



Non-communicable Disease Risk

## Distribution of chronic disease mortality and deterioration in household socioeconomic status in rural Bangladesh: an analysis over a 24-year period

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### Abstract

**Background:** Little is known about long-term changes linking chronic diseases and poverty in low-income countries such as Bangladesh. This study examines how chronic disease mortality rates change across socioeconomic groups over time in Bangladesh, and whether such mortality is associated with households falling into poverty.

**Methods:** Age-sex standardized chronic diseases mortality rates were estimated across socioeconomic groups in 1982, 1996 and 2005, using data from the health and demographic surveillance system in Matlab, Bangladesh. Changes in households falling below a poverty threshold after a chronic disease death were estimated between 1982–96 and 1996–2005.

**Results:** Age-sex standardized chronic disease mortality rates rose from 646 per 100 000 population in 1982 to 670 in 2005. Mortality rates were higher in wealthier compared with poorer households in 1982 [Concentration Index = 0.037; 95% confidence interval (CI): 0.002, 0.072], but switched direction in 1996 (Concentration Index = –0.007; 95% CI: –0.023, 0.009), with an even higher concentration in the poor by 2005 (Concentration Index = –0.047; 95% CI: –0.061, –0.033). Between 1982–96 and 1996–2005, the highest chronic disease mortality rates were found among those households that fell below the poverty line. Households that had a chronic disease death in 1982 were 1.33 (95% CI: 1.03, 1.70) times more likely to fall below the poverty line in 1996 compared with households that did not.

**Conclusions:** Chronic disease mortality is a growing proportion of the disease burden in Bangladesh, with poorer households being more affected over time periods, leading to future household poverty.

**Key words:** Chronic disease, mortality, social class, poverty

#### Key Messages

- Chronic disease mortality in Bangladesh is growing as a proportion of all deaths, and is increasingly concentrated among the poor.
- Chronic disease mortality has an exacerbating effect on household poverty, as the death of household members due to chronic disease deteriorates the socioeconomic status of the households and frequently drags more households into poverty.

## Introduction

Health and economic conditions of households influence each other bi-directionally, meaning that health influences economic status and economic status influences health. Ill health can reduce individual and household income<sup>1</sup> and lead to income shocks, particularly among rural populations.<sup>2</sup> Poor people are also more prone to overall mortality.<sup>3</sup> In Bangladesh, which is a low-income country with huge social and economic inequalities, health-related income shocks would be expected among its largely rural populations (74% of the population) and those living below the poverty line (43.8% of the population).<sup>4,5</sup>

Increases in life expectancy at birth lead to an increasing burden of chronic disease and higher healthcare expenditures.<sup>6,7</sup> In many countries, the poorest are at higher risk for chronic disease whereas they are least able to cope with the financial consequences.<sup>8</sup> Total health costs to individuals are a major loss to the society.<sup>9</sup> At the individual level, chronic diseases may lead to impoverishment through wage loss, missed schooling or catastrophic expenditures on health care.<sup>10–12</sup>

Non-communicable diseases (NCDs), another imperfect label for chronic diseases, are responsible for over 60% of all deaths globally;<sup>13,14</sup> NCD deaths in populations under 60 years of age, in low-income countries constituted 41% of total deaths whereas high-income countries had a lower proportion (13%) of deaths attributed to NCDs in the same age group. It has been observed that the share of NCD deaths increased with decreasing income levels of the countries.<sup>15</sup> Measured in disability-adjusted life years (DALYs), chronic diseases are responsible for about 50% of the total global burden of disease.<sup>9</sup> This is the equivalent of about 45% of

the total disease burden in low- and middle-income countries (LMICs); 44% of this burden occurs among people under 60 years of age, with 90% attributed to chronic conditions.<sup>9,14</sup> The differences between high- and low-income countries are less in terms of the proportion of DALYs lost (68% vs 84%) due to chronic diseases but more in terms of deaths (72% vs 20%). Due to prolonged treatment, continuous use of health services and productivity losses, household economic status may deteriorate. Levesque *et al.*<sup>16</sup> documented in Kerala, India, that chronic treatment for the poor is commonly beyond their ability to pay. Chronic illnesses may lead to higher healthcare expenses or higher production loss for households, or both. Poor people in low-income countries may be much more prone to economic loss due to chronic conditions than elsewhere. Abegunde and Stanciole<sup>17</sup> have found a positive association between chronic diseases and poverty in their empirical investigation in Russia, a middle-income country. A study comparing urban and rural areas in Hubei province of China found that chronic diseases were the major cause of death in general.<sup>18</sup> Circulatory system diseases were the leading causes in both urban and rural areas, and it was highlighted that attention should also be paid to breast cancer among women and chronic lower respiratory disease among rural residents. However, longitudinal studies on the relationships between socioeconomic status and chronic diseases in LMICs are rare, despite emerging evidence that the increasing wealth of these countries is beginning to lead to replicate the pattern of such diseases in the high-income countries.<sup>19</sup> Although a few studies have been conducted in the area of socioeconomic difference in chronic diseases in recent years, better quality data and evidence are still needed.<sup>20,21</sup>

This current study takes advantage of a unique data set in Bangladesh to assess how chronic disease mortality rates have changed across socioeconomic groups over time, and whether chronic disease mortality influences the risk of households falling into poverty. The study uses data from a longstanding Health and Demographic Surveillance System (HDSS) in Matlab, Bangladesh, operated by the International Centre for Diarrhoeal Disease Research, Bangladesh (icddr,b), to estimate the rates of non-communicable chronic disease mortality across socioeconomic groups in three intervals over a period of 24 years. This study examines how chronic disease mortality rates change across socioeconomic groups over time in Bangladesh, and whether such mortality is associated with households falling into poverty.

## Methods

### Ethics statement

The research study was approved by the Institutional Review Board of the International Centre for Diarrhoeal Disease Research, Bangladesh (icddr,b).

### Data

The study uses data on cause-specific mortality from the HDSS located in the Matlab sub-district in rural Bangladesh. The HDSS covers a population of about 225 000, and uses structured interviews to register birth, death, marriage, divorce, migration, internal movement and household splitting every 2 months in all households in the 142 villages. Periodic socioeconomic surveys also collect information on occupation and household assets. In 1982, the total population in the HDSS was 187 574, of which 49.4% was male. Working age (20–64 years) and elderly (65+ years) people constituted 43.4% and 3.2% of total population, respectively.<sup>22</sup> The total population increased by 12.7% between 1982 and 1996. In 1996, the working-age population was 48.5% of the total population, whereas elderly people (65+ years) constituted 3.6%.<sup>23</sup> The total population increased by 6.4% between 1996 and 2005. During this period, the proportion of working-age people became larger (51.7%) and elderly people also increased (5.5%).<sup>24</sup>

Panel data, i.e. data collected from the same households over years, were used in this study. Socioeconomic censuses (including asset variables) were carried out in 1982, 1996 and 2005. All people aged 20 years and above who were available in two subsequent census years, i.e. 1982 and 1996 as well as 1996 and 2005, are included in the analyses. Verbal autopsies (VAs) were conducted to identify cause-specific mortality in the regular

surveillance system in Matlab. Trained persons conducted the VA interview with a family member at the home of the deceased. The VA tool used in 1982 contained brief descriptions of 'events and symptoms leading to death' and field research assistants (with at least 10th grade education and no training in medicine) assigned a crude diagnosis of cause of death. The VA used in 1996 contained in detail signs and symptoms that led to death and medical consultations before death, and a trained MA (medical assistant with 10th grade education plus 3 years training in medicine) reviewed each VA and assigned possible cause of death with an ICD-9 code. Modular VA tools (developed by WHO and modified by INDEPTH) were used for neonatal, child and adult deaths in 2005, and the same MA assigned possible cause of death with ICD-10 codes.<sup>25,26</sup> Cause-specific chronic disease mortality rates as well as mortality from other diseases, including communicable diseases, injuries and unknown causes, were estimated for each socioeconomic group. For coding the cause of deaths, a self-developed list was applied in 1982 and 1996 by the HDSS, and the International Classification of Diseases Tenth Revision (ICD-10) was applied in 2005. A medically trained doctor assigned the coded deaths across the years (1982, 1996 and 2005) into chronic and other causes of mortality. The chronic disease label refers to a diagnosis categorized according to aetiology, pathophysiology, signs, symptoms and treatment, and also implies an expected long duration and lack of cure. Communicable diseases of long duration (e.g. AIDS) are traditionally not included in this category of chronic disease. Conditions, syndromes and disorders are similar but are less well defined.<sup>27</sup>

Socioeconomic groups are available in the HDSS database, and were created using information on the possession of household assets found at each census. Socioeconomic census data were merged with the corresponding household identification number and the mortality in the households in the respective years.

An asset index was created for households in the HDSS using the availability of a list of durable goods in a household, along with the type of housing and access to basic facilities such as water and sanitation. Principle component analysis (PCA) was used for calculating standardized asset scores and population cut-offs for quintiles of wealth in the manner used in other studies.<sup>28,29</sup> All members of a household were given the same asset score, and the population was then divided into five quintiles representing poorest to least poor wealth quintiles. We categorized people in the bottom two quintiles (i.e. poorest 40% of the population) as living below the poverty line, a level which approximates to the national poverty line in Bangladesh.

## Distribution of chronic disease mortality

The cause-specific mortality rates (per 100 000 population per year) for chronic disease and other causes of mortality across socioeconomic quintiles were calculated separately for 1982, 1996 and 2005, applying age-sex standardization<sup>30</sup> based on the Matlab population composition in 2005. This estimate was used to observe the socioeconomic gradient of cause-specific mortality. The distribution of chronic disease mortality (and other-cause mortality) was analysed across socioeconomic quintiles by estimating the concentration index.<sup>31,32</sup> The concentration index value can range between  $-1$  and  $+1$ , with negative values indicating that the distribution is skewed to poor socioeconomic groups, and positive values for wealthier groups.

## Association between NCD mortality and socioeconomic changes in households

The association between chronic disease mortality and socioeconomic change was examined by using descriptive statistics. Households in HDSS database in years 1982, 1996 and 2005 constitute the panels. The first panel includes population in common households in 1982 and 1996, and the second panel includes common households in 1996 and 2005. Households were classified into four mutually exclusive groups based on their change in socioeconomic status between these years: (i) people that fell below the poverty line (i.e. they dropped from quintiles 3, 4 or 5 to 1 or 2); (ii) people that remained in poverty (i.e. they stayed in the bottom two quintiles); (iii) people that rose out of poverty (i.e. they rose from quintiles '1 or 2' to '3, 4 or 5'); and iv) people that stayed out of poverty (i.e. they stayed above the bottom two quintiles in both years). Mortality rates due to chronic diseases and all-cause mortality in each group were also calculated. The same categorization was applied in the second panel for households in both 1996 and 2005. Standard error (SE) and confidence intervals (CIs) were also calculated for reference purposes, noting that the data were derived from population censuses.

## Results

The age- and sex-standardized chronic disease and other-cause mortality rates give an overview of the spectrum of diseases causing deaths among adults in Matlab. As shown in Tables 1–3, the all-cause age-sex standardized adult mortality rate (deaths per 100 000 populations per year) fell from 1577 in 1982 to 1012 in 1996, and 849 in 2005. In contrast, age-sex standardized chronic disease mortality rates first fell from 646 to 509 between 1982 and 1996, and then increased to 670 in 2005, with the proportion of all deaths due to chronic diseases increasing from 41% in 1982

**Table 1.** Distribution of age-sex standardized cause-specific mortality rates (per 100 000 adult population per year) across socioeconomic quintiles, Matlab, 1982

Asset quintile	Diseases											Chronic disease share (%)		
	Chronic diseases						Other diseases						All	
	Cancer	Diabetes	COPD	Stroke	Heart	Hypertension	Other chronic	Total	Communicable	Injury	Unknown/unclassified <sup>a</sup>			Total
Poorest	4.4	6.8	232.6	-	12.9	-	289.3	546.0	261.0	15.4	710.1	986.4	1532.4	35.6%
2nd	12.5	0	249.7	-	19.3	-	354.9	636.3	167.8	30.3	822.8	1020.9	1657.2	38.4%
3rd	26.4	0	216.0	-	17.6	-	390.2	650.3	126.6	34.2	828.1	988.9	1639.3	39.7%
4th	0	0	159.4	-	73.0	-	400.4	632.9	102.7	33.0	658.7	794.5	1427.4	44.3%
Richest	30.9	5.6	269.0	-	56.1	-	335.6	697.3	116.2	26.3	728.0	870.4	1567.6	44.5%
All	16.0	2.5	229.2	-	38.6	-	359.9	646.3	148.7	28.1	754.1	930.9	1577.2	41.0%
Concentration Index (95% CI)	0.221 (-0.077-0.519)	-0.003 (-0.824-0.818)	0.009 (-0.081-0.099)	0.299 (0.142-0.456)	0.025 (-0.044-0.094)	0.037 (0.002-0.072)	0.025 (-0.044-0.094)	0.037 (0.002-0.072)	-0.176 (-0.278-0.074)	0.056 (-0.099-0.211)	-0.016 (-0.053-0.021)	-0.04 (-0.056-0.024)	0.008 (-0.014-0.03)	

<sup>a</sup>Unknown and unclassified causes considering the categorization of diseases.

**Table 2.** Distribution of age-sex standardized cause-specific mortality rates (per 100 000 adult population per year) across socioeconomic quintiles, Matlab, 1996

Asset quintile	Diseases											Chronic disease share (%)		
	Other diseases										All			
	Chronic diseases		Communicable		Injury		Unknown/unclassified <sup>a</sup>		Total					
Cancer	Diabetes	COPD	Stroke	Heart	Hypertension	Other chronic	Total	Communicable	Injury	Unknown/unclassified <sup>a</sup>	Total			
Poorest	54.1	0.0	114.7	44.5	9.4	14.3	283.4	520.4	214.9	54.0	460.4	729.3	1249.7	41.6%
2nd	54.2	10.9	87.4	162.4	10.8	4.7	203.5	533.8	175.8	60.7	300.9	537.4	1071.3	49.8%
3rd	51.6	8.7	102.3	103.7	9.8	0.0	201.9	478.1	86.0	23.9	314.3	424.1	902.2	53.0%
4th	51.1	31.9	82.1	129.8	19.5	0.0	218.2	532.6	128.4	51.1	354.2	533.7	1066.4	49.9%
Richest	71.2	18.4	74.6	154.9	30.6	0.0	147.0	496.6	81.2	25.9	282.9	390.0	886.6	56.0%
All	56.9	15.5	89.3	124.0	17.2	2.9	203.6	509.4	128.3	41.8	332.8	502.8	1012.3	50.3%
Concentration	0.052	0.271	-0.073	0.106	0.256	-0.756	-0.094	-0.007	-0.175	-0.121	-0.06	-0.095	-0.051	
Index														
(95% CI)	(-0.013-0.117)	(-0.048-0.59)	(-0.126-0.02)	(-0.094-0.306)	(0.199-0.313)	(-1.064-0.448)	(-0.188-0)	(-0.023-0.009)	(-0.283-0.067)	(-0.248-0.006)	(-0.154-0.034)	(-0.189-0.001)	(-0.104-0.002)	

<sup>a</sup>Unknown and unclassified causes considering the categorization of diseases.

**Table 3.** Distribution of age-sex standardized cause-specific mortality rates (per 100 000 adult population per year) across socioeconomic quintiles, Matlab, 2005

Asset quintile	Diseases											Chronic disease share (%)		
	Other diseases										All			
	Chronic diseases		Communicable		Injury		Unknown/unclassified <sup>a</sup>		Total					
Cancer	Diabetes	COPD	Stroke	Heart	Hypertension	Other chronic	Total	Communicable	Injury	Unknown/unclassified <sup>a</sup>	Total			
Poorest	93.3	34.4	44.2	265.2	142.4	14.7	157.2	751.5	93.3	34.4	83.5	211.2	962.7	78.1%
2nd	113.3	50.4	21.0	293.8	109.1	16.8	146.9	751.2	88.1	21.0	96.5	205.6	956.8	78.5%
3rd	128.1	22.6	15.1	294.0	82.9	11.3	109.3	663.3	64.1	49.0	75.4	188.5	851.8	77.9%
4th	95.0	33.9	20.4	237.5	128.9	10.2	88.2	614.1	81.4	40.7	71.2	193.4	807.4	76.1%
Richest	105.6	37.3	21.7	223.7	133.6	12.4	80.8	615.1	28.0	49.7	40.4	118.0	733.1	83.9%
All	107.3	35.5	23.4	259.8	119.3	12.8	111.8	670.0	68.0	40.0	71.0	179.0	849.0	78.9%
Concentration	-0.004	-0.019	-0.118	-0.049	0.018	-0.064	-0.146	-0.047	-0.17	0.102	-0.137	-0.096	-0.058	
Index														
(95% CI)	(-0.059-0.051)	(-0.119-0.081)	(-0.326-0.09)	(-0.084-0.014)	(-0.076-0.112)	(-0.121-0.007)	(-0.179-0.113)	(-0.061-0.033)	(-0.348-0.008)	(0.006-0.198)	(-0.247-0.027)	(-0.188-0.004)	(-0.078-0.038)	

<sup>a</sup>Unknown and unclassified causes considering the categorization of diseases.

to 50% in 1996 to 79% by 2005. In 1982, 'Unknown' causes of death were the main category of cause of death (48% of all deaths), whereas 'Other' chronic diseases were the most common category of chronic disease deaths (23% of all deaths). Classification of causes of death improved significantly in 1996 and 2005, so that by 2005 only 8% of deaths were categorized as 'unknown' causes, and stroke was the leading cause of death (31% of all deaths).

### Socioeconomic variation in chronic disease mortality

The chronic disease mortality rate in 1982 was 646.3 per 100 000 population. The distribution of chronic disease deaths across socioeconomic groups in this shows that such mortality generally increased with higher socioeconomic status (Concentration Index = 0.037 with 95% CI: 0.037, 0.072), whereas all other causes of death were concentrated among the poor (Concentration Index = -0.040 with 95% CI: -0.056, 0.024) (Table 1). Among the five socioeconomic quintiles, the highest share of chronic disease mortality is observed in the wealthiest quintile (45%) and lowest in the poorest quintile (36%).

In 1996, the chronic diseases mortality rate was 509 deaths per 100 000 population (Table 2). Stroke, which was not present in the data set of 1982, now represents the largest share of chronic disease mortality. The distribution of such disease mortality in 1996 was nearly the same across socioeconomic groups (Concentration Index = -0.007 with 95% CI: -0.023, 0.009). It is observed that heart disease mortality was more prevalent among the richest quintile. The highest proportion of chronic disease mortality share among all mortality is observed in the richest quintile (56%), and lowest in the poorest quintile (42%).

In 2005, the chronic disease mortality rate increased to 670 deaths per 100 000 population (Table 3). These rates ranged between 614 and 751 per 100 000 population in different socioeconomic quintiles, with increasingly higher mortality rates as socioeconomic group declined, and the Concentration Index showing that the poor have disproportionately higher rates (Concentration Index = -0.047 with 95% CI: -0.061, -0.033). Higher socioeconomic quintiles had lower all-cause as well as chronic disease mortality (including stroke and hypertension), though the share of chronic disease mortality as a percentage of all-cause mortality was highest in the wealthiest quintile (84%).

### Association between chronic disease mortality and socioeconomic changes in households

The highest chronic disease mortality in 1982 was 1112 per 100 000 population in those who fell into the bottom

two quintiles in 1996, followed by those who stayed above (840), rose above (559) or remained below (544), respectively. The highest mortality in 1996 per 100 000 population was in those who fell below the poverty level (507) between 1996 and 2005, followed by those who remained below (479), stayed above (403) and rose above (347). The highest share of chronic disease mortality in all-cause mortality was in the 'fell below' group (46%), followed by the 'stayed above' group (43%) between 1982 and 1996. The corresponding shares were 58% and 51%, respectively, between 1996 and 2005.

In Table 4, the odds ratio (OR) shows that the households which experienced chronic disease mortality in the baseline year were more likely to suffer deterioration in their wealth status, and that those who rose in their wealth status had lower chronic disease mortality rates, in comparison with those that stayed above the poverty line. For example, the odds ratio of the 'fell below' group in 1996 in households observing chronic disease death in 1982 was 1.33 (95% CI: 1.03, 1.70) compared with those that remained above the poverty line. However, the odds ratio for households that remained below poverty line was significantly lower 0.65 (95% CI: 0.48, 0.85). In the next panel (1996 and 2005), the corresponding odds ratio for those who 'fell below' was 1.26 (95% CI: 0.92, 1.69), although this was not significant at 95% confidence level. Similarly, the odds ratios for rising out of the bottom two quintiles was not statistically significant (0.86; 95% CI: 0.59, 1.23) compared with those who stayed above the poverty line.

### Discussion

This study addressed an important issue in a low-income country setting by demonstrating cause-specific deaths with a focus on chronic disease mortality in an adult population and their association with poverty at three points in time (1982, 1996 and 2005) covering a 24-year period. The data suggested that the households with chronic disease deaths were more likely to fall below poverty line between 1982 and 1996. Curiously, those households that remained poor and those that rose above the poverty both had lower odds of chronic disease deaths compared with those that remained above the poverty line during this period. Between 1996 and 2005, chronic disease deaths were not statistically associated with changes in poverty status, though all-cause mortality was higher among those who stayed below the poverty line. We note that since the study was based on a census, rather than a sample, it may be reasonable to look at the odds ratios directly. In that context, the mixed picture in the first period changes in the second period where the highest risk is in the group that

**Table 4.** Change in poverty threshold 1982–96 and 1996–2005 in Matlab and age-sex standardized chronic disease mortality rates per 100 000 population in the baseline year

Disease	1982–96				1996–2005			
	Fell below poverty line <sup>a</sup>	Remained below poverty line <sup>a</sup>	Rose above poverty line <sup>a</sup>	Stayed above poverty line <sup>a</sup>	Fell below poverty line <sup>a</sup>	Remained below poverty line <sup>a</sup>	Rose above poverty line <sup>a</sup>	Stayed above poverty line <sup>a</sup>
Cancer	25.4	12.5	12.8	27.1	61.1	56.7	48.1	53.0
Diabetes	0.0	0.0	0.0	4.0	26.2	0.0	19.3	14.6
COPD	395.3	199.0	227.1	269.2	104.8	77.3	48.1	67.6
Stroke	0.0	0.0	0.0	0.0	122.3	92.8	86.6	105.9
Heart	65.6	0.0	25.9	75.4	8.7	5.2	9.6	20.1
Hypertension	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Other chronic disease	625.3	332.7	293.1	464.3	183.4	247.4	134.8	142.5
All chronic disease	1111.6	544.2	558.8	840.1	506.6	479.3	346.6	403.6
Odds ratio	1.33	0.65	0.67	1 (ref)	1.26	1.18	0.86	1 (ref)
(95% confidence interval)	(1.03 1.70)	(0.48 0.85)	(0.47 0.95)		(0.92 1.69)	(0.92 1.52)	(0.59 1.23)	
All disease	2395.8	1775.0	1449.0	1964.8	864.6	974.0	731.6	794.5
Odds ratio	1.23	0.90	0.73	1 (ref)	1.08	1.23	0.92	1 (ref)
(95% confidence interval)	(1.04 1.45)	(0.77 1.06)	(0.59 0.91)		(0.87 1.36)	(1.03 1.46)	(0.71 1.18)	
Number of individuals	8089	11547	6895	30643	11450	19405	10388	54753
Chronic disease share (%)	46.4%	30.7%	38.6%	42.8%	58.2%	49.6%	46.3%	50.5%

<sup>a</sup>Fell below poverty line from quintiles 3, 4 and 5 to 1 and 2; remained below poverty line, remained in quintiles 1 and 2 in both years; rose poverty line, rose from quintiles 1 and 2 to 3, 4 and 5; stayed above poverty line, stayed in quintiles 3, 4 and 5 in both years.

falls into poverty, followed by the group that stays in poverty, those that stay above poverty and, with the lowest risk, those that rise above poverty. Nonetheless, the association between economic impoverishment and chronic disease deaths appears to be changing, even if those changes are somewhat ambiguous. Of course there are also many other causes of poverty other than chronic diseases, such as those related to dowry, high dependency ratio, lack of work, debt, food price hikes, idleness, crop damage, loss of business and other shocks that were not considered in this study.<sup>31</sup>

The HDSS sites have provided a unique opportunity to analyse panel data, and showed how classification of causes of death has become better defined over this period. Although the large number of ‘unknown’ and ‘other chronic disease’ causes of death in 1982 leaves some uncertainty over the trends of specific causes of death, the 24-year time span demonstrates how rapidly the epidemiological transition has occurred in rural Bangladesh. There is a reduction in overall adult mortality rates, with an increasing contribution coming from chronic diseases over time. This trend is consistent with global analyses of changes in the burden of disease.<sup>6</sup> This suggests that at one time in the 1980s, chronic disease deaths were more likely

to affect the better-off groups, but that as the epidemiological transition deepened later, a more familiar pattern emerged with chronic diseases (and all mortality) becoming more concentrated among the poor.

Accurate cause of death identification is a difficult task. The performance of verbal autopsy (VA) analysis may vary over time as the profile of illness changes, especially in comparison with medical certification of cause of death at hospitals. Household members may respond to VA questions differently if the death occurs without any medical care, whereas those people who go to the hospital may have different signs and symptoms.<sup>34,35</sup> However, alternative approaches to VA are increasingly being tested in past 5 years.<sup>36</sup> The changes in coding of causes of death over the decades are also a limitation of the study. However, Matlab HDSS data give us an unusual opportunity to examine causes of deaths over a long period of time, and the problems with specific cause of death coding is reduced by using broad diagnostic categories, and having a trained medical assistant to classify causes of death across the years.

For classifying households into socioeconomic groups, the asset lists were slightly different in the three census years (1982, 1996 and 2005), but they included relevant asset

items (land ownership, house construction materials, household and agricultural asset items, water and sanitation, utilities) that were similar in all three census years. Principal Component Analysis (PCA) was used in each of these years to classify the households into a relative measure, i.e. asset quintiles, leading to assignment of households into five levels of relative wealth at each period in time.

Socioeconomic differences in chronic disease outcomes have also been observed at an aggregate level (country level) by comparing the health and economic outcomes between developing and developed countries. Abegunde *et al.*<sup>9</sup> estimated the disease burden and loss of economic output associated with chronic diseases in 23 selected countries, accounting for approximately 80% of the total burden of chronic disease mortality in developing countries. In comparison with high-income countries, mortality rates among males and females in low- and middle-income countries were 54% and 86% higher, respectively. One study in India on the relationship between socioeconomic status and cardiovascular disease (CVD) showed that CVD-related mortality rate was higher in people with lower socioeconomic status, but the proportion of deaths from CVD-related disease were greatest among higher socioeconomic groups.<sup>20</sup> Stringhini *et al.* estimated that people in the lowest socioeconomic group were at 1.95 times higher risk of CVD-related mortality than the people in the high socioeconomic groups.<sup>3</sup> Findings of these studies are consistent with this study. Unlike other studies, our findings additionally suggest that by this time, chronic diseases may have already had significant effects on moving people into poverty or keeping them in poverty, which are additional economic effects that would not be captured in a cross-sectional analysis of economic burden due to chronic diseases. Nonetheless, it can be argued that people in rural Bangladesh have limited access to health care for chronic diseases, which may cause greater mortality and household economic deterioration.

It has been observed that most of the studies on socioeconomic variation in chronic diseases considered very few conditions in their investigations, for example cardiovascular disease.<sup>19,20</sup> The current study, on the other hand, has considered a wide range of chronic diseases (cancer, diabetes, chronic obstructive pulmonary disease, stroke, heart disease, hypertension and others) in the analysis, and has been able to track changes over time. Whereas the socioeconomic gradient in NCD has been observed in many cross-sectional studies, only a few have examined interventions. For example, a study in China investigated the role of health insurance as a financial coping mechanism for addressing catastrophic health expenditure (CHE) due to stroke, and found that the uninsured workers are seven times more likely to face CHE than their insured

fellow-workers.<sup>37</sup> To protect against CHE and poverty, health insurance is potentially useful, though the financial viability of insurance schemes for NCD still require further investigation.

NCDs have been recognized as a major health problem in Bangladesh, and much progress has been made in policy development. However, implementation has been delayed for several reasons, including lack of clear lines of responsibility for NCDs, the absence of dedicated financing and competitive priorities.<sup>38</sup>

In conclusion, chronic disease mortality in Bangladesh is growing as a proportion of all deaths, and is increasingly concentrated among the poor. Chronic disease mortality has an exacerbating effect on household poverty, as the death of household members due to chronic disease deteriorates the socioeconomic status of the households and frequently drags more households into poverty. National strategies for poverty alleviation should consider placing chronic disease mortality reduction as a priority, beginning with low-cost health promotion and preventive interventions. More affordable treatment for chronic diseases should be made available in rural Bangladesh and other low- and middle-income countries.<sup>39</sup> In Bangladesh, and in other developing countries, such initiatives will require the scaling up of community-based programmes as well as increased involvement of governments in removing barriers to access.

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## Author contributions

J.A.M.K. contributed to conceptualizing the research idea and study design, literature search, variable selection from secondary data



sources, data analysis, data interpretation, writing, revising and finalizing the manuscript. A.J.T. contributed to conceptualizing the research idea and study design, variable selection from secondary data sources, data interpretation, writing and revising the manuscript. S.A. contributed to literature search, study design, variable selection from secondary data sources, data analysis, data interpretation and writing the manuscript. A.T.S. contributed to data analysis, data interpretation and writing the manuscript. N.A. contributed to data interpretation and writing and revising the manuscript. A.M. contributed to data interpretation and writing and revising the manuscript. T.P.K. contributed to data interpretation and writing and revising the manuscript. L.W.N. contributed to data interpretation and writing, revising and finalizing the manuscript. D.H.P. contributed to conceptualizing the research idea and study design, data analysis, data interpretation and writing, revising and finalizing the manuscript. All authors agree with manuscript results and conclusions.

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