can*. 2015 ;35(6):87-94.
34
35
36 369 14. Wang J, Ma JJ, Liu J, et al. Prevalence and Risk Factors of Comorbidities among
37
38 370 Hypertensive Patients in China. *Int J Med Sci*. 2017;14(3):201. doi: 10.7150/ijms.16974.
39
40 371 15. Hurst C, Thinkhamrop B. The association between hypertension comorbidity and
41
42 372 microvascular complications in type 2 diabetes patients: A nationwide cross-sectional study in
43
44 373 Thailand. *Diabetes Metab J*. 2015;39(5):395-404. doi: 10.4093/dmj.2015.39.5.395
45
46
47 374 19. Allen L, Williams J, Townsend N, et al. Socioeconomic status and non-communicable
48
49 375 disease behavioural risk factors in low-income and lower-middle-income countries: a systematic
50
51 376 review. *Lancet Glob Health*. 2017;5(3):e277-e89. doi: 10.1016/S2214-109X(17)30058-X.
52
53
54
55
56
57

- 1
2
3 377 20. Varghese C. Reducing premature mortality from non-communicable diseases, including
4
5 378 for people with severe mental disorders. *World Psychiatry*. 2017;16(1):45-7. doi:
6
7 379 10.1002/wps.20376.
8
9
10 380 21. National Institute of Population Research and Training (NIPORT), Mitra and Associates,
11
12 381 ICF International. Bangladesh Demographic and Health Survey 2011, Preliminary Report.
13
14 382 Dhaka, Bangladesh, Calverton, Maryland, USA: NIPORT, Mitra and Associates, and ICF
15
16 383 International., 2012.
17
18
19 384 22. Biswas T, Islam MS, Linton N, et al. Socio-economic inequality of chronic non-
20
21 385 communicable diseases in Bangladesh. *PloS One*. 2016;11(11):e0167140. doi:
22
23 386 10.1371/journal.pone.0167140.
24
25
26 387 23. Akter S, Rahman MM, Abe SK, et al. Prevalence of diabetes and prediabetes and their
27
28 388 risk factors among Bangladeshi adults: a nationwide survey. *Bull World Health Organ*.
29
30 389 2014;92(3):204-13A. doi: 10.2471/BLT.13.128371.
31
32
33 390 24. Ke-You G, Da-Wei F. The magnitude and trends of under-and over-nutrition in Asian
34
35 391 countries. *Biomed Environ Sci*. 2001;14(1-2):53-60.
36
37
38 392 25. National Institute of Population Research and Training (NIPORT), Mitra and Associates,
39
40 393 ICF International. Bangladesh Demographic and Health Survey 2011. Dhaka, Bangladesh,
41
42 394 Calverton, Maryland, USA: NIPORT, Mitra and Associates, and ICF International., 2013.
43
44
45 395 26. Rahman M, Williams G, Al Mamun A. Hypertension and diabetes prevalence among
46
47 396 adults with moderately increased BMI (23· 0–24· 9 kg/m²): findings from a nationwide survey
48
49 397 in Bangladesh. *Public Health Nutr*. 2017:1-8. doi: 10.1017/S1368980016003566.
50
51
52
53
54
55
56
57

- 1
2
3 398 27. Biswas T, Uddin MJ, Al Mamun A, et al. Increasing prevalence of overweight and
4
5 399 obesity in Bangladeshi women of reproductive age: Findings from 2004 to 2014. *PloS One*.
6
7 400 2017;12(7):e0181080. doi: 10.1371/journal.pone.0181080.
8
9
10 401 28. Hoque ME, Hasan MT, Rahman M, et al. Double burden of underweight and overweight
11
12 402 among Bangladeshi adults differs between men and women: evidence from a nationally
13
14 403 representative survey. *Public Health Nutr.*2017;20(12):2183-91. doi:
15
16 404 10.1017/S1368980017000957.
17
18
19 405 29. Biswas T, Garnett SP, Pervin S, et al. The prevalence of underweight, overweight and
20
21 406 obesity in Bangladeshi adults: Data from a national survey. *PloS One*. 2017;12(5):e0177395. doi:
22
23 407 10.1371/journal.pone.0177395.
24
25
26 408 30. Dietz WH. Double-duty solutions for the double burden of malnutrition. *Lancet*. 2017.
27
28 409 doi: 10.1016/S0140-6736(17)32479-0.
29
30
31 410 31. Bhowmik B, Afsana F, Ahmed T, et al. Obesity and associated type 2 diabetes and
32
33 411 hypertension in factory workers of Bangladesh. *BMC Res Notes*.2015;8(1):460. doi:
34
35 412 10.1186/s13104-015-1377-4.
36
37
38 413 32. Pradeepa R. The rising burden of diabetes and hypertension in southeast asian and african
39
40 414 regions: need for effective strategies for prevention and control in primary health care settings.
41
42 415 *Int J Hypertens*. 2013;2013. doi: 10.1155/2013/409083.
43
44
45 416 33. Sola A, Chinyere O, Stephen A, et al. Hypertension prevalence in an urban and rural area of
46
47 417 Nigeria. *J Med Sci*. 2013;4:149-54.
48
49 418 34. Berraho M, El Achhab Y, Benslimane A, et al. Hypertension and type 2 diabetes: a cross-
50
51 419 sectional study in Morocco (EPIDIAM Study). *Pan Afr Med J*. 2012;11(1).
52
53
54
55
56
57

- 1
2
3 420 35. Hashemizadeh H, Sarvelayati D. Hypertension and Type 2 Diabetes: A Cross-sectional
4
5 421 Study in Hospitalized Patients in Quchan, Iran. *Iran J Diabetes Obesity*. 2013;5(1):21-6.
6
7 422 36. Hussain MA, Huxley RR, Al Mamun A. Multimorbidity prevalence and pattern in
8
9 423 Indonesian adults: an exploratory study using national survey data. *BMJ Open*.
10
11 424 2015;5(12):e009810. doi: 10.1136/bmjopen-2015-009810.
12
13
14 425 37. Howitt C, Hambleton IR, Rose AM, et al. Social distribution of diabetes, hypertension
15
16 426 and related risk factors in Barbados: a cross-sectional study. *BMJ Open*. 2015;5(12):e008869.
17
18 427 doi: 10.1136/bmjopen-2015-008869.
19
20
21 428 38. Pearson TA. Education and income: double-edged swords in the epidemiologic transition
22
23 429 of cardiovascular disease. *Ethn Dis*. 2003;13(2; SUPP/2):S2-158.
24
25
26 430 39. Agborsangaya CB, Lau D, Lahtinen M, et al. Multimorbidity prevalence and patterns
27
28 431 across socioeconomic determinants: a cross-sectional survey. *BMC Public Health*.
29
30 432 2012;12(1):201. doi: 10.1186/1471-2458-12-201.
31
32
33 433 40. Rahman M, Williams G, Al Mamun A. Gender differences in hypertension awareness,
34
35 434 antihypertensive use and blood pressure control in Bangladeshi adults: findings from a national
36
37 435 cross-sectional survey. *J Health Popul Nutr*. 2017;36(1):23. doi: 10.1186/s41043-017-0101-5.
38
39
40 436 41. Li G, Hu H, Dong Z, et al. Urban and suburban differences in hypertension trends and
41
42 437 self-care: Three population-based cross-sectional studies from 2005-2011. *PloS One*.
43
44 438 2015;10(2):e0117999. doi: 10.1371/journal.pone.0117999.
45
46
47 439 42. Dhungana RR, Pandey AR, Bista B, et al. Prevalence and associated factors of
48
49 440 hypertension: a community-based cross-sectional study in municipalities of Kathmandu, Nepal.
50
51 441 *Int J Hypertens*. 2016;2016. doi: 10.1155/2016/1656938.
52
53
54
55
56
57

- 1
2
3 442 43. Chowdhury MAB, Uddin MJ, Haque MR, et al. Hypertension among adults in
4
5 443 Bangladesh: evidence from a national cross-sectional survey. *BMC Cardiovasc Disord.*
6
7 444 2016;16(1):22. doi: 10.1186/s12872-016-0197-3.
8
9
10 445 44. Akter S, Rahman MM, Abe SK, et al. Prevalence of diabetes and prediabetes and their
11
12 446 risk factors among Bangladeshi adults: a nationwide survey. *Bull World Health*
13
14 447 *Organ.*2014;92(3):204-13A. doi: 10.2471/BLT.13.128371
15
16
17 448 45. Connolly V, Unwin N, Sherriff P, et al. Diabetes prevalence and socioeconomic status: a
18
19 449 population based study showing increased prevalence of type 2 diabetes mellitus in deprived
20
21 450 areas. *J Epidemiol Community Health.*2000;54(3):173-7.
22
23
24 451 46. Glover JD, Hetzel DM, Tennant SK. The socioeconomic gradient and chronic illness and
25
26 452 associated risk factors in Australia. *Aust New Zealand Health Policy.* 2004;1(1):8. doi:
27
28 453 10.1186/1743-8462-1-8.
29
30
31 454 47. Hosseinpoor AR, Bergen N, Mendis S, et al. Socioeconomic inequality in the prevalence
32
33 455 of noncommunicable diseases in low-and middle-income countries: results from the World
34
35 456 Health Survey. *BMC Public Health.* 2012;12(1):474. doi: 10.1186/s12889-015-2227-y.
36
37
38 457 48. Van Minh H, Ng N, Juvekar S, et al. Self-reported prevalence of chronic diseases and
39
40 458 their relation to selected sociodemographic variables: a study in INDEPTH Asian sites, 2005.
41
42 459 *Prev Chronic Dis.*2008;5(3).
43
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3 **460 Figures:**
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6 **461 Fig 1.** Scatter plot between age with blood glucose, systolic blood pressure, diastolic blood
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8 **462** pressure and BMI.
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10 **463 Fig 2.** Prevalence of diabetes, hypertension, overweight and comorbidity by sex among
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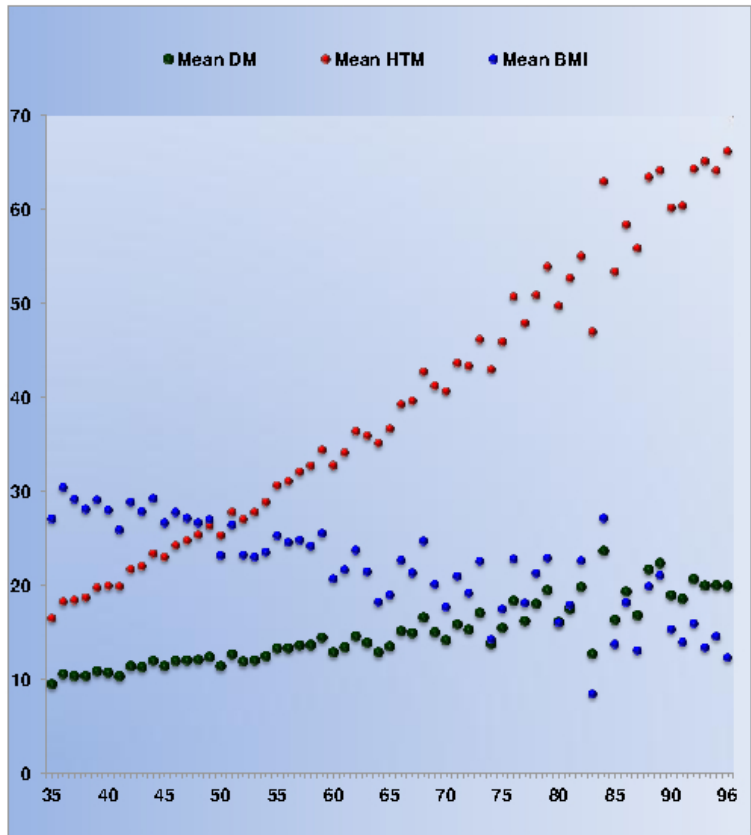
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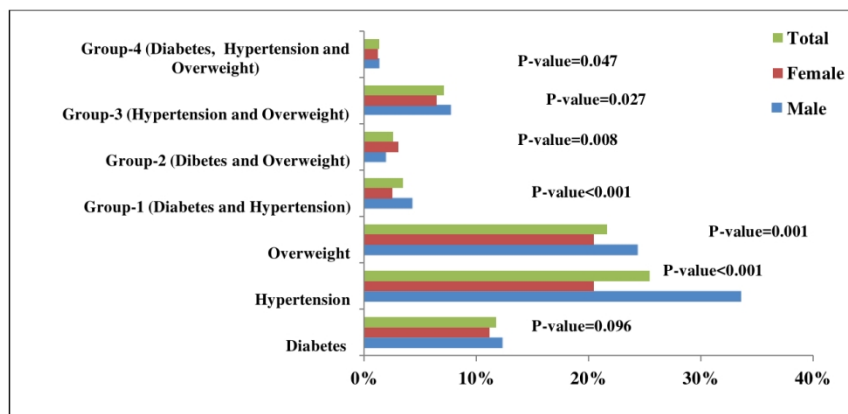
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22 **467 Supplementary File 1:** STROBE Checklist
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25 **468 Supplementary File 2:** Modified stepwise Poisson regression models showing prevalence ratios
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27 **469** (PR) and 95% confidence intervals for comorbidities by demographic characteristics among
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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.

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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.

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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)				
<i>Wealth index</i>				
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)				
<i>Wealth index</i>				
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
<i>Sex</i>				
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)				
<i>Wealth index</i>				
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
<i>Sex</i>				
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
<i>Age</i>				
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:	<i>BMJ Open</i>
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, Department 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

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30 ABSTRACT

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

34 **Design:** This was a cross-sectional study.

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

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

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

41 **Results:** Of 8,763 adults, 12% had DM, 27% HTN and 22% were overweight/obese
42 ($BMI \geq 23 \text{ kg/m}^2$). Just over 1% of the sample had all three conditions, 3% had both DM and
43 HTN, 3% DM and overweight and 7% HTN and overweight. Diabetes, hypertension and
44 overweight were more prevalent those who had higher education, were non-manual workers,
45 were in the richer to richest socioeconomic status and lived in urban settings. Individuals in
46 higher SES groups were also more likely to suffer from comorbidities. In the multivariable
47 analysis, it was found that individual belonging to the richest wealth quintile had the highest
48 odds of having hypertension (Adjusted Odds Ratio (AOR): 1.49, 95% Confidence Interval (CI):
49 1.29-1.72), diabetes (AOR: 1.63, 95% CI: 1.25-2.14) and obesity (AOR: 4.3, 95% CI: 3.32-
50 5.57).

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7 52 **Conclusions:** In contrast to more affluent countries, individuals with NCD risk factors and
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9 53 comorbidities are more common in higher socio-economic status individuals. Public health
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11 54 approaches must consider this social patterning in tackling NCDs in the country.
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18 56 **Key words:** Overweight, Diabetes, Hypertension, Non-communicable Disease, socioeconomic
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20 57 status, Bangladesh
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58 STRENGTHS AND LIMITATIONS OF THE STUDY

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

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67 INTRODUCTION

68 According to the Global Burden of Disease report, non-communicable diseases (NCDs)
69 are the leading cause of death worldwide¹⁻³ and that 80% of this NCD mortality actually occurs
70 in low- and middle-income countries (LMICs)⁴⁻⁶. Similarly, the 2014 NCDs global status report
71 showed that of 58 million deaths that occurred globally in 2012, 38 million - almost two thirds -
72 were due to NCDs, with these deaths most due to the four most common NCDs: cardiovascular
73 diseases, cancers, diabetes and chronic lung diseases.⁷ In addition, the report showed that more
74 than 40% of these deaths (16 million) occurred were in individuals under the age of 70 years,
75 often referred to as premature deaths⁷. Deaths at younger ages may be a greater demonstration of
76 its burden, as many consider them preventable. It is alarming, therefore, that the majority of
77 premature deaths (82%) occur in LMICs, with this problem likely to increase if appropriate
78 preventative actions are not taken at a population level.

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

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

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3 89 obesity, diabetes and hypertension, predominantly coming from industrialized countries¹³⁻¹⁵ and
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5 90 developing nations¹⁶⁻¹⁸; however evidence on NCD comorbidity scant in Bangladesh. This is
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8 91 important as the patterning of NCDs is not uniform across countries of different income
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10 92 classification, with a higher prevalence of some NCD risk factors, such as diabetes, found in
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12 93 higher socio-economic groups in many studies in LMICs, contradicting those from higher
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15 94 income countries.¹⁹
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18 95 With the development of a double burden from both over- and under-nutrition in these
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20 96 LMICs, understanding comorbidity and their correlates is important if we are to develop NCD
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22 97 preventative policies contextualized for these countries. Despite the availability of nationwide
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25 98 survey data in Bangladesh, the prevalence, and in particular the comorbidity of NCD medical
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27 99 risk factors remains unmapped. This understanding of the burden and patterning of NCDs and
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29 100 their risk factors is important if Bangladesh is able to meet the Sustainable Development Goals
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31 101 (SDGs) target of reducing premature death from NCDs by one third by 2030.²⁰
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35 102 This study used 2011 Bangladesh Demography and Health Survey (BDHS) data to
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37 103 estimate the prevalence and pattern of NCD risk factors and comorbidity among the general
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39 104 population aged 35 years and older, as well as determining their socio-demographic patterning
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42 105 and possible predictors of comorbidity .
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107 **METHODS**

108 **Study design**

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

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3 111 conducted between July and December 2011 through the collaboration of the National Institute
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5 112 of Population Research and Training (NIPORT), ICF International (USA), and Mitra and
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7 113 Associates. Participants in the BDHS were selected using probability sampling based on a two-
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9 114 stage cluster sample of households, and stratified by rural and urban areas in the seven
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11 115 administrative regions of Bangladesh. The detailed protocol and methods have been published
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13 116 previously.²¹ In brief, 17,500 households were surveyed, of which one in three households were
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15 117 randomly selected for biomarker measurement (blood glucose, blood pressure). All men and
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17 118 women age 35 years and above were eligible for the biomarker measures, with these collected
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19 119 from a final sample of 8,835 individuals (male: 4524, female: 4311).²² We included 8763 cases
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24 120 in our analytical sample, after excluding cases with missing values.
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122 **Measurements of outcomes**

123 A data collection team, including a health technician, measured blood pressure, blood
124 glucose concentration, body weight, and height using standard methods.²¹ Diabetes (DM) was
125 defined as a fasting blood glucose level greater than or equal to 7.0 mmol/L or self-reported
126 diabetes medication use.²³ Body mass index (BMI) was calculated as weight (kg)/height (m²).
127 We used Asian specific BMI cut-offs to define underweight as <18.5 kg/m² and overweight and
128 obese (higher BMI) as ≥ 23 kg/m².²⁴ Hypertension was defined as systolic blood pressure (SBP)
129 ≥ 140 mmHg and diastolic blood pressure (DBP) ≥ 90 mmHg or self-reported anti-hypertensive
130 medication use during the survey.²⁵ We then categorized comorbidity into four groups such as
131 respondents having DM and HTN (group A), DM and overweight/obesity (group B), HTN and
132 overweight/obesity (group C) and group D in which individuals had all three conditions (DM,
133 HTN and overweight/obesity).

134

135 **Socio-demographic factors**

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

142

143 **Statistical analysis**

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

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3 157 the log (PR) to calculate the effect size by the formula $d = \log(\text{prevalence ratio}) \times (\sqrt{3/\pi})$. The
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5 158 primary research hypothesis was to test the wealth index from poorer to richest groups with the
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7 159 joint estimate of NCDs in the regression equation. We have considered the power .90, level of
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9 160 significance 0.05 , calculated effect size from prevalence ratio and then we get the estimated
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11 161 sample size for each model of each outcomes which covers the existing sample size of our
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13 162 analysis. We have performed the power analysis using G*Power software. The authors followed
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15 163 the guidelines outlined in the Strengthening the Reporting of Observational Studies in
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17 164 Epidemiology (*STROBE*) statement in writing the manuscript (Supplementary File 1).
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166 Ethical consideration and patient involvement

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27 167 Patients were not involved in the study. BDHS 2011 received ethical approval from ICF
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29 168 Macro Institutional Review Board, Maryland, USA and National Research Ethics Committee of
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31 169 Bangladesh Medical Research Council (BMRC), Dhaka, Bangladesh. Written informed consent
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33 170 was taken from the participants before the survey was completed.
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171 FINDINGS

38
39 172 The study population (n=8763) comprised 51% males, around 56% were 56 years of age
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41 173 or older, 62% reported no education, 25% were in manual employment, and 76% lived in rural
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43 174 locations (Table 1).
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175 **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

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6 177 Among the sample 12% had diabetes, 27% had HTN and 22% were classified as
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8 178 overweight/obesity ($BMI \geq 23 \text{ kg/m}^2$). The probability of having diabetes and hypertension
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10 179 increased by increasing age group, whilst the probability of being overweight/obesity was higher
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12 180 in the younger age group (Figure 1). Prevalence of all these conditions were higher amongst
13
14 181 males than females. The prevalence of group A (DM and HTN, $n=270$) and group B (DM and
15
16 182 overweight/obesity, $n=191$) comorbidities was 3%, whilst 7% of the sample had group C
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18 183 comorbidity (HTN and overweight/obesity, $n=513$). One percent (1%) of the sample all three
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20 184 conditions (DM, HTN and overweight/obesity =104). Prevalence of all groups of comorbidity
21
22 185 was higher in males than females, except for group B (DM and overweight/obesity) (Figure 2).
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24 186 The prevalence of individual conditions and all comorbidities was higher amongst older
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26 187 individuals, those with a 'College or higher' education, 'non-manual' workers, people in the
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28 188 richest quintile for wealth index and those living in urban environments (Table 2).
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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)

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

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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)

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3 193 The prevalence ratio (PR), from modified Poisson regression models, of HTN, DM and
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5 194 overweight/obesity was significantly higher among those who had completed higher education,
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8 195 those living in urban areas, non-manual workers and those in the richer to richest socioeconomic
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10 196 status. Although there was no sex disparities for diabetes, HTN and overweight/obesity was
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12 197 higher amongst males. Overweight/obesity was the only condition that was significantly higher
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15 198 among younger participants (Table 3).
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199 **Table-3: Modified Poisson regression models showing prevalence ratios (PR) and 95% confidence intervals for diabetes,**
 200 **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

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

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

205 **Statistical significance at p<0.05

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3 206 In univariate Poisson regression models, those in the richest quintile of wealth index had the
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5 207 highest PR for all comorbidity groups. These differences remained significant in all models in a
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7 208 stepwise process (**Supplementary File 2**). In final models, once controlling for sex, age,
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9 209 education, occupation and urbanization, those in the richest quintile were 2.3 times as likely to
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11 210 have DM and HTN, 4.8 times as likely to have DM and overweight/obesity, 4.9 times as likely to
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13 211 have HTN and overweight/obesity and 4.0 times as likely to have all three comorbidities, than
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15 212 those in the poorest quintile. In these final models, non-manual workers were also significantly
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17 213 more likely than manual workers to have all comorbidity groups. Sex differences were lost on
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19 214 controlling for other factor for all comorbidities groups, except Group C (HTN and
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21 215 overweight/obesity), for which females were 1.4 times as likely to experience both. Older
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23 216 participants were significantly more likely to have group A comorbidity (DM and HTN) DM
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29 217 and Group D (all comorbidities) (Table 4).
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218 **Table-4: Modified stepwise Poisson regression models showing prevalence ratios (PR) and 95% confidence intervals for**
 219 **comorbidities by demographic characteristics among Bangladeshi adults.**

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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)				
<i>Wealth index</i>				
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)				
<i>Wealth index</i>				
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
<i>Place of residence</i>				
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

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222 ** Statistical significance at p<0.05

For peer review only

223 DISCUSSION

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

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

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

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3 245 diabetes and 1.42 and 1.28 times higher probability of hypertension, for men and women,
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5 246 respectively.³² Other studies have also found that HTN is a common comorbid condition in DM,
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7 247 and vice versa,³³ whilst there is considerable evidence for an increased prevalence of HTN in
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9 248 diabetic persons from other populations.^{34,35}

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13 249 In the current study, overweight and diabetes risk was greater among young
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15 250 people which is consistent with a similar study conducted in Indonesia.³⁶ Diabetes, hypertension
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17 251 and overweight/obesity were more prevalent in non-manual labor compared to manual labor,
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19 252 which was similar to findings from a study in Barbados.³⁷ However, the present study found
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21 253 males were more likely to suffer comorbidities than females, contradicting findings from
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23 254 previous studies.^{38,39} We also found that the prevalence of individual conditions (diabetes,
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25 255 hypertension and overweight/obesity) along with the comorbidity of them, was higher in urban
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27 256 areas compared to rural, which is consistent with a number of studies conducted in developing
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29 257 countries, including Bangladesh.^{33,40-44}

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34 258 Within our study we found a higher prevalence of individual conditions and
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36 259 comorbidities in higher socioeconomic groups. These findings conflict with trends reported by
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38 260 previous studies conducted in higher-income countries.^{45, 46} However, another multi-country
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40 261 study reported that comorbidity was more prevalent among the poor and less educated in low
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42 262 income countries.⁴⁷ However, these findings were based on self-reported diagnosis, which may
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44 263 introduce concerns of report and recall bias. Previous research in INDEPTH Asian sites has
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46 264 reported inverse associations between comorbidity and markers of socioeconomic status.⁴⁸

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51 265 The main implications of the present study are the increased burden of NCDs within
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53 266 Bangladesh, along with other LMICs, and the patterning of more than one risk factor within

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3 267 individuals in the population. In contrast to findings from high income countries, prevalence of
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5 268 individual risk factors and comorbidities was higher in higher SES groups. This points to
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7 269 differences between countries in the population level determinants of NCDs and highlights that
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10 270 context specific interventions must be developed to counter them. As a first step, it is important
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12 271 that countries collect and analyse high quality health data to allow them to develop and target
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15 272 interventions.
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21 274 **STRENGTHS AND LIMITATIONS**

24 275 The main strengths of the study were the large nationally representative sample and the
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26 276 collection of blood pressure, blood glucose concentration, body weight, and height
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28 277 measurements by health technicians follow standard methods, including biomarker analysis,
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31 278 along with validated measures of socio-economic status. The main weakness of the study is the
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33 279 cross-sectional nature, meaning that only associations can be inferred and causality cannot be
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36 280 determined. In addition although clinical measures of diabetes, hypertension and
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38 281 overweight/obesity were taken, no measurements of blood lipids were taken in the survey,
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40 282 meaning that metabolic syndrome could not be investigated. Waist and hip circumference were
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42 283 also not collected, limiting the analysis that could be performed. Finally although the study was
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45 284 reported to be representative, only participants 35 years or older had measured anthropometry
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47 285 and biomarkers meaning that the findings reflect this population of adults in the country.
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53 287 **CONCLUSION**

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3 288 In contrast to more affluent countries, individuals of higher socio-economic status in
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5 289 Bangladesh are more likely to exhibit NCD risk factors and comorbidities than individuals from
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8 290 with lower SES status. It is important that we identify the patterning of these conditions within
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10 291 countries if we are to develop effective public health approaches contextualized to the
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12 292 population. This can be done through improved monitoring and surveillance of NCDs, linked to
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14 293 primary care programmes. Such approaches also need policy and system changes, supported by
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16 294 “political will”, societal and community support.
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22 296 **Contributors**

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24
25 297 TB, NT, SKD & AAM conceptualized the study. TB, NT, SKD, RDG & AAM designed the
26
27 298 study and acquired the data. TB, SI & MRI conducted the data analysis. TB, NT, SI, MRI, SKD
28
29 299 & AAM interpreted the data. TB, NT & RDG prepared the first draft. TB, NT, SKD & AAM
30
31 300 participated in critical revision of the manuscript and contributed to its intellectual improvement.
32
33 301 All authors went through the final draft and approved it for submission.
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41 303 **Funding**

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44 304 None.
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50 306 **Acknowledgments**

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3 307 The authors thank MEASURE DHS for permission to use data from the 2011
4
5 308 Bangladesh DHS. The authors are also grateful to Mr. Mehedi Hasan, PhD student, University of
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7
8 309 Queensland, Australia.
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11 310 **Competing Interests**
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14 311 None declared.
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20 313 **Patient consent**
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29 316 **Disclaimer**
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31 317 The authors are alone responsible for the integrity and accuracy of data analysis and the writing
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33 318 the manuscript.
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39 320 **Ethics approval**
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41
42 321 The datasets were obtained from DHS Programme with proper procedure. The study exempt
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44 322 from collecting ethical approval because the survey protocols were reviewed and approved by
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46 323 ICF Macro Institutional Review Board, Maryland, USA and National Research Ethics
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48 324 Committee of Bangladesh Medical Research Council (BMRC), Dhaka, Bangladesh.
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3 326 **Data sharing statement**
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6 327 The dataset of BDHS 2011 is available at the Demographic and Health Surveys Program. Extra
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9 328 data is available which is available on request at [http://dhsprogram-com/what-we-](http://dhsprogram-com/what-we-do/survey/survey-display-349.cfm)
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11 329 [do/survey/survey-display-349.cfm](http://dhsprogram-com/what-we-do/survey/survey-display-349.cfm).
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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.

- 1
2
3 355 9. National Institute of Population Research and Training (NIPORT), Mitra and Associates,
4
5 356 ICF International. Bangladesh Urban Health Survey 2013.. Dhaka, Bangladesh, Calverton,
6
7 357 Maryland, USA: NIPORT, Mitra and Associates, and ICF International., 2015.
8
9
10 358 10. Ahsan KZ, Alam MN, Streatfield PK, et al. Has Bangladesh Entered the Fourth Stage of
11
12 359 the Epidemiologic Transition?. Proceedings of the International seminar on Mortality: Past,
13
14 360 Present and Future; 2017Aug 7-8; the University of Campinas, Brazil.
15
16
17 361 11. Zaman MM, Bhuiyan MR, Karim MN, et al. Clustering of non-communicable diseases
18
19 362 risk factors in Bangladeshi adults: an analysis of STEPS survey 2013. *BMC Public Health*.
20
21 363 2015;15(1):659. doi: 10.1186/s12889-015-1938-4.
22
23
24 364 12. Hillas G, Perlikos F, Tsiligianni I, et al. Managing comorbidities in COPD. *Int J Chron*
25
26 365 *Obstruct Pulmon Dis*.2015;10:95. doi: 10.2147/COPD.S54473.
27
28
29 366 13. Roberts KC, Rao DP, Bennett TL, et al. Prevalence and patterns of chronic disease
30
31 367 multimorbidity and associated determinants in Canada. *Health Promot Chronic Dis Prev*
32
33 368 *Can*. 2015 ;35(6):87-94.
34
35
36 369 14. Wang J, Ma JJ, Liu J, et al. Prevalence and Risk Factors of Comorbidities among
37
38 370 Hypertensive Patients in China. *Int J Med Sci*. 2017;14(3):201. doi: 10.7150/ijms.16974.
39
40 371 15. Hurst C, Thinkhamrop B. The association between hypertension comorbidity and
41
42 372 microvascular complications in type 2 diabetes patients: A nationwide cross-sectional study in
43
44 373 Thailand. *Diabetes Metab J*. 2015;39(5):395-404. doi: 10.4093/dmj.2015.39.5.395
45
46
47 374 19. Allen L, Williams J, Townsend N, et al. Socioeconomic status and non-communicable
48
49 375 disease behavioural risk factors in low-income and lower-middle-income countries: a systematic
50
51 376 review. *Lancet Glob Health*. 2017;5(3):e277-e89. doi: 10.1016/S2214-109X(17)30058-X.
52
53
54
55
56
57

- 1
2
3 377 20. Varghese C. Reducing premature mortality from non-communicable diseases, including
4
5 378 for people with severe mental disorders. *World Psychiatry*. 2017;16(1):45-7. doi:
6
7 379 10.1002/wps.20376.
8
9
10 380 21. National Institute of Population Research and Training (NIPORT), Mitra and Associates,
11
12 381 ICF International. Bangladesh Demographic and Health Survey 2011, Preliminary Report.
13
14 382 Dhaka, Bangladesh, Calverton, Maryland, USA: NIPORT, Mitra and Associates, and ICF
15
16 383 International., 2012.
17
18
19 384 22. Biswas T, Islam MS, Linton N, et al. Socio-economic inequality of chronic non-
20
21 385 communicable diseases in Bangladesh. *PloS One*. 2016;11(11):e0167140. doi:
22
23 386 10.1371/journal.pone.0167140.
24
25
26 387 23. Akter S, Rahman MM, Abe SK, et al. Prevalence of diabetes and prediabetes and their
27
28 388 risk factors among Bangladeshi adults: a nationwide survey. *Bull World Health Organ*.
29
30 389 2014;92(3):204-13A. doi: 10.2471/BLT.13.128371.
31
32
33 390 24. Ke-You G, Da-Wei F. The magnitude and trends of under-and over-nutrition in Asian
34
35 391 countries. *Biomed Environ Sci*. 2001;14(1-2):53-60.
36
37
38 392 25. National Institute of Population Research and Training (NIPORT), Mitra and Associates,
39
40 393 ICF International. Bangladesh Demographic and Health Survey 2011. Dhaka, Bangladesh,
41
42 394 Calverton, Maryland, USA: NIPORT, Mitra and Associates, and ICF International., 2013.
43
44
45 395 26. Rahman M, Williams G, Al Mamun A. Hypertension and diabetes prevalence among
46
47 396 adults with moderately increased BMI (23· 0–24· 9 kg/m²): findings from a nationwide survey
48
49 397 in Bangladesh. *Public Health Nutr*. 2017:1-8. doi: 10.1017/S1368980016003566.
50
51
52
53
54
55
56
57

- 1
2
3 398 27. Biswas T, Uddin MJ, Al Mamun A, et al. Increasing prevalence of overweight and
4
5 399 obesity in Bangladeshi women of reproductive age: Findings from 2004 to 2014. *PloS One*.
6
7 400 2017;12(7):e0181080. doi: 10.1371/journal.pone.0181080.
8
9
10 401 28. Hoque ME, Hasan MT, Rahman M, et al. Double burden of underweight and overweight
11
12 402 among Bangladeshi adults differs between men and women: evidence from a nationally
13
14 403 representative survey. *Public Health Nutr.*2017;20(12):2183-91. doi:
15
16 404 10.1017/S1368980017000957.
17
18
19 405 29. Biswas T, Garnett SP, Pervin S, et al. The prevalence of underweight, overweight and
20
21 406 obesity in Bangladeshi adults: Data from a national survey. *PloS One*. 2017;12(5):e0177395. doi:
22
23 407 10.1371/journal.pone.0177395.
24
25
26 408 30. Dietz WH. Double-duty solutions for the double burden of malnutrition. *Lancet*. 2017.
27
28 409 doi: 10.1016/S0140-6736(17)32479-0.
29
30
31 410 31. Bhowmik B, Afsana F, Ahmed T, et al. Obesity and associated type 2 diabetes and
32
33 411 hypertension in factory workers of Bangladesh. *BMC Res Notes*.2015;8(1):460. doi:
34
35 412 10.1186/s13104-015-1377-4.
36
37
38 413 32. Pradeepa R. The rising burden of diabetes and hypertension in southeast asian and african
39
40 414 regions: need for effective strategies for prevention and control in primary health care settings.
41
42 415 *Int J Hypertens*. 2013;2013. doi: 10.1155/2013/409083.
43
44
45 416 33. Sola A, Chinyere O, Stephen A, et al. Hypertension prevalence in an urban and rural area of
46
47 417 Nigeria. *J Med Sci*. 2013;4:149-54.
48
49 418 34. Berraho M, El Achhab Y, Benslimane A, et al. Hypertension and type 2 diabetes: a cross-
50
51 419 sectional study in Morocco (EPIDIAM Study). *Pan Afr Med J*. 2012;11(1).
52
53
54
55
56
57

- 1
2
3 420 35. Hashemizadeh H, Sarvelayati D. Hypertension and Type 2 Diabetes: A Cross-sectional
4
5 421 Study in Hospitalized Patients in Quchan, Iran. *Iran J Diabetes Obesity*. 2013;5(1):21-6.
6
7 422 36. Hussain MA, Huxley RR, Al Mamun A. Multimorbidity prevalence and pattern in
8
9 423 Indonesian adults: an exploratory study using national survey data. *BMJ Open*.
10
11 424 2015;5(12):e009810. doi: 10.1136/bmjopen-2015-009810.
12
13
14 425 37. Howitt C, Hambleton IR, Rose AM, et al. Social distribution of diabetes, hypertension
15
16 426 and related risk factors in Barbados: a cross-sectional study. *BMJ Open*. 2015;5(12):e008869.
17
18 427 doi: 10.1136/bmjopen-2015-008869.
19
20
21 428 38. Pearson TA. Education and income: double-edged swords in the epidemiologic transition
22
23 429 of cardiovascular disease. *Ethn Dis*. 2003;13(2; SUPP/2):S2-158.
24
25
26 430 39. Agborsangaya CB, Lau D, Lahtinen M, et al. Multimorbidity prevalence and patterns
27
28 431 across socioeconomic determinants: a cross-sectional survey. *BMC Public Health*.
29
30 432 2012;12(1):201. doi: 10.1186/1471-2458-12-201.
31
32
33 433 40. Rahman M, Williams G, Al Mamun A. Gender differences in hypertension awareness,
34
35 434 antihypertensive use and blood pressure control in Bangladeshi adults: findings from a national
36
37 435 cross-sectional survey. *J Health Popul Nutr*. 2017;36(1):23. doi: 10.1186/s41043-017-0101-5.
38
39
40 436 41. Li G, Hu H, Dong Z, et al. Urban and suburban differences in hypertension trends and
41
42 437 self-care: Three population-based cross-sectional studies from 2005-2011. *PloS One*.
43
44 438 2015;10(2):e0117999. doi: 10.1371/journal.pone.0117999.
45
46
47 439 42. Dhungana RR, Pandey AR, Bista B, et al. Prevalence and associated factors of
48
49 440 hypertension: a community-based cross-sectional study in municipalities of Kathmandu, Nepal.
50
51 441 *Int J Hypertens*. 2016;2016. doi: 10.1155/2016/1656938.
52
53
54
55
56
57

- 1
2
3 442 43. Chowdhury MAB, Uddin MJ, Haque MR, et al. Hypertension among adults in
4
5 443 Bangladesh: evidence from a national cross-sectional survey. *BMC Cardiovasc Disord.*
6
7 444 2016;16(1):22. doi: 10.1186/s12872-016-0197-3.
8
9
10 445 44. Akter S, Rahman MM, Abe SK, et al. Prevalence of diabetes and prediabetes and their
11
12 446 risk factors among Bangladeshi adults: a nationwide survey. *Bull World Health*
13
14 447 *Organ.*2014;92(3):204-13A. doi: 10.2471/BLT.13.128371
15
16
17 448 45. Connolly V, Unwin N, Sherriff P, et al. Diabetes prevalence and socioeconomic status: a
18
19 449 population based study showing increased prevalence of type 2 diabetes mellitus in deprived
20
21 450 areas. *J Epidemiol Community Health.*2000;54(3):173-7.
22
23
24 451 46. Glover JD, Hetzel DM, Tennant SK. The socioeconomic gradient and chronic illness and
25
26 452 associated risk factors in Australia. *Aust New Zealand Health Policy.* 2004;1(1):8. doi:
27
28 453 10.1186/1743-8462-1-8.
29
30
31 454 47. Hosseinpoor AR, Bergen N, Mendis S, et al. Socioeconomic inequality in the prevalence
32
33 455 of noncommunicable diseases in low-and middle-income countries: results from the World
34
35 456 Health Survey. *BMC Public Health.* 2012;12(1):474. doi: 10.1186/s12889-015-2227-y.
36
37
38 457 48. Van Minh H, Ng N, Juvekar S, et al. Self-reported prevalence of chronic diseases and
39
40 458 their relation to selected sociodemographic variables: a study in INDEPTH Asian sites, 2005.
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42 459 *Prev Chronic Dis.*2008;5(3).
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3 **460 Figures:**
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6 **461 Fig 1.** Scatter plot between age with blood glucose, systolic blood pressure, diastolic blood
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8 **462** pressure and BMI.
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10 **463 Fig 2.** Prevalence of diabetes, hypertension, overweight and comorbidity by sex among
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13 **464 Bangladeshi adults**
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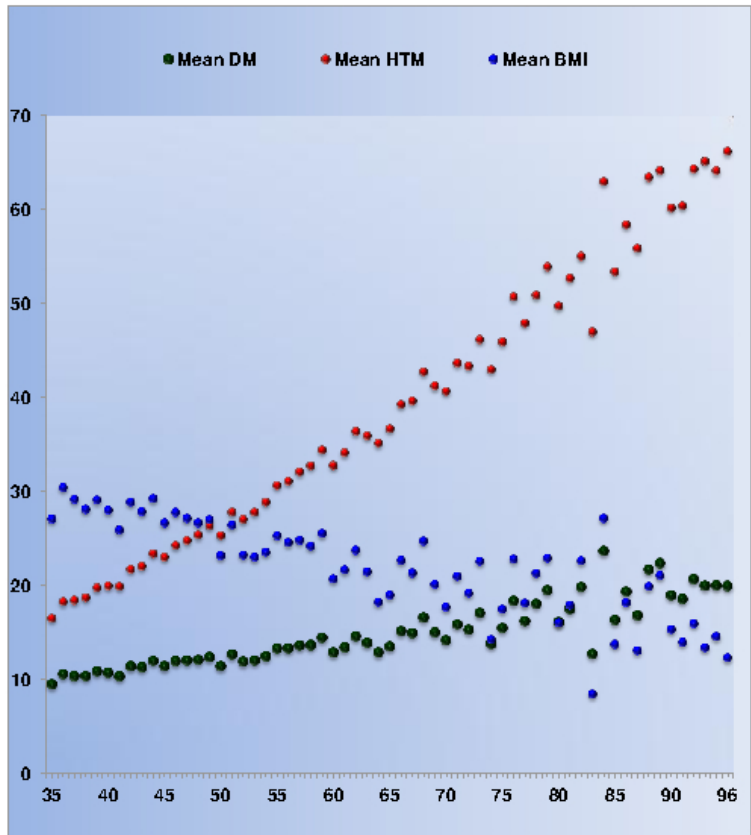
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19 **466 Supplementary Materials:**
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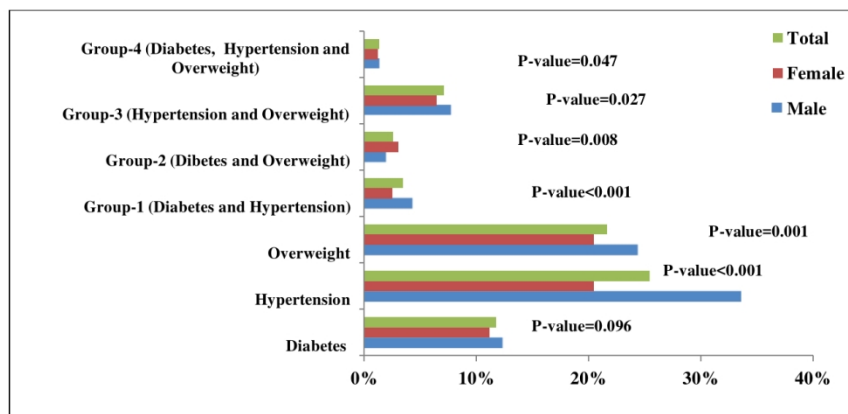
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22 **467 Supplementary File 1:** STROBE Checklist
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25 **468 Supplementary File 2:** Modified stepwise Poisson regression models showing prevalence ratios
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27 **469** (PR) and 95% confidence intervals for comorbidities by demographic characteristics among
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29 **470** Bangladeshi adults.
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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.

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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.

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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)				
<i>Wealth index</i>				
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)				
<i>Wealth index</i>				
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
<i>Sex</i>				
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)				
<i>Wealth index</i>				
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
<i>Sex</i>				
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
<i>Age</i>				
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