An Ecohealth Perspective of Non-Communicable Diseases in Bangladesh: A Population-based Study of Risk Factors

by

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Abstract

The present study focused on food habits, lifestyle, residential location or place (from an ecosystem perspective) and their roles in human health, particularly in influencing non-communicable diseases in Bangladesh. Specifically, it investigated the patterns in hypertension and diabetes prevalence and their risk factors, from an Ecohealth (i.e., interdisciplinary) perspective. The three specific objectives of this study were to: (i) determine the prevalence of hypertension and diabetes among adult population in Bangladesh; (ii) examine the distribution of hypertension and diabetes by age, gender, socioeconomic status, and place of residence; and (iii) identify and analyze the relationship between hypertension as well as diabetes and their risk factors in the country. Secondary data, collected by an IDRC-sponsored project from participants residing in eight districts across Bangladesh, in various spectrums of urbanicity, including metropolitan areas, peri-urban areas (contiguous to the cities), semi-urban areas, and rural areas, were used. Both descriptive and inferential statistical techniques, applying a quantitative approach, were followed to analyze the data.

The results revealed that individuals from higher SES groups exhibited healthier dietary habits, such as consuming more fruits and vegetables. Age, Body Mass Index (BMI), tobacco consumption and fruit and vegetable intake significantly influenced the likelihood of hypertension, highlighting the need for targeted interventions and preventative measures. The findings indicated that 10.7% of the population aged 18 years and above had diabetes, and that aging was a significant determinant of diabetes among Bangladeshi adults. A greater proportion of the participants with diabetes were overweight and/or obese. Among other factors, a higher level of education, likely to be associated with sedentary-oriented occupation and lifestyle, was found to be a significant risk factor for increased odds of diabetes. In addition, an ascending gradient of diabetes from rural to *Upazila* headquarters (semi-urban) to peri-urban and urban areas was seen. It is recommended that health policies in the country should establish standards and protocols for NCD services at all levels of healthcare. A consideration of the importance of NCD-related public education

campaign regarding the ill-effects of urbanism is needed in national policy formulation -- which would help to attain Bangladesh's commitment to the 2030 UN Sustainable Development Goals.

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Dedication

This thesis is dedicated to my **grandparents**-the ones who shaped my heart. Your love continues to inspire me, and your presence is felt in every step I take.

"Rabbi ighfir li wa li-walidayya wa-irhamhuma kama rabbayani saghira"

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CHAPTER 1

Introduction

1.1 Background and context

The Ecohealth research strand emphasizes a holistic understanding of health beyond limiting to the purely biomedical approach. Ecohealth-oriented research explores the relationships between various ecosystem components to define and value the priority determinants of health and human well-being [1,2]. It advocates a “systems thinking” to achieve a greater understanding of health problems and includes inter- and trans-disciplinary research and collaborative participation. Areas already well developed in Ecohealth, such as the relationships between health and ecosystems or between health and sustainable development, have been growing in importance [3,4]. Population growth and migration, environmental change and transformation of landscapes, and globalization of trade and economies have changed the kinds of health challenges faced by populations around the world. An ecosystem approach recognizes that health and well-being are the result of complex and dynamic interactions between determinants, and between people, social and economic conditions, and ecosystems. The conditions of ecosystems are also affected by a dynamic process of interactions, often determined by the social and economic activities of people [4].

Additionally, an ecosystem approach to health explicitly addresses unequal and unfair conditions impinging on the health and well-being of women and other disadvantaged

groups in society [2]. The differences between members of different social, economic, class, age, or gender groups in all societies are reflected in their relationships with ecosystems, their exposure to different health risks, their health status, and their well-being goals [4]. In implementing this principle, the literature not only documents social and gender differences in causal pathways, outcomes, and proposed interventions and actions, but it also takes on ethical dimensions by becoming oriented toward reducing inequities [1–4]. An overly emphasis on economic growth and improving standard of living conditions with inadequate attention to the environment and social inequities can risk health and become unsustainable over time. Similarly, ignoring the drivers of environmental and social conditions when trying to improve health can be ineffective [4]. Ecosystem approaches to health contribute to an evidence-based tool to better inform communities and decision makers, and to foster conditions for improved sustainability and health. One important underpinning of the Ecosystem approach is the recognition of the importance of place (in the social-ecological systems sense) in influencing disease occurrence [1,5] .

The epidemiological transition that occurred during the 20th century in the developing world has led to the evolution of non-communicable diseases (NCDs) that are mostly incurable. These include illnesses like cardiovascular diseases, diabetes, obesity, cancer and pulmonary and mental disorders. These diseases are equally persistent and cause high risk factors as well as the resulting human health consequences that have burdened healthcare systems. Worldwide, NCDs kill 41 million people each year [6]. Current projections estimate that, by 2030, the global average age-standardized NCD mortality rate would be 510.54 per 100,000 population and the global average mortality for NCD deaths of

the total number of deaths would be 75.26% [7]. NCDs are a kind of “rich and noble diseases” in people’s conventional perception. On one hand, wealthier nations, indeed, wealthier people in all nations, face a growing burden of diseases of affluent and sedentary lifestyles: cardiovascular disease, diabetes, cancer, and obesity [5]. This impact has been attracting more attention in countries and regions with rapidly growing economies and an ageing population, and they are also a matter of significant concern internationally [7] . On the other hand, low-and-middle income countries (LMICs) are burdened with NCDs that are associated with poor diets, environmental conditions, and unhealthy lifestyles. A 2022 WHO [8] report depicts that the burden of NCDs is coupled with that of infectious diseases, known as “double burdened”, in LMICs as they still struggle to overcome infectious diseases like TB and HIV/AIDS.

The convergence of infectious diseases with NCDs is also a significant cause for concern as this can occur not only in the same communities or states, but also the same individual may be affected by both. This means that the burden of disease is double and the developing economies in the LMICs, with their weak healthcare systems, struggle to keep up. In a WHO [8] report, it was highlighted that, in most LMICs, the data gap in diseases and health seeking behavior has worsened during the post COVID period. As the spread of communicable diseases was generally brought under control by the early 1990s, it was assumed that medical care costs would plateau or even fall in the coming years. However, with technological advancements and a fast-ageing population, the costs and burden relating to NCDs proved otherwise. In addition, the prevalence of NCDs is higher in LMICs, like Bangladesh, where the outcomes are also a threat to their economic sustainability. In

the same WHO [8] report, it was cited that in most LMICs the data gap in diseases and health seeking behavior has worsened during the post COVID period.

In epidemiology, prevalence and proportion are both fundamental measures used to describe disease occurrence, but they differ in their definitions, applications, and interpretations.

a). Definition and Calculation

Prevalence refers to the proportion of individuals in a population who have a specific disease or condition at a given time. It is calculated as:

$$\text{Prevalence} = \frac{\text{number of existing cases}}{\text{total population at risk}}$$

Prevalence can be expressed as point prevalence (at a specific time) or period prevalence (over a defined time period) [9–11].

Proportion, on the other hand, is a general mathematical as well as epidemiological measure that compares a part to the whole. It is a ratio where the numerator is included in the denominator. In epidemiology, proportions are used to describe the magnitude of a health problem within a population, such as the proportion of deaths due to a specific disease among all deaths [9,12].

b). Key Differences

Feature	Prevalence	Proportion
Definition	Measures the frequency of a disease in a population at a specific time	Compares a subset of a population to the whole
Numerator	Number of individuals with the disease	Number of individuals with a specific characteristic
Denominator	Total population at risk	Total population or another relevant group
Application	Used to assess disease burden and healthcare planning	Used to compare disease magnitude across different groups
Time Component	Can be point or period prevalence	Typically, does not include a time component

c). Epidemiological Applications

- Prevalence is widely used in chronic disease epidemiology, as it helps in understanding the burden of diseases like hypertension and diabetes in a population. It is crucial for healthcare resource allocation and policy formulation.
- Proportion is often used in mortality studies, risk factor analysis, and comparative epidemiology, where researchers examine the proportion of cases within different demographic groups to identify disparities in disease occurrence [9,12].

Throughout this thesis, with a broader perspective, the term 'prevalence' is used with both connotations, considering the appropriateness to the context.

Common, preventable risk factors underly most NCDs. Most of these diseases are the result of four behaviors: tobacco use, physical inactivity, unhealthy diet, and the harmful use

of alcohol. These commonly lead to four key metabolic/physiological changes: raised blood pressure, raised blood glucose, overweight/obesity, and raised cholesterol. NCDs result in "premature" deaths, as a person often dies before reaching the average age of 70 years. According to WHO's Global Health Estimates, the deaths from diabetes and cardiovascular diseases increased steadily during 2020-21 [13]. The alarming increase in premature deaths from NCD's threatens the progress of the 2030 Agenda for Sustainable Development Goals (SDGs), which includes a target of reducing premature deaths from NCDs by one third by 2030 [14].

Today's human health and environmental challenges are interlinked and symptomatic of many problems facing the world [4]. As noted above, place of residence or residential location is an important determinant for an individual's health. NCDs are distributed along social lines. When combined with non-modifiable risk factors for NCDs (age, race, gender, ethnicity), the influence of place and area of residence on health increases. Often this influence is perhaps the most important determinant for healthcare and is termed as "area level deprivation in health care" [15]. Individuals in socially deprived areas (urban-rural or geographical) are mostly at a higher risk of NCDs such as hypertension, obesity, and various types of environmentally associated cancers [16]. Rural and urban living can determine health through a range of environmental, social, and cultural factors. Even in rural settings, living in areas with more urban attributes is associated with an increase in unhealthy behaviors, including low fruit and vegetable consumption, reduced physical activity, and having higher Body Mass Index (BMI)[16–23]. The concept of "urbanicity" is relevant in this context. While urbanization refers to an increase in city size, density and heterogeneity,

"urbanicity" points to the effects of living in urban areas at a particular time [23]. Urbanicity captures urban features such as reduction in agricultural occupations, access to more services, and longer time spent in education.

Bangladesh is an LMIC in South Asia that is home to over 170 million people. Research focusing on NCDs in Bangladesh is important, as the country is undergoing an "epidemiological transition" wherein degenerative diseases such as hypertension, diabetes, and obesity are rapidly displacing infectious diseases as the major cause of death [6,7,11,21,26,27]. With varying rates and pace, several studies have found that the prevalence of both hypertension and diabetes has followed an ascending trend over time. A national STEPS survey from 2018 found that 21% of the population was hypertensive, 26% were overweight and 5% had diabetes [30]. Similarly, a WHO-sponsored study in 2016 had reported the prevalence of diabetes and hypertension among Bangladeshi adults at 8% and 26.4%, respectively [28]. A national survey data comprising of a targeted population of around 9,900 Bangladeshi adults were analyzed by Riaz et al.[30] and they revealed that only 3% of the population had no risk factors associated with diabetes and hypertension whereas over 70% of the population had faced one or more risk factors.

Some notable studies further cited the noticeable rate of prevalence of hypertension in the country. For example, Islam and Majumder study [31] estimated that approximately 20% of adults and 40–65% of elderly people were suffering from hypertension, mainly as a result of metabolic syndromes and lifestyle and behavioral factors, such as obesity, high salt intake, and less physical activity. Fottrell et al. [26] noted that research estimates of hypertension prevalence ranged from 11% to 40%, with higher frequencies generally being

observed in urban locations, among the elderly cohorts, among higher socioeconomic strata, and alongside individual comorbidities, such as diabetes.

An analysis of data from the BDHS by Akter et al. [32] revealed an increase in the prevalence of diabetes across age groups, but no significant differences in diabetes rates or impaired fasting glucose levels between males and females. However, significant differences in diabetes rates were observed between the poorest (6.4%) and richest households (19.2%), although these differences were much lower for impaired fasting glucose levels (19.7% and 23.5%, respectively). Perhaps most alarmingly, several studies have documented a threefold to fourfold increase in diabetes rates in Bangladesh between 1992 and 2015 [29]. Rahman et al. [29] projected prevalence of diabetes to reach 23.6% in men and 33.5% in women by 2030 [33]. These projected levels are two times higher than the WHO's 2022 age-standardized global prevalence estimate of 14.1% (12.9-15.5) for adults [34].

Bangladesh is currently undergoing rapid economic growth and consequential urbanization [35]. The proportion of urban population rose from 19.8% in 1990 to 40.5% in 2023 [36]. Currently, about 39% people are living in urban areas of Bangladesh; this was only 10% in 1975 [14]. Urbanization in this country has led to changes in population dynamics, alteration of rural forms with pre-selected urban patterns and lifestyles [37] and disease patterns [38,39]. Alongside socio-economic development, the food demand and consumption patterns have also undergone rapid change across both rural and urban areas. Several recent studies have revealed that not only is this change evident in urban and peri-

urban areas of the country but also among the rural populations where mass-media and infrastructure development have led to changing diets and lifestyles [17,20,40–43].

Numerous studies focusing on Bangladesh have identified socioeconomic status and inequalities in the distribution of wealth as close associates of hypertension, diabetes and obesity and their risk factors. For instance, Biswas et al. [29] found that NCDs more significantly affected low-wealth quintile populations in rural areas and wealthier populations in urban areas. However, several other studies have shown a positive relationship between higher levels of wealth and educational attainment and the likelihood of developing hypertension and diabetes [44,45]. As people attain higher education and better jobs, especially white-collar jobs, they often live in urban areas and belong to the "upper" wealth category. These better living conditions are accompanied by an intake of high-calorie food [46], less likely to engage in physical labor and tendency to be overweight and obese [44]. Hence, these urban residents are more at risk of hypertension and diabetes. Similarly, Rahman et al. [28] found that people in lower socioeconomic strata with co-morbid diabetes and hypertension are less likely to be diagnosed, receive treatment, or take measures to control their blood pressure.

Overall, in the existing literature, being variable, the effects of place of residence, reflecting the degree of urbanism (urban, peri-urban and rural), on the occurrence of NCDs are poorly studied and understood; as well as they remain inconclusive. Residential characteristics profoundly affect the lifestyle choices and options and is thus an important risk factor that require urgent research attention in the Bangladesh context. Understanding these relationships, with a focus on investigating the determinants for the rising prevalence

of diabetes and hypertension in communities across Bangladesh -- as they are undergoing modernization and urbanicity -- is critically important. A comprehension of the dynamics of these determinants would help develop targeted interventions to manage and prevent diabetes and hypertension more effectively.

1.2 Purpose and Objectives

This study was undertaken in recognition that an understanding of the patterns and trends in hypertension and diabetes prevalence and their risk factors, from an Ecohealth (i.e., interdisciplinary) perspective, is crucial to formulating appropriate interventions aimed at prevention and control of non-communicable diseases (NCDs). It also aimed at improving our understanding of the differences in the distributions of NCDs caused by varied magnitude of urbanicity. The three specific objectives of this study are to:

I. determine the prevalence of hypertension and diabetes among adult population in Bangladesh;
II. examine the distribution of hypertension and diabetes by age, gender, socioeconomic status, and place of residence; and
III. identify and analyze the relationship between hypertension as well as diabetes and their risk factors in the country.

Four research questions were formulated to pursue the above-mentioned objectives:

1. What are the patterns in the distribution of hypertension by age, gender and socio-economic status among the rural population?

2. What are the characteristics of the relationship between hypertension and its risk factors among the rural population?
3. What sociodemographic and socioeconomic variables are associated with the varying prevalence of diabetes when other variables are adjusted?
4. Whether and how the prevalence of diabetes is associated with varied magnitudes of urbanicity (i.e. urban, peri-urban, *Upazila* HQ and rural residential locations), when other variables are adjusted.

1.3 Methodological Approaches

At the outset, it is important to highlight that my thesis research used selected secondary data from an International Development Research Centre (IDRC)-funded international collaborative project in Bangladesh. The IDRC sponsored *Reducing Dietary Risks Associated with Non-Communicable Diseases* (RDRNCD) project was aimed at enhancing capacity in understanding and contributing to the promotion of coordinated actions of NCD related policies and practices across sectors. This was targeted to effectively promote a balanced diet and vegetable consumption alongside associated benefits across multiple stakeholders (e.g., consumers, producers, healthcare systems) and reduce dietary related risks associated with NCD's in Bangladesh [47]. This research project involved collaboration between specialists, communities, NGO, media, key policymakers and other stakeholders.

A quantitative approach using the most appropriate statistical models was used for analyzing the obtained data as per the objectives of my study [48]. The following sections

describe briefly the overall study design, strategies of inquiry, sampling procedure, and how the field datasets were generated.

I completed the required course on Research Ethics based on the Tri-Council Policy Statement in March 2023 and obtained the CORE Certificate (See Appendix A). The research and data collection protocols were approved by the Joint Faculty Research Ethics Board at the University of Manitoba, Canada [Protocol Numbers: J2019:068 (HS 23008 and HE2023-0279)] (see Appendix B).

1.3.1 Study Area and Population

Bangladesh is made up of eight administrative divisions, which are the largest units in the country. Each division is divided into several districts (*Zilas*) and sub-districts (*Upazilas*), which are in turn made up of several *Unions*. These *Unions* are the smallest geographic and administrative areas with defined boundaries. Urban areas are sub-divided into Wards, which are similar to *Unions* in terms of scale. Therefore, unions comprised the primary sampling units (PSUs) for rural areas and wards were selected as the PSUs for the urban and peri-urban areas. Upazila headquarters were selected for semi-urban areas.

The RDRNCD Project targeted the population in Bangladesh residing in all geographic areas. The surveys conducted in the study areas included participants aged 18 years and over. The research objectives and distribution of samples for my study are listed in Table 1.1. For objective 1 and 2, 149 villages were randomly selected from sampling units consisting of 16 *Upazilas* in eight districts, representing all major agroclimatic regions of Bangladesh:

Moulvibazar, Sunamganj, Sherpur, Jamalpur, Munshiganj, Pabna, Satkhira, and Khulna. This sample represented 12% of the rural population across Bangladesh's 64 districts.

For the research questions 3 and 4, the study population included male and female permanent residents of a metropolitan city, a peri-urban *Upazila*, three *Upazila* headquarters (i.e., denoted as semi-urban) and eights rural *Upazilas* from four districts. The urban and peri-urban participants were chosen from the metropolitan city of Dhaka South (Ward 1 and Ward 42) and Keraniganj *Upazila* (Keraniganj District), Ward 1 and Ward 2) respectively. The semi-urban (*Upazila* headquarters) participants were from Sylhet Sadar *Upazila* (Sylhet district), Bakshiganj *Upazila* (Jamalpur district), and Shymnagar *Upazila* (Satkhira district). The rural participants were selected from the villages of Sunamganj, Jamalpur, Munshiganj and Satkhira districts.

Table 1.1 : Data collection objectives and distribution

Research Question	Method	District	Sample Size (households)
1. What are the patterns in the distribution of hypertension by age, gender and socio-economic status among the rural population? 2. What are the characteristics of the relationship between hypertension and its risk factors among the rural population?	Household survey	Moulvibazar Sunamganj Sherpur Jamalpur Pabna Khulna Satkhira Munshiganj	Rural: 7384

3. What sociodemographic and socioeconomic variables are associated with varying prevalence of diabetes, when other variables are adjusted? 4. Whether and how the prevalence of diabetes is associated with varied magnitudes of urbanicity (i.e. urban, peri-urban, *Upazila* HQ and rural residential locations), when other variables are adjusted.	Household survey	**Rural-** Sunamganj, Jamalpur, Munshiganj & Satkhira ***Upazila* HQ -**Sylhet, Jamalpur, Satkhira **Peri-urban & Urban-** Dhaka & Keraniganj	Rural: 1562 *Upazila* HQ: 532 Peri-urban: 482 Urban: 445

1.3.2 Data Collection Methods

A detailed description of the approaches, sampling and data collection methods, along with the field procedures of the IDRC-sponsored RDRNCD Project has been provided by Shahidullah et al. [49]; it can be consulted for further clarifications. In the RDRNCD project, the sampling unit was the households. Households in this survey were defined according to Bangladesh Bureau of Statistics (BBS) as "a dwelling in which persons either related or unrelated living together and taking food from the same kitchen" [39]. The respondent was the household head, adult male or female member of the household. The project research team designed the questionnaires and tools for survey based on the project objectives (Appendix C). While designing the questionnaires, the intention was not only to procure objective-oriented data, but also to collect information to address largely overlooked aspects of existing NCD related knowledge. It identified knowledge gaps and addressed them in the questionnaire.

The survey process consisted of two components: (i) data collection using a semi-structured questionnaire, and (ii) a physical examination (conducted with participant consent). The questionnaires, which were translated into Bangla and validated, were administered via direct interviews, while the standardized physical examinations measured height, weight, blood pressure, and blood sugar/glucose. The equipment used in the examinations included measuring tapes, digital scales, blood pressure monitors, stethoscopes, and glucometers. Field organizers and Information Technology personnel from Bangladesh's Centre for Natural Resource Studies (CNRS) provided necessary technical support and troubleshooting throughout our fieldwork. The questionnaire consisted of multiple modules, with the preliminary questionnaire being modified to incorporate additional questions based on pre-testing in communities outside the study areas. Data collection took place between July and November of 2017 via semi-structured interviews with the household heads (HHs) and their spouses in each PSU.

1.3.3 Data Analysis

A data repository of the survey data that was collected for the RDRNCD project, as described above, was used for the statistical analysis. To analyze the survey data, I performed several statistical steps, including data cleaning, data validation, data coding, data exploration, and finally data analysis. SAS 9.4 (SAS Institute Inc., Cary, NC, USA) was used for all statistical analyses.

To investigate the risk factors associated with hypertension for Research Questions 1 and 2, the prevalence of hypertension and its relationship with different age groups, genders, and wealth quintile was calculated. A chi-square test was then performed to assess any

statistically significant relationships. Finally, we conducted a multivariable logistic regression with a stepwise selection method to determine how these risk factors, independently and collectively, influenced the prevalence of hypertension.

For Research Questions 3 and 4, the association between participant sociodemographic characteristics, lifestyle, and the prevalence of self-reported diabetes was calculated. A chi-square test was then employed to assess any statistically significant relationships. Finally, the multivariable logistic regression technique with stepwise selection was used to assess how the risk factors, both independently and collectively, influenced diabetes prevalence.

The odds ratio was used to quantify the strength of association between two categorical variables, with a p-value <0.05 being considered statistically significant throughout the analyses.

1.4 Organization of the Thesis

A "sandwich", or grouped, manuscript style was adopted in preparing this thesis. The thesis comprises of four chapters. Chapter One serves as the introduction, by laying out the context and background, purpose and objectives of the study, methodological approaches and procedures of data collection and data analysis. The thesis consists of two journal manuscripts (Chapters Two and Three) that were prepared according to the specific objectives of the thesis. The style of these two chapters has been tailored according to the guidelines of the intended journal. Manuscript One (Chapter Two) has been submitted as a manuscript titled "*Prevalence and risk factors of hypertension in rural Bangladesh: A*

population-based cross-sectional study" to PLOS ONE and is currently under review. This chapter focuses on hypertension and its associated risk factors in the rural population of Bangladesh. Manuscript Two (Chapter Three) has also been submitted as a manuscript, titled "*Sociodemographic and socioeconomic factors, and urbanicity associated with the prevalence of diabetes among the adult population of Bangladesh*", to the *International Health* journal for publication. This chapter investigates the effects of urbanicity across different administrative regions in Bangladesh on the prevalence of diabetes. Chapter Four offers a detailed discussion and draws conclusions about the overall research, along with directions for future research.

It is worth noting that there are overlaps in the methodological sections of Chapters One and Three, as the data collection tools and analysis processes were the same.

1.5 Contribution of Authors

I am the sole author for Chapters One and Four. I wrote both these chapters under the supervision and guidance of Dr. C. Emdad Haque, Professor, Natural Resources Institute, University of Manitoba.

Chapters Two and Three were developed as manuscripts for publication, with both co-authored under my lead authorship. The contributions of the co-authors are outlined below:

- *Dr. C. Emdad Haque* provided critical feedback and assisted with manuscript writing for both chapters. He also reviewed the results and supported the integration of relevant literature into the introduction and discussion sections.

- *Dr. Shakhawat Hossain,* Professor, Department of Mathematics and Statistics, University of Winnipeg, and Adjunct Professor, Natural Resources Institute, University of Manitoba, contributed to data coding, management, and analysis. He reviewed the results sections of both manuscripts and provided constructive input on the analysis and data interpretation in the discussion.

- *Dr. Gias Uddin Ahsan,* Professor, Department of Public Health, Daffodils International University, Dhaka, Bangladesh, and Adjunct Professor, Natural Resources Institute, University of Manitoba, reviewed both manuscripts and offered insights into the epidemiological interpretation and categorization of findings.

- *Dr. Alan Katz,* Professor, Max Rady College of Medicine, University of Manitoba, reviewed Chapter Two and provided feedback on data interpretation and adherence to categorization guidelines.

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CHAPTER 2

Prevalence and risk factors of hypertension in rural Bangladesh: A population-based cross-sectional study

Abstract

Non-communicable diseases (NCDs), such as hypertension, are amongst the most fatal conditions afflicting people living in low- and middle-income countries (LMIC), including Bangladesh. This study addresses the lack of population-based studies focusing on rural Bangladesh by investigating the prevalence and distribution patterns of hypertension and its associated risk factors. To this end, we surveyed adults aged ≥18 years (i.e., household heads and their spouses) from 7384 households across 149 villages in rural Bangladesh using a semi-structured questionnaire to collect data relating to blood pressure, anthropometric, socioeconomic, lifestyle, and behavioral risk factors. Multivariable logistic regression analyses identified age, gender, and socioeconomic status as potential predictors of hypertension. The findings also showed that men and women from higher socioeconomic status (SES) groups had higher rates of overweight and obesity, risk factors for the development of hypertension (4.29% and 1.4% in men; 5.8% and 2.29% in women), as well as higher rates of fruit and vegetable consumption (10.29% and 7.25% in men; 9.95% and 6.84% in women). A significant association between tobacco consumption and age was observed for women (p=<0.0001), while higher levels of physical activity were found among men aged 45-54 years [OR:1.9, CI 95% (1.1-3.1)]. Furthermore, women from the highest SES brackets were 1.3 times more likely to engage in “moderate” physical activity compared to women from the lowest brackets. Age and overweight/obesity were found to be the strongest risk factors for hypertension in both genders, while education was not found to be significantly associated with hypertension in women. Notably, the findings revealed that 33.7% of men and 28.6% of women had elevated blood pressure, qualifying them as either prehypertensive or hypertensive. As such, we recommend that policy interventions aimed at

stemming the growth of hypertension among Bangladesh's rural populations should take gender-specific risk factors and socioeconomic context into serious policy consideration.

2.1 Introduction

Non-communicable diseases (NCDs) kill 41 million people each year [1], accounting for a staggering 74% of deaths worldwide [2]. Notably, NCDs are a leading cause of premature death, with the associated human health consequences placing tremendous strain on healthcare systems. In addition, the higher prevalence of NCDs in low- and middle-income countries (LMIC) [3,4], particularly their outcomes, pose a threat with respect to economic sustainability [5]. The majority of NCDs in LMICs are correlated with poor diets, environmental conditions, and unhealthy lifestyles. In LMICs, many adults, especially those from rural areas or lower socioeconomic status (SES) backgrounds, are likely to have experienced early-life nutritional stress. This pattern prevailed until recent improvements in food systems, including food distribution, stabilized grain markets, and other measures to mitigate famine risk [6]. Such early nutritional stress may have lasting effects and increase the risk of chronic disease later in life, particularly when individuals are exposed to obesogenic and diabetogenic diets. Nevertheless, the relationship between SES and health outcomes in LMICs is complex. While higher-income countries often associate obesity and hypertension with lower SES, data from LMICs suggest the opposite [3,4,7]; that is, in LMICs, people become more prone to NCDs as their SES improves. Typically, most NCDs in these countries are associated with common preventable risk factors related to four main behavioral variables: tobacco use, physical inactivity, unhealthy diet, and excessive alcohol

use [8-13]. These behavioral risk factors commonly result in four key metabolic/physiological changes: raised blood pressure (hypertension); overweight/obesity; raised blood glucose (diabetes); and raised cholesterol.

Bangladesh is an LMIC in South Asia that is home to over 170 million people. Research focusing on NCDs in Bangladesh is important, as the country is undergoing an "epidemiological transition" wherein degenerative diseases such as hypertension, diabetes, and obesity are rapidly displacing infectious diseases as the major cause of death [8,9,12,14-16]. Hypertension is one of the leading causes of death in the Bangladesh [5], with many such deaths being premature [8,9]. To compound the problem, the prevalence of hypertension in Bangladesh is projected to grow from 26% in 2000 to 29% in 2025 [17]. Additionally, hypertension and diabetes share a complex interconnection, with both being high-risk factors for heart disease [8,10,11]; as such, Bangladesh has a higher comorbidity of diabetes-hypertension compared to other LMICs [8,10,14] and, by extension, greater risk for heart disease. Recent studies have confirmed that the prevalence of hypertension in Bangladesh is on the rise among adults aged 35 years and older [11,18,20], while others have identified an increase in risk factors, such as lifestyle and behavioral factors (e.g., obesity, diet, and physical activity levels), among both men and women [8,10,18,21-24]. Indeed, findings have revealed a significant association between obesity/overweight and hypertension [8,21,25,26] and have identified physical activity as an important risk factor [8,9,10,12] for hypertension. Several studies have also demonstrated that socioeconomic status and inequalities in wealth distribution pose significant risk factors for

prehypertension and hypertension [8-10,12,14,27], and that the associated risk factors vary based on place of residence, educational attainment, occupational level, and tobacco use.

The most recent STEPwise Surveillance for NCD risk factors (STEPS) survey (2018) and two nationally representative datasets, namely, the Bangladesh Demographic and Health Survey (BDHS) 2011 and 2017–18, have highlighted the growing prevalence of NCDs and various risk factors [11,28]. However, the literature on these subjects possesses an urban bias, with very little research examining Bangladesh's rural population. Furthermore, existing studies typically do not consider the larger population, and are instead targeted towards a specific area, age group, or gender [22,25,27-30]. Moreover, studies examining and comparing the association between certain risk factors for hypertension are also rare. While precisely measuring hypertension and its risk factors in the general population is a challenge, access to such data is critically important, as it would help researchers and policy makers understand rates and patterns of hypertension, and thus, how to formulate effective policy interventions.

Bangladesh has high rates of diabetes-hypertension comorbidity that are associated with risk factors such as dietary habits and lifestyle. Considering that hypertension is one of the most important NCDs in Bangladesh, this study investigates its distribution patterns among rural populations, with a particular focus on physical, behavioral, and dietary risk factors. This research aims to achieve two specific objectives: i) to identify and analyze the physical, behavioral, and dietary risk factors associated with prehypertension and hypertension among adult males and females in rural Bangladesh, and ii) to determine the

magnitude of the effects of the identified risk factors upon prehypertension and hypertension among this cohort.

2.2 Methods

2.2.1 Data sources, study population, and survey design

Using a multi-stage sampling method, 149 villages were randomly selected from sampling units consisting of 16 *Upazilas* (sub-districts) in eight districts, representing all major agroclimatic regions of Bangladesh: Moulvibazar, Sunamganj, Sherpur, Jamalpur, Munshiganj, Pabna, Satkhira, and Khulna. This sample represented 12% of the rural population across Bangladesh's 64 districts, with the household being taken as the *Primary Sampling Unit* (PSU). The following formula was used to calculate the optimal sample size (n) for the study:

$$n = \text{Design Effect} \times \frac{Z_{1-\frac{\alpha}{2}}^2 \; p\, q}{\delta^2} \qquad (1)$$

where $Z_{1-\frac{\alpha}{2}}$ is the $1-\frac{\alpha}{2}$ quantile of standard normal distribution, δ is the margin of error, and p represents the proportion of the target indicator, $q = 1 - p$.

To ensure a confidence level of 95%, it was assumed that $\alpha = 0.05,\ Z_{1-\frac{\alpha}{2}} = 1.96,$ and the margin of error was 5% (i.e., $\delta = 0.05$). Finally, the design effect was set as 1, as the simple random sampling method was applied to select households within the village.

Since the value of p was unknown, it was assumed that p=0.5 would yield a maximum number of samples appropriate for measuring multiple indicators. Ultimately, a sample size

of $n = 384$ for each sampling unit (i.e., rural *Upazila*) was deemed necessary to achieve a confidence interval of 95%. The rural areas consisted of 384 PSUs x 16 Upazilas, yielding a total required sample size of 6144 PSUs. This sample was then extrapolated to 7000 to obtain better coverage. Finally, a control group of 384 PSUs was added via probability proportionate sampling based on the population sizes of 149 villages, bringing the final sample to 7,384 households (PSUs). Data collection took place between July and November of 2017 via semi-structured interviews with the household heads (HHs) and their spouses in each PSU.

The survey process consisted of two components: (i) data collection using a semi-structured questionnaire, and (ii) a physical examination (conducted with participant consent). The questionnaires, which were translated into Bangla and validated, were administered via direct interviews, while the standardized physical examinations measured height, weight, blood pressure, and blood sugar/glucose. The equipment used in the examinations included measuring tapes, digital scales, blood pressure monitors, stethoscopes, and glucometers. Field organizers and Information Technology personnel from Bangladesh's Centre for Natural Resource Studies (CNRS) provided necessary technical support and troubleshooting throughout our fieldwork. The questionnaire consisted of multiple modules, with the preliminary questionnaire being modified to incorporate additional questions based on pre-testing in communities outside the study areas.

2.2.2 Outcome variable

Hypertension served as the primary outcome variable. Blood pressure was measured using standard aneroid sphygmomanometers, which was placed on the participant's right arm (which was supported) for at least 5 minutes while resting in a seated position. Korotkoff phase V was used to determine diastolic blood pressure, with systolic and diastolic measurements being recorded in mmHg. Prehypertension was defined as systolic blood pressure of ≥120 mmHg and <140 mmHg or diastolic blood pressure of ≥80 mmHg and <90 mmHg. Hypertension was defined as systolic blood pressure ≥140 mmHg or diastolic blood pressure ≥90 mmHg [8,10,12,14,31].

2.2.3 Independent variables

Principal component analysis (PCA) was conducted to identify the key household assets related to wealth from a list of 38 assets. These assets included: house and land ownership; fruits and vegetables produced and sold; number of rooms in one's house; wall materials; water sources; sanitation infrastructure; electricity supply; and ownership of household assets, such as refrigerators, televisions, sewing machines, bicycles, or motorcycles. The results of the PCA were then used to calculate a "wealth quintile" score for each household, and the households were placed in one of five socio-economic quintiles based on their score: "most poor," "least poor," "lower-middle," "higher-middle," and "rich."

The independent variables were selected based on the existing literature on risk factors for hypertension in LMICs and Bangladesh. The following independent variables were selected: place of residence (rural); wealth status (as defined above); age of participants (18-34, 35-44, 45-54, 55-64, ≥65); sex (male and female); level of education (no schooling vs.

formal education such as elementary, secondary (SSC, JSC), higher secondary and above (HSC and other degrees)); occupation (farming/fishing, day laborer/other labor, other service holders (village doctor, service, small business), unemployed and other non-wage earners (student, retired, unemployed, housewife)); and consumption of tobacco and related products.

Body mass index (BMI) was measured based on the WHO's definition of obesity for the Asian population [6]: underweight (BMI <18.5kg/m^2), normal weight (BMI 18.5-23.0 kg/m^2), overweight (BMI 23.0-27.5 kg/m^2), and obese (BMI ≥ 27.5kg/m^2). Physical activity was measured by asking respondents how much time (in minutes) they spent per day and per week engaging in moderate and/or vigorous activity. In addition, this portion of the survey probed activity related to work, leisure, transportation, and time spent sedentary. This data was then used to calculate the MET-minutes, which was performed using the following STEPS protocol [13]: (a) 1 minute in a sedentary position (sitting quietly) equals 1 MET-minute; (b) 1 minute engaging in moderate and transportation-related activities equals 4 MET-minutes; and (c) 1 minute engaged in vigorous activity equals 8 MET-minutes. Individuals' physical activity levels were then classified as either high (≥ 3000 MET-minutes), moderate (600-3000 MET-minutes), or low (≤ 600 MET-minutes) based on their total MET-minutes.

Adequate intake of fruits and vegetables was defined using the WHO's (2010) guidelines. In general, these guidelines define one standard serving of vegetables as 80 grams; one serving raw leafy green vegetables as one cup; one serving of cooked or chopped vegetables as one half cup; one serving of fruit (apple, banana, orange) as equaling one medium size

piece; one serving of chopped, cooked, or canned fruit as one half cup; and one serving of fruit juice as one half cup.

2.2.4 Statistical analyses

To investigate the risk factors associated with hypertension, we conducted a series of statistical analyses using SAS 9.4 (SAS Institute Inc., Cary, NC). First, we described the sociodemographic characteristics of the study population and the household characteristics of the respondents (Tables 1 and 2). Next, we calculated the prevalence of hypertension and examined its relationship with different age groups, genders, and wealth quintile (Table 3). A chi-square test was then employed to assess any statistically significant relationships. Finally, we conducted a multivariable logistic regression with a stepwise selection method to determine how these risk factors, independently and collectively, influenced the prevalence of hypertension (Table 2.4). The odds ratio was used to quantify the strength of association between two categorical variables, with a p-value <0.05 being considered statistically significant throughout the analysis.

2.2.5 Ethics statement

The research and data collection protocols were approved by the Joint Faculty Research Ethics Board at the University of Manitoba, Canada [Protocol Numbers: J2019:068 (HS 23008 and HE2023-0279)]. Data for the study were collected only after obtaining the explicit written and verbal consent (with appropriate witness) of all participants, following the University of Manitoba's ethics protocol. In addition, the procedures used in this study also adhere to the tenets of the Declaration of Helsinki. Prior to data collection and obtaining informed consent, participants were provided with information about the study's scope and

objectives and notified that they had the right to withdraw from the study at any time, for any reason. A debriefing session was also held with the respondents to share the preliminary results of this research.

2.3 Results

2.3.1 Sociodemographic characteristics

In total, 14,745 respondents from 7384 households were surveyed, with complete responses being received from 14,343 participants (97.3% response rate). Of these respondents, 49.6% (n=7,123) were male and 50.3% (n=7,220) were female. Table 2.1 presents the sociodemographic characteristics of the study population. The distribution of the sample revealed a potential age bias, as over 56% of respondents were aged 18-44 years compared to only 7.5% being aged 65 years or above. Furthermore, over 80% of the study population had received minimal to no education, with 42.7% having no formal education and 37.3% having only completed elementary or primary education (i.e., up to class 5). Only 3% of the population had attained higher secondary qualifications.

The study population's occupations were distributed almost evenly between economic sectors: farming and fishing, 15.7% (n=2252); day laboring, 17.6% (n=2525); and other services and small business ownership, 14.3% (n=2053). Most respondents, 52.3% (n=7513) were non-wage earners or housewives. In terms of marital status, 97.2% of the respondents were married; hence, 52.3% (n=7513) of the study population consisted of housewives who primarily were non-wage earners. Regarding SES, 39.9% of the population fell into the “poor”

category, while 39.9% were in the middle category. Within this "middle" category, 19.9% qualified as being "lower-middle" SES. The remaining 20.1% of the population was classified as "rich."

Table 2.2:Background characteristics of the respondents

Variables	(n)	(%)
AGE		
18-34	4263	29.72
35-44	3880	27.05
45-54	3174	22.13
55-64	1951	13.6
≥65	1075	7.49
SEX		
Male	7123	49.66
Female	7220	50.34
MARITAL STATUS		
Married	13954	97.29
Unmarried	44	0.31
Divorced/separated	71	0.49
Widowed	274	1.91
EDUCATION		
No schooling and formal education	6135	42.77
Elementary/primary (up to Grade 5)	5356	37.34
Secondary (6-10 grade)	2409	16.8
Higher secondary and above (Grade 11 and above)	443	3.09
OCCUPATION		
Farming and fishing	2252	15.7
Day labors and labors	2525	17.6
Other services	2053	14.31
Unemployed and other non-wage earners	7513	52.38
SOCIO-ECONOMIC STATUS (SES) INDEX (based on wealth quintile)		
Most poor	2630	20.07
Least poor	2604	19.88
Lower-middle	2607	19.9
Higher middle	2623	20.02
Rich	2637	20.13

The sociodemographic characteristics of the respondents by sex (male n=7123; female n = 7220), along with their corresponding household characteristics (n=7384), are presented

in Table 2.2. Regarding age, the females in the sample tended to be younger on average, with 40.1% belonging to the 18-34 age group (vs. 19.2% of males); in contrast, 49.7% of the males belonged to either the 35-44 or 45-54 age groups. There were no notable differences between sexes with respect to wealth quintiles, as the males and female respondents belonged to same households. However, significant differences existed in terms of occupation. Whereas 9.2% (n=657) of male household heads were unemployed, with 29.2% (n=264) being 65 years or above, 94.9% (n=6,856) of females were non-wage-earning housewives. The overwhelming majority of these housewives (96.5%; n=2799) fell into the 18-34 age category. In terms of education, 44.5% (n=3173) of male respondents and 41.0% (n=2962) of female respondents had no formal schooling, indicating low overall levels of literacy and education. Indeed, the majority of male (51.1%) and female (57.2%) respondents had only completed up to Grade 10 or less.

2.3.2 Risk factors

We explored numerous potential risk factors for hypertension, including respondent characteristics, household features, and behavioral factors. Table 2.3 provides an overview of these self-reported risk factors by sex, calculated wealth quintile, and age. Notably, male respondents exhibited higher levels of physical activity and lower rates of obesity and overweight. In contrast, female respondents had higher vegetable and fruit intake, with significantly higher rates of overweight being observed among women in the younger age groups (i.e., 34 years).

While overweight rates tended to increase alongside SES for both males and females, the odds of being overweight were similar for both the “most poor” and the “rich”

respondents across sexes. Interestingly, the prevalence of underweight and overweight/obesity decreased with age among female respondents. Conversely, the relationship between age and body mass index (BMI) was less consistent among male respondents. For males, the odds of being overweight or obese were 1.4 to 1.3 times higher (compared to normal weight) with increasing age. Notably, males aged 45-54 reported significantly higher physical activity levels (1.9 times) compared to those with low activity levels, while physical activity levels declined with increased age and SES among female participants. Among female participants, the 18-34 age group reported the highest activity levels. Furthermore, “rich” female participants were 1.3 times more likely to engage in moderate physical activity compared to those in the “most poor” category.

The strongest associations were observed in vegetable and fruit intake among age groups and wealth quintiles. As expected, higher SES correlated with greater vegetable (2.6 times for males; 2.5 times for females) and fruit (3.2 times for males; 3 times for females) consumption. Similarly, male and female respondents in the 45-54 age group were more likely to consume vegetables (1.4 times for males; 1.5 times for females) compared to those in the 18-34 group. Among female respondents, fruit intake remained significant across all age categories, particularly ages 45 and above (1.6-1.8 times vs. inadequate intake). Regarding tobacco consumption, older females consumed tobacco products at a higher rate (up to 2.5 times) compared to younger females (ages 18-34); however, SES was not significantly associated with tobacco consumption in either gender (Table 2.3).

Table 3.2: Household characteristics of respondents by age group and gender

Male Household Heads (n=7123)

		Age (years)					
		18-34	**35-44**	**45-54**	**55-64**	**65+**	**Total**
EDUCATION							
No schooling & formal education	n	390	746	827	691	519	3173
	(%)	(28.59)	(41.12)	(47.86)	(52.55)	(57.54)	(44.55)
Elementary/primary (up to Grade 5)	n	641	686	546	382	231	2486
	(%)	(46.99)	(37.82)	(31.60)	(29.05)	(25.61)	(34.90)
Secondary (Grade 6-10)	n	260	300	282	193	118	1153
	(%)	(19.06)	(16.54)	(16.32)	(14.68)	(13.08)	(16.19)
Higher secondary & above (Grade 11 and above)	n	73	82	73	49	34	311
	(%)	(5.35)	(4.52)	(4.22)	(3.73)	(3.77)	(4.37)
OCCUPATION							
Farming & fishing	n	291	471	554	550	352	2218
	(%)	(21.33)	(25.96)	(32.06)	(41.83)	(39.02)	(31.14)
Day labor & labor	n	614	664	569	320	157	2324
	(%)	(45.01)	(36.60)	(32.93)	(24.33)	(17.41)	(32.63)
Other services	n	368	592	510	325	129	1924
	(%)	(26.98)	(32.64)	(29.51)	(24.71)	(14.30)	(27.01)
Unemployed & other non-wage earners	n	91	87	95	120	264	657
	(%)	(6.67)	(4.80)	(5.50)	(9.13)	(29.27)	(9.22)
MARITAL STATUS							
Currently married	n	1304	1804	1720	1300	863	6991
	(%)	(95.60)	(99.45)	(99.54)	(98.86)	(95.68)	(98.15)
Total	n	1364	1814	1728	1315	902	7123
	(%)	(19.15)	(25.47)	(24.26)	(18.46)	(12.66)	(100)
WEALTH QUINTILES (SES Status)							
Most poor	n	291	348	298	211	156	1304
	(%)	(24.41)	(21.13)	(18.56)	(17.09)	(18.77)	(20.03)
Least poor	n	248	334	298	255	158	1293
	(%)	(20.81)	(20.28)	(18.56)	(20.65)	(19.01)	(19.86)
Lower-middle	n	229	313	315	265	169	1291
	(%)	(19.21)	(19.00)	(19.61)	(21.46)	(20.34)	(19.83)
Higher middle	n	213	327	352	235	173	1300
	(%)	(17.87)	(19.85)	(21.92)	(19.03)	(20.82)	(19.97)
Rich	n	211	325	343	269	175	1323
	(%)	(17.70)	(19.73)	(21.36)	(21.78)	(21.06)	(20.32)
Total	n	1192	1647	1606	1235	831	6511
	(%)	(18.31)	(25.30)	(24.67)	(18.97)	(12.76)	(100)

Female Spouses (n=7220)							
		Age (years)					
		18-34	**35-44**	**45-54**	**55-64**	**65+**	**Total**
EDUCATION							
No schooling & formal education	n	505	937	914	472	134	2962
	(%)	(17.42)	(45.35)	(63.21)	(74.21)	(77.46)	(41.02)
Elementary/primary (up to Grade 5)	n	1454	832	417	132	35	2870
	(%)	(50.16)	(40.27)	(28.84)	(20.75)	(20.23)	(39.75)
Secondary (Grade 6-10)	n	850	271	103	29	3	1256
	(%)	(29.32)	(13.12)	(7.12)	(4.56)	(1.73)	(17.40)
Higher secondary & above (Grade 11 and above)	n	90	26	12	3	1	132
	(%)	(3.10)	(1.26)	(0.83)	(0.47)	(0.58)	(1.83)
OCCUPATION							
Farming & fishing	n	4	12	12	5	1	34
	(%)	(0.14)	(0.58)	(0.83)	(0.79)	(0.58)	(0.47)
Day labor & labors	n	54	76	50	17	4	201
	(%)	(1.86)	(3.68)	(3.46)	(2.67)	(2.31)	(2.78)
Other services	n	42	41	33	11	2	129
	(%)	(1.45)	(1.98)	(2.28)	(1.73)	(1.16)	(1.79)
Unemployed & other non-wage earners (including housewives)	n	2799	1937	1351	603	166	6856
	(%)	(96.55)	(93.76)	(93.43)	(94.81)	(95.95)	(94.96)
MARITAL STATUS							
Currently married	n	2876	2008	1359	582	138	6963
	(%)	(99.21)	(97.19)	(93.98)	(91.51)	(79.77)	(96.44)
Total	n	2899	2066	1446	636	173	7220
	(%)	(40.15)	(28.61)	(20.03)	(8.81)	(2.40)	(100)
WEALTH QUINTILES (SES STATUS)							
Most poor	n	608	343	240	106	29	1326
	(%)	(23.41)	(17.95)	(17.76)	(18.40)	(18.71)	(20.12)
Least poor	n	520	379	274	102	36	1311
	(%)	(20.02)	(19.83)	(20.28)	(17.71)	(23.23)	(19.89)
Lower middle	n	502	391	267	120	36	1316
	(%)	(19.33)	(20.46)	(19.76)	(20.83)	(23.23)	(19.97)
Higher middle	n	505	403	277	114	24	1323
	(%)	(19.45)	(21.09)	(20.50)	(19.79)	(15.48)	(20.08)
Rich	n	462	395	293	134	30	1314
	(%)	(17.79)	(20.67)	(21.69)	(23.26)	(19.35)	(19.94)
Total	n	2597	1911	1351	576	155	6590
	(%)	(39.41)	(29.00)	(20.50)	(8.74)	(2.35)	(100)

For both sexes, the bivariate analysis highlighted key risk factors for hypertension based on age, including physical activity levels (p-value < 0.0001), BMI (p-value < 0.0001), and inadequate ("too low") intake of vegetables and fruits (p-value < 0.0001). Tobacco consumption (p-value < 0.0001) was only a significant risk factor among female respondents. Similarly, when examining wealth quintiles (i.e., SES), inadequate vegetable and fruit intake (p-value < 0.0001) stood out as significant risk factors for both male and female respondents. While BMI was the most significant risk factor for males, no significant association was observed among the female respondents (p-value = 0.1080). Furthermore, the relationship between physical activity and wealth quintile was significant in both male (p-value = 0.0241) and female (p-value = 0.0218) respondents, while tobacco consumption was more pronounced in males (p-value = 0.0117) compared to females (p-value = 0.1419).

Table 2.4 presents the results of a multivariable logistic regression analysis aimed at identifying key risk factors associated with hypertension (after adjusting the explanatory variables) in both the male and female respondents. As can be seen, three factors significantly influenced hypertension rates among female respondents: age (p-value < 0.0001), BMI (p-value < 0.0001), and fruit intake (p-value < 0.0001). Age played a significant role, with women aged 45-54 years being 5.3 times (CI: 3.9-7.2) more likely to have hypertension compared to those aged 18-34 years, after adjusting all other factors. This likelihood further increased to 12.9 times (CI: 7.9-21.0) for women aged 65 years and above. Obesity was also a strong risk factor, with obese women being 4.2 times (CI: 3.1-5.6) more likely to have hypertension compared to women with a normal body weight, after adjusting all other factors. Similarly, women who were overweight were 1.9 times (CI: 1.6-2.2) more

likely to be diagnosed with pre-hypertension compared to women with a normal weight. Tobacco consumption was not a statistically significant factor for female respondents.

A multivariable logistic regression analysis on the male respondents identified the same four variables as being significant with two additional variables: education and occupation. Age emerged as a strong risk factor, with men aged 65 years and above being 9.5 times more likely to have hypertension than those in the 18-34 age bracket (CI: 5.9-15.1), after adjusting all other factors. Similarly, the 45-54 age group was 3.0 times more likely to suffer from hypertension compared to the youngest group (CI: 1.9-4.8). BMI was also identified as a significant risk factor, with overweight men being 2.1 times more likely to be pre-hypertensive compared to those with normal weight (CI: 1.8-2.9). This likelihood further increased to 3.8 times for obese men compared to their normal-weight counterparts (CI: 2.6-5.7), after adjusting all other factors.

The results further revealed that men with higher levels of education were 1.7 times more likely to be afflicted by hypertension compared to those with no formal education (CI: 1.2-2.8), after adjusting all other factors. This direct correlation between education levels and hypertension is further elaborated in Table 2.4. While men employed in the service sector showed a slightly elevated risk of pre-hypertension (1.1 times) compared to non-hypertensive individuals, the confidence interval (CI: 0.9-1.4) suggests this finding requires further investigation.

Table 2.4: Prevalence and ORs of risk factors of hypertension by age and wealth quintile in rural Bangladesh

		Male										Female									
		Age					Wealth Quintile					Age					Wealth Quintile				
		18-34	35-44	45-54	55-64	65+	Most poor	Least poor	Lower middle	Higher middle	Rich	18-34	35-44	45-54	55-64	65+	Most poor	Least poor	Lower middle	Higher middle	Rich
Physical Activity		p=<0.0001*					p=0.0241					p=<0.0001*					p=0.0218				
Moderate physical activity		1.97	3.00	3.54	2.88	3.16	2.58	2.52	3.21	3.07	3.12	4.32	4.31	3.30	1.94	0.79	2.53	2.59	3.13	3.17	3.13
	OR (95% CI)	1	1.7 (1.1-2.9)	2.7(1.6-4.7)	1.7 (1.0-2.8)	1.3 (0.8-2.0)	1	0.6 (0.3-1.0)	1.0 (0.6-1.8)	1.1 (0.6-2.0)	1.1 (0.6-2.0)	1	1.2 (0.8-1.9)	1.3 (0.8-2.1)	0.8 (0.5-1.2)	0.7 (0.4-1.4)	1	0.7 (0.4-1.1)	1.0 (0.6-1.7)	1.3 (0.8-2.4)	1.3 (0.7-2.3)
High physical activity		16.65	22.00	20.37	15.12	8.83	7.05	16.66	16.14	16.48	16.77	5.04	3.67	6.27	6.40	1.41	17.15	16.62	16.30	16.49	16.40
	OR (95% CI)	1	1.5 (0.9-2.4)	1.9 (1.1-3.1)	1.0 (0.7-1.7)	0.4 (0.3-0.6)	1	0.6 (0.4-0.9)	0.8 (0.5-1.3)	0.9 (0.5-1.6)	0.9 (0.5-1.6)	1	0.8 (0.6-1.2)	0.8 (0.5-1.2)	0.3 (0.2-0.5)	0.2 (0.1-0.3)	1	0.6 (0.4-1.0)	0.8 (0.5-1.3)	1.0 (0.7-1.8)	1.0 (0.6-1.7)
Body Mass Index		p=<0.0001*					p=<0.0001*					p=<0.0001*					p=0.1080				
Underweight		5.49	6.51	6.36	5.38	4.27	6.16	5.94	5.33	5.42	4.53	9.39	5.43	4.27	2.44	0.61	4.32	4.72	4.23	4.39	3.64
	OR (95% CI)	1	0.95 (0.8-1.1)	0.9 (0.8-1.1)	1.1 (0.9-1.3)	1.3 (1.1-1.6)	1	1.0 (0.9-1.2)	0.9 (0.7-1.0)	0.9 (0.7-1.0)	0.7 (0.6-0.8)	1	0.9 (0.8-1.0)	0.9 (0.8-1.1)	1.2 (0.9-1.5)	1.0 (0.7-1.5)	1	1.1 (0.9-1.4)	1.0 (0.8-1.2)	1.0 (0.8-1.2)	0.8 (0.7-1.0)
Overweight		3.06	5.18	4.96	3.45	2.16	3.33	3.87	4.33	3.82	4.29	9.85	8.75	5.22	1.95	0.61	5.52	5.02	5.20	5.40	5.80
	OR (95% CI)	1	1.4 (1.1-1.6)	1.4 (1.1-1.7)	1.3 (1.0-1.6)	1.2 (0.9-1.6)	1	1.2 (1.0-1.5)	1.3 (1.0-1.6)	1.1 (0.9-1.4)	1.2 (1.0-1.5)	1	1.4 (1.2-1.6)	1.1 (0.9-1.3)	0.9 (0.7-1.1)	1.0 (0.7-1.5)	1	0.9 (0.8-1.1)	0.9 (0.8-1.1)	0.9 (0.8-1.1)	1.0 (0.8-1.2)
Obese		0.7	1.43	1.12	0.86	0.52	0.91	0.92	0.65	1	1.40	4.03	3.50	2.63	0.76	0.14	2.28	2.43	2.50	2.06	2.29
	OR (95% CI)	1	1.6 (1.2-2.3)	1.3 (0.9-1.9)	1.4 (0.9-2.0)	1.3 (0.8-1.9)	1	1.0 (0.7-1.6)	0.7 (0.5-1.1)	1.1 (0.8-1.6)	1.5 (1.0-2.0)	1	1.3 (1.1-1.6)	1.4-1.1-1.7)	0.8 (0.6-1.1)	0.6 (0.3-1.1)	1	1.1 (0.9-1.4)	1.1 (0.8-1.4)	0.9 (0.7-1.1)	0.9 (0.8-1.3)
		p=<0.0001*					p=<0.0001*					p=<0.0001*					p=<0.0001*				
Inadequate ("Too low") vegetable intake		6.21	9.08	9.48	7.78	4.84	5.85	7.05	7.63	8.14	10.29	13.42	10.82	8.57	3.19	0.80	5.87	7.03	7.60	7.95	9.95
	OR (95% CI)	1	1.2 (0.9-1.3)	1.4 (1.2-1.6)	1.5 (1.3-1.8)	1.3 (1.1-1.6)	1	1.4 (1.2-1.6)	1.6 (1.3-1.8)	1.7 (1.5-2.0)	2.6 (2.2-3.0)	1	1.2 (1.1-1.4)	1.5 (1.3-1.7)	1.1 (0.9-1.4)	1.0 (0.7-1.4)	1	1.3 (1.1-1.6)	1.5 (1.3-1.8)	1.6 (1.4-1.9)	2.5 (2.1-2.9)
		p=<0.0001*					p=<0.0001*					p=<0.0001*					p=<0.0001*				
Inadequate ("Too low") fruit intake		3.54	4.90	5.66	4.83	3.24	2.98	4.04	4.19	4.81	7.25	7.51	6.00	5.35	2.20	0.71	3.00	4.07	4.22	4.69	6.84
	OR (95% CI)	1	1.1 (0.9-1.3)	1.4 (1.1-1.6)	1.6 (1.3-1.9)	1.5 (1.2-1.9)	1	1.5 (1.2-1.8)	1.5 (1.2-1.9)	1.8 (1.5-2.2)	3.2 (2.7-3.9)	1	1.2 (1.0-1.3)	1.6 (1.3-1.8)	1.4 (1.2-1.8)	1.8 (1.3-2.6)	1	1.5 (1.2-1.8)	1.5 (1.2-1.9)	1.7 (1.4-2.1)	3.0 (2.5-3.6)
		p= 0.0117					p=0.0213					p=<0.0001*					p=0.1419				
Tobacco consumption		11.23	15.39	15.39	11.85	7.99	12.19	11.96	12.27	12.82	11.78	15.14	13.8	10.79	5.24	1.44	8.92	9.09	9.09	9.82	8.92
	OR (95% CI)	1	1.1 (0.9-1.2)	1.2 (1.1-1.4)	1.3 (1.2-1.5)	1.2 (1.0-1.4)	1	0.9 (0.8-1.1)	1.0 (0.9-1.2)	1.2 (1.0-1.4)	0.9-(0.8-1.0)	1	1.5 (1.4-1.7)	1.9 (1.7-2.1)	2.4 (2.0-2.9)	2.5 (1.8-3.4)	1	1.1 (0.9-1.2)	1.0 (0.9-1.2)	1.2 (1.1-1.4)	1.0 (0.9-1.2)

Table 2.5: Logistic regression model identifying risk factors influencing hypertension in rural Bangladesh

	Male			Female		
	Pre-hypertensive vs non-hypertensive		Hypertensive vs non-hypertensive	Pre-hypertensive vs non-hypertensive		Hypertensive vs non-hypertensive
		OR (95% CI)	OR (95% CI)		OR (95% CI)	OR (95% CI)
AGE	P=<0.0001*			P=<0.0001*		
18-34		1	1		1	
35-44		0.9 (0.8 - 1.1)	1.8 (1.1- 2.9)		1.3 (1.1- 1.5)	2.2 (1.6 - 3.0)
45-54		1.1 (0.9 - 1.3)	3.0 (1.9 - 4.8)		1.9 (1.6 - 2.2)	5.3 (3.9 - 7.2)
55-64		1.3 (1.1- 1.6)	5.4 (3.4 - 8.7)		2.9 (2.3 - 3.6)	10.4 (7.4 -14.6)
65+		1.7 (1.4 - 2.2)	9.5 (5.9 - 15.1)		2.7 (1.8 - 4.2)	12.9 (7.9 - 21.0)
BODY MASS INDEX	P=<0.0001*			P=<0.0001*		
Underweight		0.6 (0.5 - 0.7)	0.6 (0.4 - 0.8)		0.6 (0.5 - 0.7)	0.9 (0.7 - 1.2)
Normal		1	1		1	1
Overweight		2.1 (1.8 - 2.9)	2.9 (2.3 - 3.8)		1.9 (1.6 - 2.2)	1.9 (1.5 - 2.5)
Obese		2.2 (1.7 - 2.9)	3.8 (2.6 - 5.7)		2.8 (2.3 - 3.4)	4.2 (3.1 - 5.6)
INADEQUATE ("TOO LOW") FRUIT INTAKE	P=<0.0001*			P=<0.0001*		
Yes		1.7 (1.5 -1.9)	1.6 (1.3 - 2.1)		1.5 (1.3 - 1.7)	1.4 (1.1 - 1.7)
No		1	1		1	1
TOBACCO CONSUMPTION	P=0.0003			P=0.0229		
Yes		0.8 (0.7 - 0.9)	0.8 (0.7 - 1.0)		0.9 (0.8 - 1.0)	0.8 (0.6 - 0.9)
No		1	1		1	1
OCCUPATION	P=<0.0001*					
Farming & fishing		0.9 (0.7 - 1.1)	0.5 (0.3 - 0.6)			
Day labor & labor		1.0 (0.8 - 1.2)	0.4 (0.3 - 0.6)			
Other services		1.1 (0.9 - 1.4)	0.6 (0.5 - 0.9)			
Unemployed & other non-wage earners		1	1			
EDUCATION	P=0.0015					
No schooling & formal education		1	1			
Elementary/primary (up to Grade 5)		0.9 (0.9 - 1.1)	1.3 (1.0 - 1.7)			
Secondary (Grade 6-10)		1.1 (0.9 - 1.3)	1.8 (1.4 – 2.5)			
Higher secondary & above (Grade 11 and above)		1.4 (1.0 – 1.8)	1.7 (1.2 – 2.8)			

*Significant at P <0.05 level.

2.4 Discussion

Our field investigation examined the distribution and associated risk factors of hypertension (physical, behavioral, dietary habits, and socioeconomic status) among individuals living in rural Bangladesh. Our findings indicated that one-third of respondents aged 18 years or older (33.7% of males and 28.6% of females) had elevated blood pressure, qualifying them as either prehypertensive or hypertensive. This finding represents a significant increase in the prevalence of hypertension among residents of rural Bangladesh, as the 2018 national STEPS survey only found 21% of respondents to be hypertensive [32]. Likewise, we found that the prevalence of hypertension had increased considerably compared to the WHO's 2016 study [9], which found that diabetes and hypertension were prevalent among the rural adult population at a rate of 8% and 26.4% respectively [9]. In recent decades, the findings of population-based studies have demonstrated a significant global increase in the prevalence of NCDs, particularly hypertension and diabetes. Similarly, previous studies have reported that hypertension has become a major health concern in Bangladesh [33], which they have ascribed to changes in dietary patterns, food insecurity, poverty, lifestyle factors, and urbanization [19,34-36].

Age has been consistently shown to be a significant risk factor for hypertension, with findings showing a direct correlation between age and hypertension prevalence [37-39]. For instance, one recent study found the prevalence of hypertension to be especially high among participants in the 50-53 age group [11]. Furthermore, findings suggest that, after the age of 59, hypertension rates tend to be higher among women compared to men [37-39]. Our

results confirm these findings, revealing a steady increase in hypertension prevalence with age, particularly among older individuals in rural Bangladesh. Indeed, we observed the highest rates of hypertension in women aged 45-54 years and above 65 years. While previous studies have found lower hypertension rates among adults younger than 39 [12], our findings indicate a shift in this trend. In addition, we also find that individuals under 45 years old are both at greater risk of hypertension, with men and women being 1.8 and 2.2 times more likely to develop hypertension compared to older age groups, respectively. This finding aligns with Fottrell's [8] data, which shows a high prevalence of hypertension in the elderly population (aged 60 and over). These results underscore the growing problem of hypertension among older age groups and emphasize the need for targeted interventions and preventative measures.

Gender disparities in hypertension rates have been well-established [5,37-43]. Although our data indicated that the overall prevalence of hypertension did not differ significantly between sexes (6% of males and 6.8% of females were hypertensive), it was revealed that some of the risk factors related to hypertension among the sexes are significant. This result is consistent with previous studies of Bangladesh, which have found a close association between risk factors such as age, BMI, occupation, tobacco consumption, and fruit and vegetable consumption and high blood pressure across genders [8,10,22,28].

Studies of LMICs have identified education as one of the most important risk factors for hypertension, with many demonstrating a strong inverse relationship between educational attainment and hypertension in women [19,20,29,39,44-47]. For instance, Rahman [9] found

significantly higher rates of hypertension among women with little or no education. Interestingly, although 80.7% of the females in our sample had a maximum education level of Grade 5, our findings did not indicate a significant association between their level of education and prehypertension or hypertension rates. This finding contradicts the trend observed in other LMIC studies, including findings from studies in Bangladesh [18,19,21,26,29,32,48-50]. The patterns in our study are likely attributable to other confounding factors, such as age, socio-economic status and BMI, similar to prior findings reported by Chowdhury et al. [18] and Zahangir et al. [51].

Indeed, the impact of limited education on dietary choices cannot be ignored, and it remains a crucial dimension for dietary and health improvements. Previous studies of rural Bangladesh have found that female household heads tend to make healthier food choices for their families, and that their understanding of “healthy” and “unhealthy” diets is significantly influenced by their own educational background [23,51,52]. This lack of awareness, coupled with potential disparities in access to adequate quantities and quality of food, can negatively affect the health outcomes of women and their dependents [52-54], regardless of their control over household decisions.

In our study of rural Bangladesh, we found that, across all ages and socio-economic levels, women were significantly more likely to consume adequate amounts of fruits and vegetables. Specifically, wealthy, affluent women were 2.5 times more likely to eat sufficient vegetables and 3 times more likely to consume enough fruit. In contrast, wealthy men exhibited a minimal increase, with odds of adequate vegetable and fruit consumption rising by 1.7 and 1.8 times, respectively. In many cultures, food consumption patterns are highly

symbolic, reflecting underlying power differentials with respect to gender. For instance, diets that are high in meat are often perceived as masculine, while the consumption of fruits and vegetables is typically seen as being more feminine [54], which can be protective against hypertension. This gendered lens influences food availability and distribution, particularly in LMICs where gender preference and bias can impact dietary intake from early childhood [55]. These factors, along with lifestyle and SES differences between urban and rural populations, can intensify the risk factors for NCDs in women [29].

For the male participants, the odds of being prehypertensive or hypertensive increased with higher educational attainment and employment in non-physical occupations. This aligns with previous studies of Bangladesh conducted by Sathi [11], Fottrell [8], and Kibria [14], whose findings indicate that educated populations experience higher rates of diabetes, hypertension, and obesity due to sedentary lifestyles. We also found a notable positive association between wealth and risk of obesity/overweight, as men who qualified as being "rich" were 1.2 and 1.5 times more likely to be obese and overweight, respectively, compared to the poorest respondents. Our findings align with those of Ali et al. [22], who also observed increased obesity and hypertension rates among Bangladeshi men from middle to higher SES backgrounds.

Similarly, being overweight or obese also significantly increased the odds of hypertension among women, with obese women being 4.2 times more likely to be hypertensive compared to those with normal body weight. In one study of young adults across various regions of Bangladesh, Ali [22] identified abdominal obesity as a major risk factor for hypertension in women, particularly among those living in Dhaka, Barisal, and

Rangpur Divisions. However, as Zahangir [51] notes, underweight women are also at risk of hypertension. Research focusing on rural Bangladesh has revealed a unique trend wherein wives of migrant laborers, both in urban Bangladesh and abroad, tend to be overweight or obese rather, than undernourished. This phenomenon has been attributed to these women's increased purchasing power, which enables them to access better quality food and allows them to hire domestic help [6]. In addition, the literature indicates that women from higher-income households generally have lower levels of physical activity [11,21]. This trend is reflected in our results, which show a significant inverse relationship between SES and physical activity ($p=0.02$) among the female participants. However, the association between SES and BMI ($p=0.10$) was not found statistically significant in our study. This finding runs counter to those of previous studies showing a strong positive relationship between SES and overweight/obesity among female participants [8,14,21,22,51].

Tobacco use, including smoking and chewing, is a significant health burden in South Asian countries such as India, Pakistan, and Bangladesh, as such behavior contributes to oral and lung cancers, as well as increased rates of NCDs such as hypertension and cardiovascular diseases, particularly among men [6,47,56-59]. However, our results could not establish a positive association between tobacco consumption and hypertension among the rural adults in Bangladesh, which is likely due to Type II error (i.e., false-negative rejection of null hypothesis). However, our findings showed a significant positive correlation between tobacco consumption and age among women, with older women (65+) being 2.5 times more likely to use tobacco products compared to women in the 18-34 age group.

Notably, a study by Rahman [30] found a strong association between cigarette smoking and hypertension in Bangladeshi men. While tobacco use has declined among younger generations in recent years, older men and women continue to engage in these habits. The social stigma associated with women using tobacco is likely a major reason for the higher rates of tobacco use observed among men compared to women [18,43]. Although our study revealed a significant association between SES and tobacco consumption ($p= 0.02$) in men, usage rates were found to be lower among men qualifying as "rich." Similar results have been reported in previous studies, where findings show tobacco consumption being prevalent in all SES categories, but lower among higher SES cohorts [8,24,27].

Results of our study did not find a direct association between SES and hypertension prevalence. This diverges from the findings of numerous prior studies, which successfully demonstrate a positive relationship between household wealth and hypertension [8-10,14,22,27]. However, according to our findings, SES does impact lifestyle choices, particularly physical activity and diet. Consistent with prior findings, we found that individuals from higher SES groups exhibited healthier dietary habits, such as consuming more fruits and vegetables [8,51]. This suggests that, while lifestyle factors play an important role in risk for hypertension, other complex factors, such as age and gender, are likely to contribute to its prevalence [14].Kirschbaum's [5] study of 76 LMICs found that significant regional differences in NCD prevalence were largely driven by socioeconomic disparities. While increased per capita GDP generally correlated with decreased hypertension risk factors, particularly among men, this pattern did not hold true for South-Asian countries, where risk factors continued to rise alongside SES [11]. Our findings indicate significant

socioeconomic inequality in the prevalence of hypertension risk factors, specifically physical activity levels, BMI, fruit and vegetable intake, and tobacco consumption, across genders and age categories among residents of rural Bangladesh.

2.4.1 Contributions and limitations of the study

The major strength of this study was its population survey-based coverage, which enabled a very large sample consisting of men and women from eight divisions in Bangladesh. As such, the results presented herein are generalizable to Bangladesh's rural adult population. Furthermore, the findings of this work are detailed and comprehensive, as the collected data consisted of both individual- and household-level components. Moreover, the use of standardized physical examinations to determine the participants' height, weight, and blood pressure mitigated recall bias and enhanced the accuracy of the findings. Along with appropriate statistical methods for estimating the age-standardized prevalence of hypertension risk factors in the population, a principal component analysis was used to determine the wealth quintiles and, thus, the SES of the surveyed households.

Our study has several limitations. First, instead of using longitudinal data, our study relied on a cross-sectional methodology, which precluded our ability to identify causal relationships between hypertension and the selected risk factors over time. Second, the data relating to physical activity was obtained retrospectively, with participants being required to recall several activity scenarios in minutes/hours/days/weeks. As a result, participants may have under- or over-estimated their physical activity levels. Similarly, the questions regarding adequate vegetable and fruit intake may have been difficult for participants to conceptualize, as recalling one's intake during a typical week/day is highly

contextual to temporal food availability and affordability. Thus, future research could develop and incorporate objective measures to increase data validity for these variables.

2.5 Conclusion

Consistent with prior studies, our findings revealed that the one third of Bangladesh's rural adult population is living with elevated blood pressure, with hypertension rates being highest among older men and women. High blood pressure was also found to be associated with inadequate fruit vegetable intake. Obesity and overweight were also found to significantly influence the prevalence of hypertension in the study sample. While prior studies have shown tobacco consumption and education attainment to be important risk factors among both sexes and women, respectively, our findings could not establish a significant positive association between smoking and hypertension and showed no significant association between education and hypertension among women. Moreover, although our findings show no direct association between SES and hypertension prevalence, they did show a clear link between SES and hypertension via various related behavioral and physical risk factors.

Our findings contribute to the existing understanding of hypertension epidemiology in rural Bangladesh by demonstrating the multi-layered and interconnected nature of the risk factors. While access to information and health resources may reduce risk factors for advantaged individuals, the relationship between SES and risk factors highlights the need for equity-based techniques to minimize their impact.

Targeted efforts should focus on promoting healthy aging strategies, enhancing access to cardiovascular screening and management, and advocating for lifestyle modifications, including increased physical activity and healthier dietary practices. Customized interventions that consider sex-specific risk factors and socioeconomic contexts are essential to reducing the prevalence of hypertension in this population effectively.

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CHAPTER 3

Sociodemographic and socioeconomic factors, and urbanicity associated with the prevalence of diabetes among the adult population of Bangladesh

Abstract

Background: This study examines the association between the prevalence of diabetes and sociodemographic and socioeconomic attributes, and degree of urbanicity (measured in terms of different types of residential locations i.e., rural, semi-urban, peri-urban, urban) in Bangladesh.

Methods: A sample of 5 878 participants was analyzed using individual histories of diabetes as the primary outcome variable. With respect to place of residence, 3 033 (51.6%) participants lived in rural areas, 1 036 (17.6%) lived in semi-urban areas (*Upazila* headquarters), 993 (15.9%) lived in peri-urban areas, and 876 (14.9%) lived in urban areas. Additionally, participants' height, weight, blood pressure, current levels of physical activity, household characteristics and lifestyle were also collected. Stepwise multivariable logistic regression was employed to identify the factors associated with diabetes.

Results: The overall prevalence of diabetes was 10.7% (95% CI 9.9-11.5). Diabetes prevalence increased from 7.9% (95% CI 0.95-1.57) in adults aged 18-34 years to 15.6% (95%CI 1.58-2.88) in the 65-years and older group. Individuals with higher educational attainment (Grade 11 and above) had a diabetes prevalence of 16.9% (95%CI 2.06-3.59), with an upward trend being observed with respect to occupation. Notably, obese and overweight individuals were 1.39 (CI 1.1-1.82) and 1.28 (CI 1.02-1.60) times more likely to have diabetes, respectively. Whereas prevalence rates were nominal in rural areas, more than one-fifth (more than 21%) of adults in the other urbanized areas reported being diagnosed with diabetes. This finding supports our postulation that prevalence of diabetes is closely associated with urbanicity in Bangladesh.

Conclusions: The findings of this study reveal that; besides age, the prevalence of diabetes is significantly influenced by education, occupation, and urbanization, which is often accompanied by a transition to sedentary lifestyles and negative dietary habits. In addition to considering individual histories of diabetes and the numerous related metabolic risk factors, future research should longitudinally examine how changes in beliefs and value systems and overt behaviour relating to urbanicity influence diabetes rates.

Keywords: diabetes, urbanicity, prevalence, risk factors, wealth quintiles

3.1 Introduction

Diabetes mellitus, often simply referred to as "diabetes," is a chronic metabolic disorder characterized by elevated blood glucose levels. One of the fastest growing global health emergencies of the 21st century,[1,2] diabetes currently affects more than 540 million people worldwide, with this number expected to rise to 643 million by 2030 and 783 million by 2045.[2] Research indicates that approximately 80% of diabetes patients reside in low- and middle-income countries (LMICs), and that global prevalence rates of diabetes and hypertension are largely driven by socioeconomic disparities.[34] Nonetheless, as diabetes is influenced by a diverse set of factors, prevalence rates may vary over time and by region.[1] Diabetes is an emerging epidemic in Bangladesh, where it is estimated that as many as 13.7 million Bangladeshis could be living with diabetes by 2045.[2,5–7] Diabetes persist over long period of time (for years or even decades), which means that the related burden is accumulated over time. It is estimated that Bangladesh is likely to experience an increase of two million new cases each year over the next decade. [2,8]

Studies have consistently demonstrated a strong correlation between urbanization and increased risk of non-communicable diseases (NCDs),[3,7–15] as well as stark urban-rural

differences in prevalence rates, especially with respect to diabetes and hypertension. The concept of "urbanicity" is relevant in this context. Whereas "urbanization" refers to an increase in city size, density, and heterogeneity, "urbanicity" relates to the effects of living in urban areas at a particular time.[16] One critical group of effects is the influence of urban living on health and chronic diseases. The World Health Organization has concluded that rapid urbanization is associated with numerous health effects, including an increase in communicable and non-communicable diseases.[17] Similarly, Sobngwi et al.'s study in Cameroon revealed a strong positive correlation between rapid urbanization and heightened rates of chronic diseases such as a diabetes, hypertension, and metabolic syndrome.[18] Researchers have compellingly argued that the apparent association between rising diabetes rates and urbanization is largely due to the rapid and continuous socioeconomic and dietary transitions that come with urbanization.[19–21] For instance, findings indicate that higher consumption of sugar and sweetened beverages,[20] refined carbohydrates,[22] red meat, and trans-fatty acids,[21] combined with an increase in sedentary behavior, [23] all serve as factors mediating the increased risk of diabetes.

In the early 1990s, Bangladesh liberalized its economy and began to open itself up to international trade, which was accompanied by rapid urbanization.[24] Since then, the extent of this urbanization has been remarkable with an annual rate of urbanization in the range of 3-7%: consequently, in 1990, only 19.8% of Bangladesh's population lived in urban areas; as of 2023, urban areas were home to 40.5% of the country's population.[25] This urbanization and urbanicity has ultimately resulted in rural forms of life being replaced with pre-selected urban patterns and lifestyles.[26] Thus, it is critical to understand the factors driving the rising

prevalence of diabetes in communities undergoing economic growth and urbanicity across Bangladesh, as such an understanding would be invaluable in developing targeted interventions aimed at managing and preventing diabetes more effectively.

The growing prevalence of diabetes and its various risk factors in Bangladesh have been highlighted in the most recent STEPwise Surveillance for NCD risk factors (STEPS; 2018) and two nationally representative datasets, namely, the Bangladesh Demographic and Health Survey (BDHS) 2011 and 2017–18.[6,27] However, studies of these subjects have seldom utilized data acquired via overall population surveys and have typically overlooked patterns in diabetes prevalence at multiple levels of urbanization (i.e., urban, peri-urban, *Upazila* HQ) in Bangladesh. Instead, prior research has generally targeted a specific area, age group, or gender using small sample sizes.[10–12,28–30] Notably, the STEP surveys in Bangladesh procured diabetes data using a dichotomized rural-urban framework, which overlooks diabetes patterns among people living in locations with varying degrees of urbanicity (e.g., peri-urban).[16] Therefore, there is value in developing an in-depth understanding of diabetes prevalence across the spectrum of urbanicity, including metropolitan areas, peri-urban areas (contiguous to the cities), semi-urban areas (*Upazila* headquarters which are newly urbanizing places), and rural areas (non-urban locations).

Given this gap in the literature and the threat posed by diabetes in Bangladesh, this work seeks to achieve two key objectives: i) to determine whether and how different sociodemographic (i.e., ascribed characteristics, such as age and sex) and socioeconomic (i.e., non-ascribed characteristics, such as education and occupation) attributes impact diabetes prevalence in Bangladesh; and ii) to examine the relationship between level of

urbanicity (i.e., rural, semi-urban, peri-urban, urban) and the prevalence of diabetes in Bangladesh.

3.2 Methods

3.2.1 Data sources, study population, and survey design

Bangladesh is made up of eight administrative divisions comprised of districts (*Zilas*) and sub-districts (*Upazilas*), which are in turn divided into *unions*. Urban areas are sub-divided into wards, which are similar to *unions* in scale.

We categorized residential locations based on two main criteria: rural characteristics and degree of urbanicity. While metropolitan areas feature the highest degree of urbanization, adjacent areas have also experienced rapid urbanicity in recent years. In addition, *Upazila* headquarters, which are usually located in rural areas, have undergone development aimed at equipping them with all urban amenities and utilities, thus fostering considerable urbanicity. We conducted a cross-sectional population-based study with 5 878 participants living in rural areas (n= 3 033, 51.6%), semi-urban areas (*Upazila* headquarters; n=1 036, 17.6%), peri-urban areas (n=993, 15.9%), and urban areas (n=876, 14.9%) (Figure 1). The final sample represented Bangladesh's adult population across all eight divisions and, therefore, each of the country's major agroclimatic regions (i.e., Moulvibazar, Sunamganj, Sherpur, Jamalpur, Munshiganj, Pabna, Satkhira, and Khulna). The "household" was taken as the *primary sampling unit* (PSU), with "household" being defined as a dwelling in which people, related or unrelated, live together and take food from the same kitchen. [31]

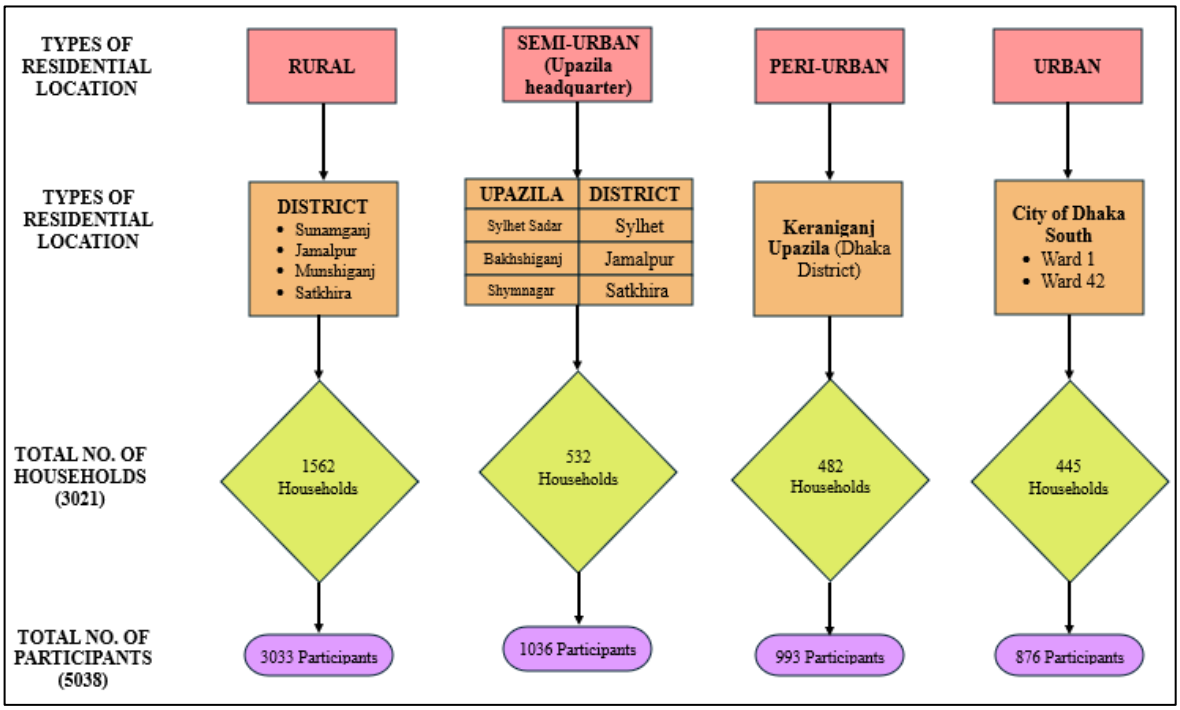
The optimal sample size (n) was calculated using the following formula:

$$n = \text{Design Effect} \times \frac{Z^2_{1-\frac{\alpha}{2}}\ p\ q}{\delta^2} \qquad (1)$$

where $Z_{1-\frac{\alpha}{2}}$ is the $1-\frac{\alpha}{2}$ quantile of the standard normal distribution, δ is the margin of error, and p is the proportion of the target indicator, $q = 1 - p$.

To ensure a confidence level of 95%, it was assumed that $\alpha = 0.05,\ Z_{1-\frac{\alpha}{2}} = 1.96,$ and the margin of error was 5% (i.e., $\delta = 0.05$). Finally, the design effect was set as 1, as households in each area were selected using a simple random-sampling method. Since the value of *p* was unknown, it was assumed that p=0.5 would yield the maximum number of sample participants required to measure multiple indicators. Ultimately, a sample size of $n = 384$ for each study sub-population (i.e., *Upazila* headquarters, peri-urban, urban, and rural) was deemed necessary to achieve a confidence interval of 95%.

Figure 3.1 : Study design and distribution of Primary Sampling Units (PSUs)



The study design is illustrated in Figure 3.1. The study population consisted of adult males and females permanently residing in one metropolitan city, one peri-urban *Upazila*, three *Upazila* headquarters (denoted as semi-urban), and eights rural *Upazilas* from four districts. The urban and peri-urban participants were chosen from the metropolitan city of Dhaka South (Ward 1 and Ward 42) and Keraniganj *Upazila* (Keraniganj District; Ward 1 and Ward 2), respectively. The semi-urban (*Upazila* headquarters) participants were from Sylhet Sadar *Upazila* (Sylhet district), Bakshiganj *Upazila* (Jamalpur district), and Shymnagar *Upazila* (Satkhira district). The rural participants were selected from the villages of Sunamganj, Jamalpur, Munshiganj, and Satkhira districts (Figure 1).

The *sampling frame* was developed by a census survey of the selected Unions, and all sampled households, considered to be *primary sampling units* (PSUs), were drawn using a

simple random sampling procedure. Field data were collected from the 3021 selected households between July and November of 2017. In total, 5878 face-to-face interviews were conducted with the household heads using a semi-structured interview questionnaire. The survey process consisted of two components: (i) the collection of sociodemographic and socioeconomic data using a semi-structured questionnaire, and (ii) physical examinations of the respondents (conducted with their consent). The questionnaire, which was translated into Bangla and validated, was administered by 15 teams of trained field investigators and supervisors, while the physical examinations, which measured height, weight, blood pressure, and blood sugar/glucose, were administered by 15 teams of trained and licensed female nurses. The equipment used in the examinations included measuring tapes, digital scales, blood pressure monitors, stethoscopes, and glucometers. Field organizers and information technology personnel from Bangladesh's Centre for Natural Resource Studies (CNRS) provided technical support and troubleshooting assistance throughout the fieldwork. The questionnaire consisted of multiple modules, with the preliminary questionnaire being modified to incorporate additional questions based on pre-testing in communities outside the study areas.

3.2.2 Outcome variable

Participants' personal histories of diabetes served as the primary outcome variable. The participants were asked if a health professional had diagnosed them with diabetes or informed them of sugar in their urine or high blood glucose levels. Participants who answered "yes" were categorized as having a history of diabetes. We also measured the participants' random blood glucose (RBG) levels using a glucometer and then classified

them into one of three categories: “possible diabetic” (7.0 mmol/L or greater), “possible pre-diabetic” (6.0 mmol/L—6.9 mmol/L), or “unlikely diabetic” (below 6.0 mmol/L).[16]

3.2.3 Independent variables

To determine key household assets indicative of wealth, we applied a Principal Component Analysis (PCA) of pertinent variables. The PCA considered the following factors: house and land ownership, number of rooms, wall materials, water sources, sanitation infrastructure, electricity supply, and possession of household assets including refrigerators, televisions, sewing machines, bicycles, and motorcycles. The PCA results were used to calculate a "wealth quintile" score for each household, enabling us to categorize them into one of five socio-economic quintiles: "most poor," "least poor," "lower-middle," "higher-middle," and "rich”.

Based on the existing literature relating to risk factors for diabetes mellites in LMICs and Bangladesh, the following independent variables were selected: place of residence (rural, semi-urban, peri-urban, and urban); wealth status (as defined above); age (18-34, 35-44, 45-54, 55-64, ≥65); sex (male and female); level of education (no schooling, elementary, secondary, higher secondary and above); occupation (farming, fishing, day laborer, other laborer, other service holders (e.g., doctor), service, small business, unemployed, other non-wage earner (student, retired, unemployed, housewife)); and consumption of tobacco and related products.

Body mass index (BMI) was measured and defined based on the WHO’s obesity guidelines for the Asian population [32]: underweight (BMI <18.5kg/m^2), normal weight (BMI 18.5-23.0 kg/m^2), overweight (BMI 23.0-27.5 kg/m^2), and obese (BMI ≥ 27.5kg/m^2). Physical activity was measured by

asking the participants how much time (in minutes) they spend per day and per week engaging in moderate and/or vigorous activity. This portion of the survey also probed activity related to work, leisure, transportation, and time spent being sedentary. The participants' MET-minutes were then calculated using this data and the following STEPS protocol[33]: (a) 1 minute in a sedentary position (sitting quietly) equals 1 MET-minute; (b) 1 minute engaging in moderate and transportation-related activities equals 4 MET-minutes; and (c) 1 minute engaged in vigorous activity equals 8 MET-minutes. The participants' physical activity levels were classified as either high (≥ 3 000 MET-minutes), moderate (600-3 000 MET-minutes), or low (≤ 600 MET-minutes) based on their total MET-minutes per week.

Blood pressure was measured using standard aneroid sphygmomanometers placed on the participant's right arm (which was supported) for at least 5 minutes while resting in a seated position. The participants' diastolic blood pressure was determined using Korotkoff phase V, and systolic and diastolic measurements were recorded in mmHg. "Possible prehypertension" was defined as systolic blood pressure between 120 mmHg and 140 mmHg or diastolic blood pressure between 80 mmHg and 90 mmHg. Hypertension was defined as systolic blood pressure ≥140 mmHg or diastolic blood pressure ≥90 mmHg.[5,7–9,16,32]

3.2.4 Statistical analysis

We employed SAS 9.4 (SAS Institute Inc., Cary, NC, USA) to conduct a series of statistical analyses investigating the sociodemographic and lifestyle risk factors associated with diabetes. We began by describing the relationship between participant sociodemographic characteristics, lifestyle, and the prevalence of self-reported diabetes. A chi-square test was then employed to assess any statistically significant relationships. Finally, multivariable logistic regression with stepwise selection

was applied to assess how the risk factors, both independently and collectively, influenced diabetes prevalence. Throughout the analysis, an odds ratio was used to quantify the strength of association between categorical variables, with a p-value < 0.05 being considered statistically significant.

3.3 Results

3.3.1 Participant profile

Overall, 5878 participants were included in this study. Of the respondents, 50.9% (n=2 993) were female, 49.1% (n=2885) were male, and 96.6% (n=5679) were married. The distribution of diabetic status by participant's socio-demographic characteristics is presented in Table 3.1. In is seen that a significant majority (n=4461, 75.9%) of participants were between the ages of 18-54 years, with only 35.1% (n=2062) having no formal education. With regards to employment, 52.1% (n=3062) of the participants were unemployed or non-wage earners (including housewives), and 23.9% (n=1 402) were employed in service-based occupations or were small business owners. In terms of economics, 39.9% of participants fell into the "poor" category (i.e., "most poor" and "least poor"), 19.7% fell into the "lower middle" wealth category, and 20.4% fell into "higher middle" category. Only about one-fifth of the participants were relatively "rich" in terms of wealth-possession and earnings.

The random blood glucose (RBG) level results revealed that 76.4% (n=4 491) of the participants were non-diabetic (blood glucose levels lower than 6.0 mmol/L) compared to 23.6% that were possible diabetic or possible pre-diabetic (blood glucose levels greater than 6.0 mmol/L). While41.9% (n=2 462) of non-diabetic participants resided in rural areas, 34.8% of participants in the pre-diabetic/diabetic group resided in peri-urban areas.

The results further indicated that more than one-third (38.4%) of the participants were either hypertensive or possible prehypertensive. Notably, 18.1% of the hypertensive participants had also been diagnosed with diabetes and were 2.14 times (95%CI 1.64-2.78) more likely to have diabetes compared to non-hypertensive participants. Of the 629 participants who were diabetic and aware of their diabetic status, 206 (27.9%) had random blood glucose levels of ≥7.0 mmol/L. Conversely, 12.2 % (n=79) of these participants were found to be possible pre-diabetic and 344 (7.7%) were found to be unlikely diabetic (≤ 6.0 mmol/L).

Table 3.6: Distribution of diabetic status by participant's socio-demographic characteristics.

	Diabetic Status (n=5874)		**Total**	**Prevalence Ratio**	**p-value**
	Yes (n=629, 10.7%)	**No** (n=5245, 89.3%)		**OR (95% CI)**	
AGE (n,%)					
18-34	124 (7.9)	1431 (92.0)	1555	Reference	<0.0001*
35-44	141 (9.6)	1331(90.4)	1472	1.22 (0.95-1.57)	
45-54	172 (12.0)	1260 (87.9)	1432	1.58 (1.24-2.01)	
55-64	113(12.5)	788 (87.5)	901	1.66 (1.26-2.17)	
65+	79 (15.6)	428 (84.4)	507	2.13 (1.58-2.88)	
GENDER (n,%)					
Male	303 (10.5)	2580 (89.5)	2883	0.96 (0.81-1.13)	0.629
Female	326 (10.9)	2665 (89.1)	2991	Reference	
EDUCATION (n,%)					
No schooling & formal education	144 (7.0)	1915 (93.0)	2059	Reference	<0.0001*
Elementary/primary (up to Grade 5)	209 (10.3)	1827 (89.7)	2036	1.52 (1.22-1.90)	
Secondary (Grade 6-10)	179 (14.8)	1034 (85.2)	1213	2.30 (1.83-2.91)	
Higher secondary & above (Grade 11 and above)	96 (16.9)	469 (83.0)	565	2.72 (2.06-3.59)	
OCCUPATION (n,%)					
Farming & fishing	33 (5.2)	600 (94.8)	633	Reference	<0.0001*
Day labor & labor	59 (7.6)	722 (92.5)	781	1.49 (0.96-2.31)	
Other services	194 (13.9)	1207 (86.2)	1401	2.92 (1.99-4.28)	
Unemployed & other non-wage earners	343(11.2)	2709 (88.8)	3059	2.30 (1.59-3.33)	
WEALTH QUINTILE (n,%)					
Most poor	114 (10.3)	963 (88.5)	1088	Reference	0.536
Least poor	122 (10.9)	990 (89.0)	1112	0.95 (0.73-1.24)	
Lower middle	132 (12.1)	956 (87.9)	1088	1.06 (0.83-1.38)	
Higher middle	114 (10.1)	1012 (89.9)	1126	0.89 (0.66-1.14)	
Rich	114 (10.3)	993 (89.7)	1107	0.88 (0.68-1.16)	
BODY MASS INDEX (n,%)					
Underweight	83 (7.2)	1069 (92.8)	1152	0.85 (0.65-1.12)	<0.0001*
Normal	183 (8.4)	2002 (91.6)	2185	Reference	

Overweight	229 (13.7)	1448 (86.3)	1677	1.73 (1.41-2.13)	
Obese	126 (15.6)	680 (84.4)	806	2.03 (1.59-2.59)	
PHYSICAL ACTIVITY (n,%)					
Low	30 (12.7)	207 (87.3)	237	Reference	
Moderate	193 (13.4)	1246 (86.6)	1439	0.74 (0.49-1.09)	0.0002*
High	406 (9.7)	3792 (90.3)	4198	1.07 (0.71-1.61)	
HYPERTENSION (n,%)					
Non-hypertensive	340 (9.4)	3278 (90.6)	3618	Reference	
Possible Pre-hypertensive	207 (11.5)	1597 (88.5)	1804	1.25 (1.04-1.50)	<0.0001*
Hypertensive	82 (18.1)	370 (81.9)	452	2.14 (1.64-2.78)	
TOBACCO CONSUMPTION (n,%)	219 (9.6)	2068 (90.4)	2287	0.82 (0.69-0.97)	0.0252*
RANDOM BLOOD SUGAR (n,%)					
Unlikely Diabetic	344 (7.7)	4145 (92.3)	4489	Reference	
Possible Pre-diabetic	79 (12.2)	568 (87.8)	647	1.68 (1.29-2.17)	<0.0001*
Possible Diabetic	206 (27.9)	532 (72.1)	738	4.67 (3.84-5.67)	

*Significant at 95% level of confidence

3.3.2 Prevalence of diabetes and its association with sociodemographic attributes

We also investigated the association between the participants' socioeconomic attributes and diabetes prevalence (Table 3.1), as well as other potential risk factors for diabetes, including household features and relevant behavioural factors. The overall prevalence of diabetes among our sample was 10.7% (95% CI 9.9-11.5), with no significant differences being observed between the genders (males: 10.5%, females: 10.9%).

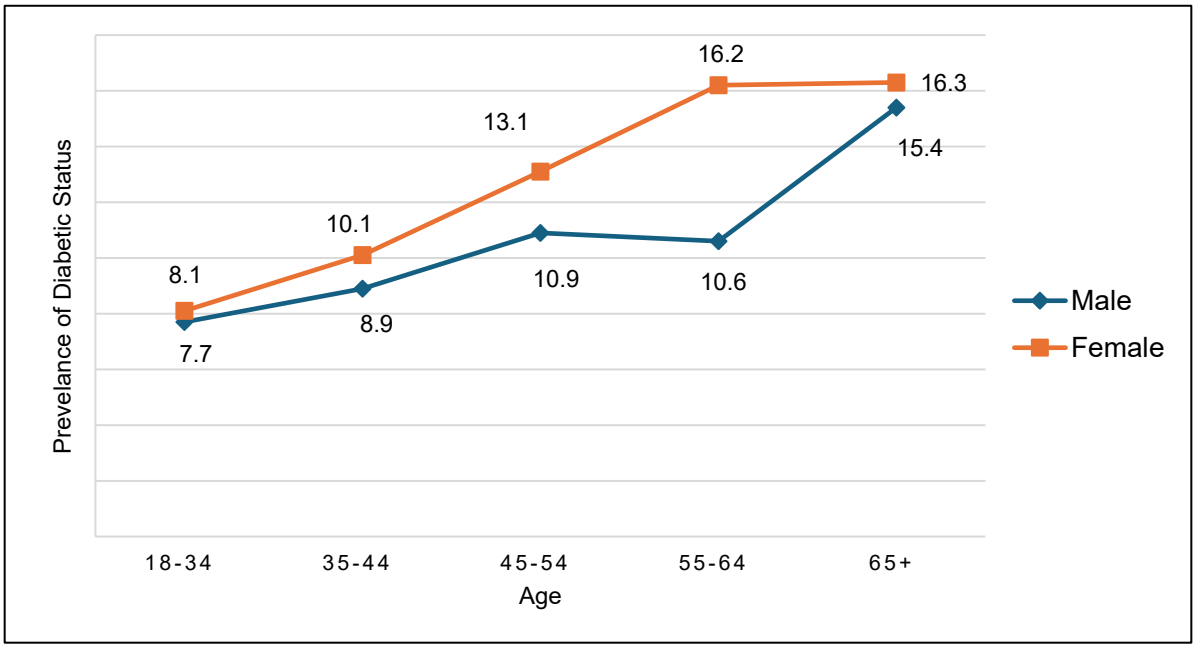
Interestingly, diabetes prevalence appeared to have a linear relationship with age, increasing from 7.9% (95%CI 0.95-1.57) among 18-34 years old to 15.6% (95%CI 1.58-2.88) among participants aged 65 years and over. Figure 3.2 illustrates the age-specific prevalence of diabetes by gender. In our sample, diabetes prevalence increased with age, peaking at the age of 65 and above. In this elderly group, diabetes rates were 16.3% for females and 15.4% for males, with an additional 16.2% of females in the 55-64 age group also having diabetes.

Thus, nearly one-third of women in their 50s and 60s are vulnerable to diabetes, suggesting that, after the age of 34, women may be more susceptible to this condition.

3.3.3 Association between diabetes and socioeconomic attributes

The prevalence of diabetes also increased alongside educational attainment, affecting 16.9% (95%CI 2.06-3.59) of participants who had completed Grade 11 or higher. A similar upward trend was also observed with respect to occupation, as participants employed in small businesses and services were 2.92 times (95%CI 1.99-4.28) more likely to have diabetes compared to those who farmed and fished for a living. Similarly, housewives and unemployed participants were 2.3 times (95%CI 1.59-3.33) more likely to have diabetes compared to those employed in farming and fishing. In general, these findings indicate a positive correlation between diabetes and sedentary lifestyles associated with white collar jobs and non-wage-earning activities.

Figure 3.2: Distribution of diabetic status by age and gender.



The data presented in Table 3.1 shows the distribution of diabetes based on the participants' socioeconomic status. As can be seen, diabetes afflicted 21.2% of participants in the "poor" ("most poor" and "least poor") category, 22.2% of participants in the "middle income" (lower middle & higher middle) category, and 10.3% of participants in the "rich" category. However, a closer examination of diabetes rates by wealth quintiles does to reveal any significant variations (Table 3.1).

3.3.4 Association between diabetes and lifestyle, and physical activity

Diabetes rates were also directly related to BMI, with 13.7% and 15.6% of overweight and obese participants suffering from this condition, respectively. Although 8.4% of participants with normal BMIs also had diabetes, obese and overweight participants were

2.03 (95% CI 1.59-2.59) and 1.73 (95%CI 1.41-2.13) times more likely to be diagnosed with diabetes, respectively.

The results shown in Table 3.1 further reveal that the prevalence of diabetes was inversely related to physical activity levels. For instance, 12.7% of participants with diabetes reported engaging in low levels of physical activity and 13.4% reported engaging in moderate physical activity. Notably, the analysis indicated that tobacco consumption was not significantly correlated to diabetes rates, despite 38.9% of the participants consuming tobacco products (OR: 0.82, 95%CI 0.69-0.97).

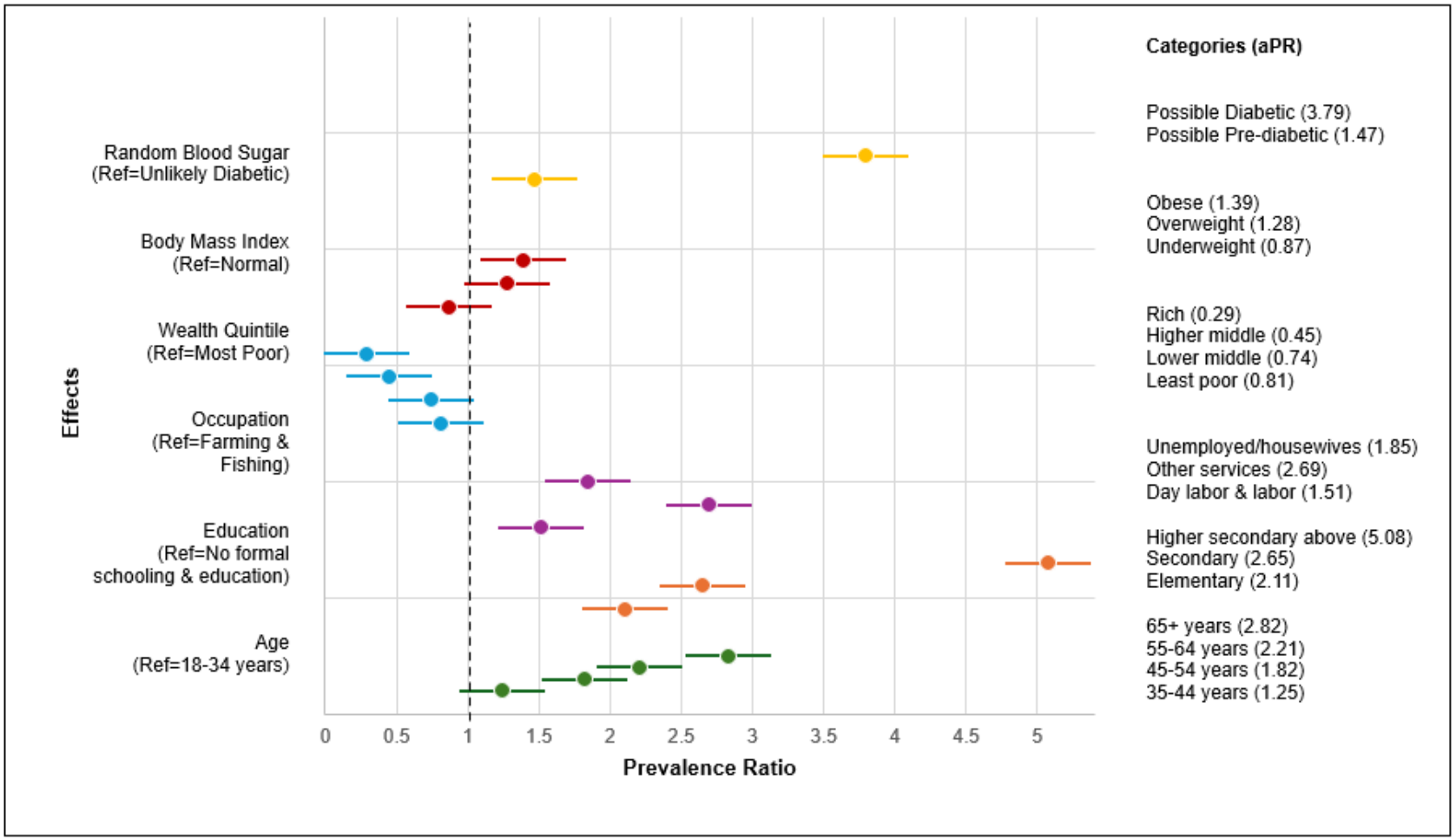
3.3.5 Risk factors and their effects on diabetes

Multivariable logistic regression modeling was employed to examine the significance of various risk factors vis-à-vis diabetes rates. To this end, the odds ratio for each factor was calculated, after adjusting for all other factors. The results are shown in Figure 3.3. The results revealed age, education, occupation, wealth quintile, BMI, and RBG levels to be the most significant risk factors for a history of diabetes ($p < 0.05$). Participants in the 65 years and above category were 2.82 (CI 2.0-3.99) times more likely to have diabetes compared to those in the 18-34 age group. This pattern prevailed across the other age groups as well: participants in the 35-44 age group were 1.25 (CI 0.95-1.6) times more likely to have diabetes compared to those in the 18-34 age group; participants in the 45-54 age group were 1.82 (CI 1.39-2.39) times more likely to have diabetes compared to the youngest age group; and participants in the 55-64 age bracket were 2.21 (CI 1.63-3.0) times more likely to have diabetes compared to the 18-34 year group. With regards to education, participants with higher secondary education were 5.08 (CI 3.5-7.38) times more likely to have diabetes

compared to those with no formal schooling (i.e., no education). Similarly, participants who had obtained a secondary education were 2.65 (CI 2.03-3.46) times more likely to have diabetes compared to those with no formal education.

The results also showed that participants employed in service-based professions and small business owners were 2.69 (CI 1.78-4.07) times more likely to have diabetes compared to those who farmed and fished for a living. Similarly, housewives and other non-wage earners were 1.85 (CI 1.24-2.75) times more likely to have diabetes compared to those employed in farming and fishing. In addition, participants categorized as obese and overweight were 1.39 (CI 1.1-1.82) and 1.28 (CI 1.02-1.60) times more likely to have diabetes compared to those with normal BMIs, respectively.

Figure 3.3: Adjusted prevalence ratio plot of positive diabetic status by diabetic risk factors.



Conversely, the results indicated that participants in the “rich” and “higher middle” categories were 0.29 (CI 0.20-0.42) and 0.45 (CI 0.33-0.62) times less likely to have diabetes compared to those in the “most poor” category (Figure 3). Furthermore, RBG levels were found to be strongly associated with diabetic status, as the likelihood of diabetes was 3.79 (95%CI 3.1-4.72) times higher among participants with RBGs ≥7.0 mmol/L compared to those with normal RBG levels (≤ 6.0 mmol/L).

3.3.6 Effects of urbanicity on diabetes

The results relating to the relationships between the aforementioned risk factors and location of residence are shown in Table 3.2. Overall, there were no significant differences between the various age categories and location of residence. However, 28% of the population in the peri-urban region were over the age of 55. While 44.2% of participants in the rural areas had no formal schooling (i.e., no education), 29.6% of urban participants had attained a secondary education and 32.9% had obtained a post-secondary degree or above. Small business owners and other service employees accounted for 29.7%, 30%, and 39.2% of the semi-urban, peri-urban, and urban population, respectively. Labor-intensive occupations (e.g., farming, fishing, and day labor) accounted for only 7.6% of the urban participants. In terms of wealth quintiles, 42.2% of the urban population fell into the “higher middle” and “rich” categories, while 18.4% belonged to the “lower middle” category. In the peri-urban population, 20.8% fell into the “least poor” category.

Table 3.7: Distribution of socio-demographic characteristics of participants by location of residence (%)

	Location of Residence			
	Rural (n=3033) %	Semi-urban (n=1036) %	Peri-urban (n=933) %	Urban (n=876) %
AGE (n=5871)				
18-34	26.54	28.57	22.94	27.85
35-44	24.36	26.25	24.65	26.6
45-54	24.52	25	24.33	23.29
55-64	15.43	13.32	18.01	14.73
65+	9.15	6.85	10.08	7.53
EDUCATION (n=5877)				
No schooling & formal education	44.18	35.27	26.05	13.01
Elementary/primary (up to Grade 5)	34.85	32.08	46.41	24.43
Secondary (Grade 6-10)	17.71	19.03	23.69	29.57
Higher secondary & above (Grade 11 & above)	3.26	13.62	3.86	32.99
OCCUPATION (n=5878)				
Farming & fishing	17.05	4.92	6.86	0.11
Day labor & labor	14.54	16.6	10.93	7.53
Other services	15.53	29.73	30.01	39.16
Unemployed & other non-wage earners	52.88	48.75	52.2	53.2
WEALTH QUINTILE (n=5525)				
Most poor	19.86	19.84	19.25	19.81
Least poor	20.12	20.14	20.75	19.58
Lower middle	19.97	19.94	19.78	18.41
Higher middle	20.04	19.94	20.22	22.14
Rich	20.01	20.14	20	20.05
BODY MASS INDEX (n=5824)				
Underweight	23.21	17.28	2.73	28.08
Normal	43.09	41.22	35.61	15.98
Overweight	23.9	31.76	40.73	30.25
Obese	9.79	9.75	20.93	25.68
PHYSICAL ACTIVITY (n=5878)				
Low	3.86	2.61	5.14	5.37
Moderate	17.38	25	19.94	53.31
High	78.77	72.39	74.92	41.32
HYPERTENSION (n=5878)				
Non-hypertensive	62.71	64.29	57.02	59.47
Possible Pre-hypertensive	30.07	28.19	34.62	31.74
Hypertensive	7.22	7.53	8.36	8.79
TOBACCO CONSUMPTION (n=2287)	42.57	49.42	32.26	20.89

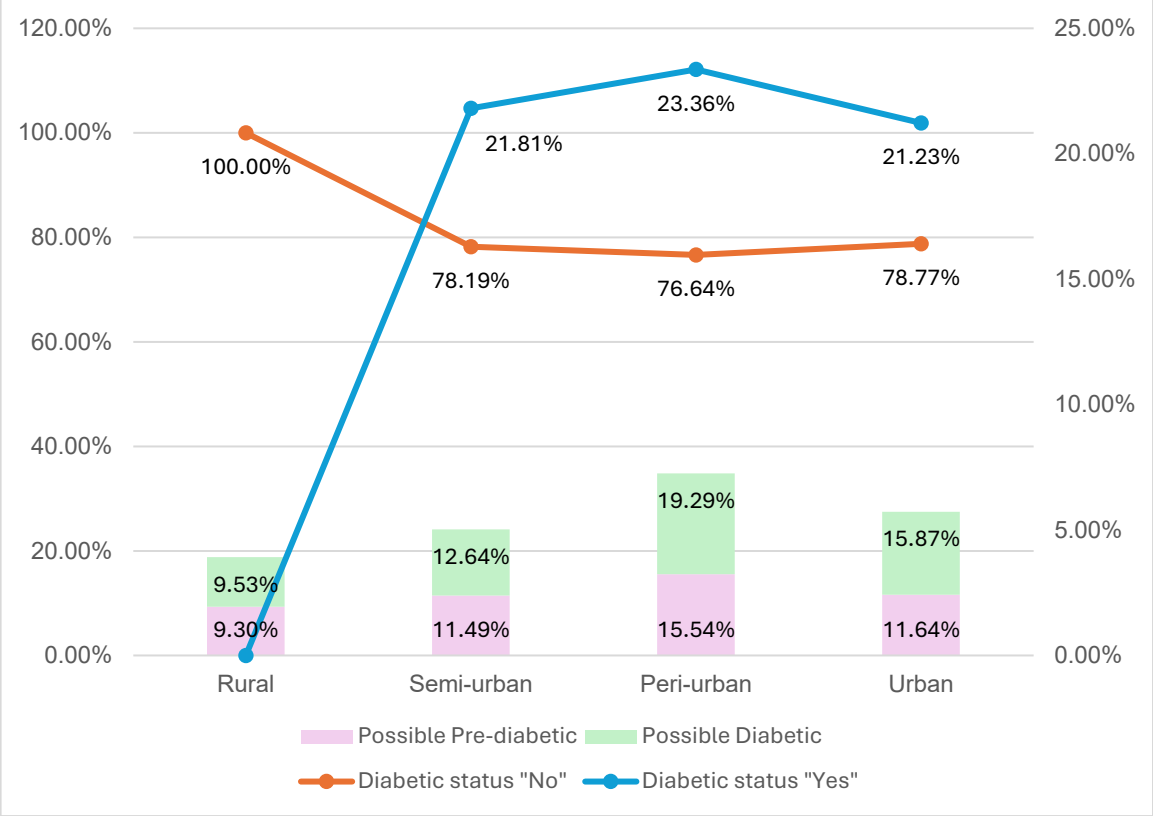
Only 15.9% of urban respondents had a “normal” BMI, while 40.7% and 20.9% of peri-urban participants were classified as overweight and obese, respectively. Notably, only 41.3% of urban participants engaged in high levels of physical activity, which was about half of the rates reported by their rural (78.8%), peri-urban (74.9%), and semi-urban (72.4%) counterparts. In addition, 64.3% of semi-urban participants were non-hypertensive, while 42.9% of the peri-urban participants were either pre-hypertensive or hypertensive. Tobacco consumption was lowest among the urban residents, with only 20.9% of them consuming tobacco.

Compared to rural participants, the diabetes rates were higher among semi-urban, peri-urban, and urban respondents (21.8%, 23.4%, and 21.2%, respectively) (Figure 3.4). Our results clearly indicate that RBG levels for pre-diabetic and diabetic participants increased alongside the scale of urbanicity. The most significant increase was observed for participants in peri-urban areas, where the prevalence of possible pre-diabetes and possible diabetes, as measured by the RBG levels, was 19.29% and 15.54%, respectively.

A very distinct dichotomized pattern of diabetes prevalence was observed between rural and urbanized residential areas. While diabetes was not nominally prevalent among rural participants, the findings revealed that more than one-fifth (more than 21%) of participants in urbanized (semi-urban, peri-urban and urban) areas were living with diabetes. This pattern

indicates that, while urbanicity and diabetes prevalence are not linearly related, urbanicity and its related attributes considerably influence diabetes rates in Bangladesh.

Figure 3.4: Distribution of diabetic status by location of residence.



3.4 Discussion

This study examined the relationship between various demographic and socioeconomic attributes and the prevalence of diabetes mellitus in Bangladesh. To do this, we sought to determine whether and how diabetes rates were influenced by selected risk factors (e.g., metabolic, behavioral, socioeconomic), urbanicity, and place of residence (i.e., rural, semi-

urban, peri-urban, and urban) impacted the prevalence of diabetes mellitus among Bangladeshi adults. Based on our interview findings, we estimate that 10.7% (95% confidence interval 9.9 to 11.5) of Bangladesh's adult population (i.e., aged 18 years or older) is living with diabetes. This finding represents an increase diabetes prevalence from 8.0% in 2016[3] and 9.9% in 2019.[8] The findings also align with the 11.0% prevalence rate reported by Roy[13] in 2019 and conform with the prevalence rate of 14.1% in 2021 projected by the International Diabetes Federation (IDF).[2]

Given Bangladesh's current stage of epidemiological transition, the burden of major NCDs like diabetes, hypertension, and cancers is likely to increase in the coming years. Indeed, the IDF estimates that 22.3 million Bangladeshi adults will have diabetes by 2045.[2] One possible reason for the projected rapid rise in diabetes prevalence may be changing socioeconomic status and other social determinants of health; age; BMI; co-morbidities (e.g., hypertension); food insecurity; poverty; and urbanization.[34–37] In this section, we critically examine these factors in relation to the existing literature.

Aging has been identified as a significant predictor of diabetes among adults in Bangladesh. Our findings revealed that 57.9% of respondents with diabetes were above the age of 45, which is consistent with the findings of numerous other studies conducted in similar settings.[5,9,12,13,16,32,38–40] These results underscore the continued problem of diabetes among older age groups and highlight the need for targeted interventions and preventative

measures. Gender disparities in diabetes and hypertension co-morbidity are also well-documented in the literature.[3,5,8,41] Although our results indicated no significant differences in the overall prevalence of diabetes between the sexes (10.5% of males and 10.9% of females were found to be diabetic), significant gender differences were observed in some risk factors related to diabetes, namely, age, occupation, BMI, and tobacco consumption. This finding is consistent with previous research in Bangladesh, which has found close associations between hypertension and risk factors such as age, BMI, occupation, education, physical activity levels across genders.[1,3,5,16,27,32]

Increased body weight is associated with an increased risk of diabetes, hypertension, and certain cancers. Our findings revealed that 42.7% of the participants were overweight and/or obese. A 2020 study in Bangladesh found that overweight/obese individuals were twice as likely to develop diabetes compared to their normal-weight counterparts.[1] Our results reaffirm such a pattern revealing that the majority (56.4%) of the respondents with diabetes were overweight and/or obese. Obesity and overweight rates are rising in Bangladesh due to changes in lifestyle factors, such as reduced physical activity levels, more jobs that are largely sedentary in nature, a shift to poorer dietary options, and urbanization.[3,11,30] Sedentary occupations, such as office work with sitting long hours, are significantly correlated to higher rates of diabetes, independent of age, BMI, and location of residence.[40] Notably, 11.2% of diabetic participants in this study were unemployed (non-

wage earners), including housewives. Furthermore, 14.6% of participants with diabetes were employed as day laborers or were occupied in farming and fishing—physically intensive occupations.

Individuals suffering from diabetes often also suffer from hypertension. As such, studying this comorbidity is crucial for research into either of these conditions.[5] Our findings revealed that 45.9% of the participants with diabetes were also possible pre-hypertensive or hypertensive, and that individuals with pre-existing hypertension were 2.14 times more likely to have diabetes compared to those who were not. Tobacco use, including smoking and chewing, is a significant health burden in South Asian countries such as India, Pakistan, and Bangladesh. This behavior contributes to oral and lung cancers, as well as increased rates of diabetes and cardiovascular diseases.[14,42–46] Our results, however, did not indicate a positive association between tobacco use and diabetes, which is likely the result of a Type II error (i.e., false-negative rejection of null hypothesis).

Among other factors, post-secondary higher levels of education were found to be a significant risk factor for diabetes among participants in our study. Participants with secondary and higher secondary education were 2.3 and 2.72 times more likely to have diabetes compared to those with no formal schooling. These results are consistent with prior work focusing on India, which found higher rates of diabetes among educated older adults.[14] Moreover, our results showed that educational attainment was positively correlated to

wealth status and, by extension, more sedentary lifestyles. Prior work has shown that, in general, increased per capita GDP is correlated with a decrease in diabetic risk factors.[4] However, this pattern does not hold for South-Asian countries, where risk factors continued to rise alongside socioeconomic status.[3,9] Our findings indicated a significant association between the prevalence of diabetes among individuals in the "lower middle" socioeconomic category (OR:1.06, 95%CI :0.83-1.38). This increase is likely to be attributed to these individuals' improved economic conditions and the associated lifestyle changes, a relationship which has been demonstrated in many studies on the link between socio-economic disparities and diabetes prevalence.[3,5,8–10] Hoque et al.'s study of the 2011 BDHS found that individuals living in rural areas and belonging to lower socio-economic groups were less likely to be aware of underlying health conditions and more likely to remain undiagnosed.[8,47] Our survey results indicated that all (i.e., 100%) rural participants had no prior diabetic status, likely due to being undiagnosed.[32] However, blood testing showed that 18.1% of rural participants had RBG levels that were high enough to qualify them as possible pre-diabetic or possible diabetic.

While previous studies[3,8–10,13,14] have shown a strong association between location of residence and diabetes prevalence, our multivariable analysis did not find a statistically significant association between these two variables, after adjusting for other factors. Nonetheless, it is important to note that the univariate analysis revealed a strong correlation

between urbanicity and diabetes prevalence through various related behavioral and physical risk factors. The results showed an ascending gradient, wherein diabetes rates increased from rural areas to *Upazila* headquarters (semi-urban) to peri-urban and urban areas. We found that 21.2% or respondents in urban and 23.4% of respondents in peri-urban areas were living with diabetes. The results for the peri-urban participants reflects a change in lifestyle: 30% of this group was engaged in service-related work, 52.2% were unemployed (including housewives), and over 61.6% were overweight/obese (vs. 33.7% of rural respondents). These results are supported by those reported in a previous study in India, which found that the "urbanizing population would have a prevalence of diabetes intermediate to that of the urban and rural population."[40(p208)] Comparing the rates of diabetes in *Upazila* HQ (semi-urban) and peri-urban areas, our findings showed that diabetes was slightly more prevalent among respondents in the latter group (21.81% and 23.36%). This result further underscores the impact of urbanicity and the transitional stages of urbanization in the fringe areas of major urban centers on diabetes rates in Bangladesh.

3.4.1 Contributions and limitations of the study

This study's major strength was its population survey-based coverage, which enabled a very large sample consisting of men and women living in areas with varying degrees of urbanization in Bangladesh's eight divisions. As such, the results presented herein are generalizable to Bangladesh's adult population in different administrative and geographical

regions. Furthermore, the findings of this work are detailed and comprehensive, as the collected data consisted of both individual- and household-level components. Moreover, the use of standardized physical examinations to determine the participants' height, weight, and blood pressure mitigated recall bias and enhanced the accuracy of the findings. Along with appropriate statistical methods for estimating the age-standardized prevalence of diabetes risk factors in the population, a principal component analysis (PCA) was used to determine the wealth quintiles and, thus, the socioeconomic status of the surveyed households for the administrative regions.

Nonetheless, our study has several limitations. First, instead of using longitudinal data, our study relied on cross-sectional data, which precluded our ability to identify causal relationships between diabetes and the selected risk factors over time. Second, we were limited to collecting RBG levels, as we were unable to collect fasting blood glucose levels. Hence, diabetes was classified as self-reported information. Third, asset-based quantification was used to define the wealth quintiles, which enables easier comparison between regional locations; however, this approach is not comprehensive and is poor at capturing financial inequalities. Lastly, data relating to physical activity were obtained retrospectively, with participants being required to recall several activity scenarios in minutes/hours/days/weeks. As a result, participants may have under- or over-estimated

their physical activity levels. Thus, future research could develop and incorporate objective measures to increase data validity for these variables.

3.5 Conclusion

This study provides a comprehensive analysis of the patterns and factors influencing diabetes mellitus among Bangladeshi adults. Consistent with prior studies, our findings revealed that over 18 million adults in Bangladesh are currently living with diabetes. Diabetes status was found to be associated with increasing age, sedentary occupations, and various lifestyle factors (e.g., diet). Obesity and being overweight were also found to be significant factors influencing the prevalence of diabetes among the participants. While previous studies have shown a strong association between diabetes rates and location of residence, our univariate analysis indicated a strong correlation between urbanicity and diabetes prevalence through various related behavioral and physical risk factors. The results demonstrated an ascending gradient wherein diabetes rates increased from rural areas to *Upazila* headquarters (semi-urban) to peri-urban areas and, finally, to urban areas. Additionally, our findings show a direct association between socioeconomic status and diabetes prevalence, particularly among respondents in the “lower middle” category. Notably, the multivariable analysis did not find that urbanicity is a significant predictor of diabetes prevalence when other factors are adjusted simultaneously. Based on the findings of recent studies,[15,16] we can presume that this result was likely due to a Type II error.

Our findings contribute to the existing understanding of diabetes epidemiology in Bangladesh by highlighting the multi-layered and interconnected nature of the risk factors. While access to information and health resources may reduce risk factors for advantaged individuals, the relationship between socioeconomic status and risk factors underscores the need for equity-based approaches to minimize their impact. As such, it is critical to develop targeted interventions focused on promoting healthy aging strategies; enhancing access to diabetes education, screening, and management; and advocating for lifestyle modifications, including increased physical activity and healthier dietary practices. Furthermore, customized interventions that consider area-specific risk factors and socioeconomic contexts will also be essential to reducing the prevalence of diabetes among the adult population of Bangladesh.

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CHAPTER 4

Discussion and Conclusion

4.1 Introduction

Recognizing that an understanding of the patterns and trends in hypertension and diabetes prevalence and their risk factors, from an Ecohealth (i.e., interdisciplinary) perspective, is crucial to formulating appropriate interventions aimed at prevention and control of non-communicable diseases (NCDs), the present study was conceptualized. It was further realized that an understanding of the differences in the distributions of NCDs caused by varied magnitude of urbanicity is important from a policy perspective. In this backdrop, the present study has examined the patterns in the distribution of hypertension, diabetes mellites and degree of influence of various risk factors, including sociodemographic, socioeconomic and urbanicity variables.

Existing literature on hypertension and diabetes in Bangladesh typically is not population survey-based; these studies are primarily focused specific areas, specific age groups, or gender with a very small sample size of the targeted population or of a particular cohort [1–6]. Also, inquiry into the patterns in diabetes at multiple levels of urbanized areas (urban, peri-urban, *Upazila* HQ) has not yet been pursued. Thus, the ultimate purpose of this research was to fill in the gaps and explore any inconclusive results. To this end, this study

aimed to achieve three broad objectives: (i) to determine the prevalence of hypertension and diabetes among adults in Bangladesh; (ii) to examine the distribution of hypertension and diabetes by age, gender, socio-economic status and place of residence; and (iii) to identify and determine the relationship between hypertension and diabetes and their risk factors in Bangladesh by age, gender, socio-economic status and place of residence.

The connection between Ecohealth variables and non-communicable diseases (NCDs) is strong as they are closely intertwined. Ecohealth thinking and it associated models, which have a strong influence on public health, are based essentially on four broad components that have impacts on the health of individuals and communities, namely the biophysical setting (environment), social factors (including economic and structural aspects), behavioral aspects of individuals (lifestyle), and their genetic baggage (biologic makeup) [7–9]. These health models provide the framework for understanding the complex factors that contribute to NCDs which themselves represent a major global health challenge. NCDs are also caused by a combination of various socio-demographic, geographic, behavioral, and physical factors. NCD risk factors are broadly classified into modifiable and non-modifiable categories. On one hand, gender, age, ethnicity, and underlying genetic factors are beyond an individual's control and are therefore non-modifiable. On the other hand, lifestyle, food choices and place of residence are modifiable and can be changed by an individual's control or choice. This has often been termed as a social justice issue of the present and future

generations – as the distribution of NCDs is not only linked with political and regional change, but also with the socioeconomic development status of the country concerned, the communities at large and individuals at the micro level. Such an increase in the global burden of NCDs has been followed closely by the loss of traditional food habits and an increase in the intake of processed foods that were high in sugar, salt, and fat. In addition to the changes in cultural norms, the decline in physical activity has also led to a rise in NCDs [10]. During 1986-2006, NCDs, primarily cardiovascular diseases, diabetes, chronic obstructive pulmonary disease, and cancers, increased by 60% globally [11].

Equity aspects relevant to NCDs can be divided into the following broad (and overlapping) categories [7–9]: vulnerability in contracting disease; access to health resources; coping capacity in experiencing disease; and the ability to influence policy and decision-making that impact health production. Inequities in each category are shaped by social and/or ecological processes and to a large extent determine who is affected by a disease and how the person and household are affected. These occur at different ecosystem levels, the individual, the household, and the community levels. [9].

Prior studies on NCD prevalence in Bangladesh revealed that an increasing trend in NCDs is primarily associated with changes in dietary patterns, food insecurity and poverty, lifestyle, and urbanization [10,12–14]. Bangladesh society experienced a remarkable improvement in food production and availability in recent decades, yet the typical diet in the

country, at both the individual and household level, remains predominantly carbohydrate-heavy and imbalanced [15]. With increasing wealth and improved opportunities to consume better food choices, although it was expected that the country would see more diverse food patterns among its urban population, it did not occur. Families have slowly started consuming foods that are leading up to accumulated risk factors and targeted mineral and vitamin deficiencies [16]. Such imbalanced and inadequate dietary intake is one of the main reasons for the increasing "double burden" of NCDs, coexistence of hypertension and diabetes, being overweight and obesity. In addition, the prevalence of inadequate physical activity has increased significantly over the years in Bangladesh. Riaz [11] reported that, due to a sedentary lifestyle in the population across the country, there is fear of a looming health catastrophe for the nation in the near future.

The prevalence of NCDs in the eight divisions of Bangladesh is representative of the lifestyle of the populations in those regions. The administrative regions in Bangladesh reveal an inequality in the prevalence of diabetes and hypertension. The socioeconomic differences due to the varying magnitudes of urbanicity in the country highlight the inaccessibility to healthcare services due to poor and/or developing infrastructure, weak communication systems, low level of education and income. Al-Zubayer [17] focused on both individual and community level factors associated with NCDs. The study revealed that the richest communities and the richest individuals residing in poor communities were more

vulnerable to NCDs. This further affirms that the communities that had less modernized ways of living and higher levels of occupation-related physical activities had lower NCDs [11]. The prevalence of the "double burden" of NCDs- hypertension and diabetes, in Mymensingh and Rajshahi division were at 16.5% and 17.8% respectively, whereas the prevalence was 24.8% in Chittagong and 24.5% in Dhaka divisions as larger urban centers. Previous studies on division level prevalence of NCDs have also emphasized on the association of place of residence on the prevalence of NCDs [18].

Women in Dhaka had a higher hypertensive rate when compared to the other divisions surveyed. The Rahman [19] study concluded that there is a significant socio-economic inequality in hypertension prevalence across regions (districts), and across the various economic strata in society. In a study on Bangladeshi adults from Dhaka, Barisal and Rangpur Divisions, it was reported that men were increasingly obese in these divisions due to a sedentary lifestyle and occupation [5]. Studies had also identified a rising trend in, and greater proportion of, women being obese and overweight due to a sedentary lifestyle and prevalence of insufficient physical activity in "urbanized" population [5,20–23]. Low physical activity has an environmental component, through transport modes, city design, and access to green spaces [23–25]. In addition to insufficient physical activity and poor dietary habits, raised blood pressure, unfavorable blood cholesterol levels and raised glucose levels had also been identified as NCD risk factors in several epidemiological studies in Bangladesh

[12–14,22]. This further reinforced the findings by Al-Zubayer [17] that urbanicity has led to higher prevalence of NCDs with growing double and triple burden- hypertension, diabetes and obesity.

4.2 Key findings of the study

Each of the three aforementioned objectives was achieved, and the related findings and analyses have been detailed in the preceding two chapters. The key findings in these chapters are synthesized below.

Prevalence and risk factors of hypertension in rural Bangladesh: The main goal of Chapter 2 was to examine the distribution and associated risk factors of hypertension (physical, behavioral, dietary habits, and socioeconomic status-SES) among individuals living in rural Bangladesh. It was revealed that 33.7% of males and 28.6% of females had elevated blood pressure, qualifying them as either prehypertensive or hypertensive. This finding represented an increase in the prevalence of hypertension [19,26]. Education in women did not indicate a significant association with hypertension rates, which was contradictory to the trends observed in other studies across the LMICs, including Bangladesh [1,21,26–32]. In addition, the results of this study did not find a direct association between SES and hypertension prevalence. This diverged from the findings of numerous prior studies, which successfully demonstrated a positive relationship between household wealth and hypertension [6,7,9,11,16,22]. Within the context of rural

Bangladesh, improvements in household wealth index score, household size, occupational status of household head and spouse, spousal educational status, vegetable and fruit cultivation all impact the wealth quintile categorization. The majority of participants included in this study worked as day laborers or in agricultural fields and the women were majorly housewives. Therefore, the wealth-quintiles for SES were categorized adjusted off of the resulting wealth score variance. However, consistent with prior findings, we found that individuals from higher SES groups exhibited healthier dietary habits, such as consuming more fruits and vegetables [6,48]. Age, BMI, tobacco consumption and fruit and vegetable intake significantly influenced the likelihood of hypertension, highlighting the need for targeted interventions and preventative measures. The overall findings of the study suggested that while lifestyle factors play an important role in risk for hypertension, other non-ascribed sociodemographic factors, such as age and gender, are likely to contribute to its prevalence [11] in rural Bangladesh.

Prevalence of diabetes among the adult population of Bangladesh - effects of urbanicity and other risk factors: In the third chapter association between prevalence of diabetes and the effects of associated risk factors (metabolic, behavioral and socioeconomic status) on diabetes was examined. A specific postulation regarding the effects of urbanicity on diabetes prevalence among Bangladeshi adults was of particular interest of this study – which was examined in terms of various place of residential location

(i.e., rural, semi-urban, peri-urban, and urban). The findings revealed that 10.7% of the population aged 18 years and above had diabetes, and that aging was a significant determinant of diabetes among Bangladeshi adults.

The results also revealed that 56.4% of the participants with diabetes were overweight and/or obese. Among other factors, a higher level of education was found to be a significant risk factor for increased odds of diabetes in our study. Individuals with secondary and higher secondary education were 2.3 and 2.72 times more likely to have diabetes compared to their counterparts with no formal schooling. The results showed that education levels improve wealth status which in turn leads to a more sedentary lifestyle. Although the multivariable analysis did not reveal a statistically significant association between residential location and diabetes, it is important to signify that the univariate analysis revealed a strong correlation between urbanicity and diabetes prevalence through various related behavioral and physical risk factors. The results demonstrated an ascending gradient of diabetes from rural to *Upazila* headquarter (semi-urban) to peri-urban and urban areas. We found the prevalence of diabetes in urban areas at 21.2% and at 23.4% in peri-urban areas. Our survey results indicated that all (i.e. 100%) of the rural participants had no prior diabetic status, likely due to being undiagnosed [34]. The results emphasized the importance of an in-depth perspective on the prevalence of diabetes in the metropolitan cities, peri-urban areas (contiguous to the cities), semi-urban areas (*Upazila* headquarters which are newly

urbanizing places) as well as in rural areas (non-urban locations), in the context of an ongoing urbanicity process in Bangladesh.

4.3 Major contributions of the research

The world is subject to the influence of many complex factors that undermine the health of living beings. Social, cultural, and economic activities of people – from local household decisions to national policies are all occurring within ecosystems while controlling human health and shaping the relationships people have with ecosystems. These interconnected risk factors for diseases cannot be resolved solely with the conventional biomedical approach[8]. In contrast, ecosystem approaches to health draws on both natural and social sciences, and their consideration of system behaviors, as well as methodologies and interpretation of results. This research deals with the production of knowledge that can be immediately applicable to change conditions related to diabetes and hypertension [9].

There are numerous biomedical and epidemiological contributions to the study of NCDs and their risk factors in Bangladesh. However, there are very few interdisciplinary population survey-based research on these themes. Recognizing the need for current interdisciplinary contributions to existing knowledge about the relationship between hypertension and diabetes risk factors, particularly lifestyle, physical activity and place of residence, this study will aid immensely. Aside from the conventional rural-urban split, the study included results from peri-urban and semi-urban areas. This highlighted the transitional levels of

urbanization in Bangladesh and the need to formulate healthcare education and interventions accordingly.

This study also identified considerable gaps between the knowledge and awareness of diabetes in rural Bangladesh. The finding revealed that all (i.e. 100%) of the rural participants had no prior diabetic status, likely due to being undiagnosed. This may also be attributed to Type II statistical error. In this regard, the need to reassess the barriers to seeking healthcare is an urgent research agenda.

4.4 Limitations of the study

This study had the following limitations:

- The data collected used the 24h recall method for food consumption. The questions regarding adequate vegetable and fruit intake may have been difficult for participants to conceptualize, as recalling one's intake during a typical week/day is highly contextual to temporal food availability and affordability. Data for physical activity was also collected retrospectively, with participants being required to recall several activity scenarios in minutes/hours/days/weeks. As a result, participants may have under- or over-estimated their physical activity levels.
- For the socio-economic index- wealth quintiles, asset-based quantification was used, which is easier for comparison between regional locations broadly, but it is not

comprehensive to the financial inequalities, hence the urbanicity scores may be over-or-under estimated.

- Though the sample size used in the study was large, it was not a national-scale sample. Therefore, the inferences made in this work should be taken with caution.

4.5 Recommendations

The study highlighted the association of lifestyle, socio-economic status and place of residence with hypertension and diabetes in Bangladesh. As the magnitude of urbanicity progresses, there is an urgency to control the diabetogenic and hypertensive environment that is being created. The success and sustainability of interventions will depend largely on the degree of social mobilization and public participation. The following are the specific policy and research recommendations that are aligned with the objectives of the study:

Objective I: Determine the prevalence of hypertension and diabetes among the adult population in Bangladesh

- As the risk factors for NCDs are determined by the social, environmental and economic settings [7–9,37], coordinated action across multiple sectors in Bangladesh is required. Sectoral policies, including transport, finance, education, and local governments shape these conditions and therefore, a comprehensive public policy and participatory governance approach [7,9] is needed to reduce and contain NCDs.

- Prioritizing interdisciplinary, longitudinal studies to enhance understanding of NCD trends across time and generations. In order to inform policy development, monitoring and evaluation, population-based and clinical research data alongside local evidence are required. In this regard, interdisciplinary, longitudinal studies in regional and local contexts should be given priority.
- Effective leadership, multisectoral partnership, and community mobilization, apart from other interventions that have been cited in all NCD-relevant documents [37], e.g., advocacy, research, and surveillance are essential for the prevention and management of non-communicable diseases. The government should develop collaboration among different institutions related to NCD care, including education, to incorporate relevant materials into the curriculum and establish standards and protocols for NCD services at all levels of healthcare.
- Strategies should be formulated to establish dialogues and collaborations with the private sector-including food and beverage, tobacco and service industries-to balance their influences.
- Evaluation programs and diabetes awareness research to improve knowledge of risk factors among the population should be strengthened. Effective policy formulation and programming are needed to enhance public awareness about the importance of balanced diet, options for behavioral modification and lifestyle changes.

- Population-based and clinical research to track prevalence, alongside local evidence should be pursued. Health promotion and disease-risk-reduction policies and intervention programs require attention to gendered risk factors. There are several religious and cultural constraints in rural areas that challenge the success of such programs, these aspects need to be carefully addressed through public education and social mobilization.

Objective II: Examine the distribution of hypertension and diabetes by age, gender, socioeconomic status, and place of residence

- Health promotion and risk reduction policies, with attention to gender-specific risk factors and cultural constraints should be formulated. Women play a vital role as family health managers within the Bangladeshi society. This study was not able to establish a significant association between hypertension and the level of education in women. Further research on this topic is recommended as it would provide the scholarly and policy communities with more robust understanding of how women's education impacts family health management, which can translate into better public health outcomes. Epidemiological research has generally considered each NCD as a separate health outcome, and a comprehensive approach to the diseases of adulthood and aging is still lacking. In addition, there is growing evidence that NCDs largely arise not only as a consequence of adult exposure but, more importantly, because of exposure to risk

factors in critical periods of development *in utero* or during childhood and adolescence [38]. Long-term research in this theme is therefore recommended, particularly for a better understanding of NCDs across years and generations. Targeted policies and programs for children are therefore necessary.

- Socioeconomic determinants of diet and lifestyle through targeted interventions and nutrition-sensitive policies should be identified and appropriate programing should be developed. Interventions aimed at promoting healthy balanced diets, particularly the intake of fruits and vegetables, are urgently needed. Mass media campaigns about the benefits of healthy dietary practices and their associations with hypertension and diabetes are recommended.
- Place-of-residence-specific interventions in national policy formulation to accommodate urban and rural disparities should be implemented. A consideration of the importance of the place of residence-specific interventions in national policy formulation will help to attain Bangladesh's commitment to the 2030 UN Sustainable Development Goals.
- Early detection and screening efforts, especially in rapidly urbanizing rural areas should be ensured. Furthermore, strategic planning to address issues of rapid expansion of urban settings is necessary. More stakeholders need to be involved in carrying out healthcare interventions in the context of the risk factors identified.

Objective III: Identify and analyze the relationship between hypertension and diabetes and their risk factors

- Government leadership and multisectoral collaboration across different institutions should further be strengthened.
- Balanced diet education through public awareness campaigns, including mass media initiatives should be promoted. Researchers could explore simple and low-cost prompts for changing food consumption patterns towards healthier diets. This would help design sustainable food policies with a nutrition-sensitive lens. Income increase alone does not lead to better nutritional outcomes. Therefore, nutrition awareness and accessibility to nutritious food are also suggested.
- Food consumption patterns, engaging the private sector to balance influences from food, beverage, and tobacco industries should be sensitized, and where needed, should be regulated. Food consumption and demand changes need to be examined in Bangladesh, particularly in relation to different socio-economic groups and location of residence. Increasing urbanicity and socio-economic status has revealed an increasing obesity amongst the population. Therefore, there is a growing need to reinforce nutrition awareness campaigns in urbanizing areas to encourage people to avoid fatty food and to adopt healthy eating.

- Tobacco control legislation to reduce smoking-related risk factors should be enforced. Tobacco consumption in any form should be discouraged amongst all sectors of the population. Enforcing tobacco control legislation, including smoke-free public places and bans on advertising and promotion are suggested.
- Regular physical activity, improving neighborhood walkability and access to active areas should be encouraged by policy initiatives. Better access to physical activity, neighborhood walkability and accessibility to “active areas” is important. More years of education have increased sedentary work opportunities. Though this has led to a higher socioeconomic status, it has also increased urban obesity. Access to physical activity in conjunction to the scheduled workday would immensely benefit the urban population.
- Explore long-term studies on early-life exposure to risk factors, ensuring comprehensive prevention strategies.

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Appendices

Appendix A: TCPS 2 Core Certification

PANEL ON RESEARCH ETHICS

Navigating the ethics of human research

TCPS 2: CORE 2022

Certificate of Completion

This document certifies that

Sobiya Badat

successfully completed the Course on Research Ethics based on the Tri-Council Policy Statement: Ethical Conduct for Research Involving Humans (TCPS 2: CORE 2022)

Certificate # 0000822141

16 March, 2023

Appendix B: Research Ethics and Compliance approval

University of Manitoba | Research Ethics and Compliance

Human Research Ethics - Fort Garry
66 Chancellors Circle
Winnipeg, MB R3T 2N2
humanethics@umanitoba.ca

RENEWAL APPROVAL

Effective: August 23, 2024 New Expiry: September 18, 2025

Principal Investigator:	Sobiya Aziz Badat
Advisor(s):	C Haque
Protocol Number:	HE2023-0279
Protocol Title:	*Non-communicable disease risk factors in Bangladesh: A focus on dietary habits, place of residence, and gender*

Office of Human Research Ethics as designated by REB2

Research Ethics Board 2 has reviewed and renewed the above research. The Office of Human Research Ethics (OHRE) is constituted and operates in accordance with the current *Tri-Council Policy Statement: Ethical Conduct for Research Involving Humans- TCPS 2 (2022).*

Please note the following important information about your renewal approval:

i. Any changes to the protocol or research materials must be approved by the OHRE **before implementation.**

ii. Any **deviations** to the research or **adverse events** must be reported to the OHRE immediately through an **REB Event**.

iii. This renewal is valid for **one year only**. A Renewal Request must be submitted and approved prior to the above expiry date.

iv. A **Protocol Closure** must be submitted to the OHRE when the research is complete or if the research is terminated.

Appendix C: Final Baseline Survey – English

Study on Reducing Dietary Related Risks associated with Non-Communicable Diseases Baseline Survey 2017

Module A: Household Identification Information

Name of the respondent		Member No.(**MID Code**)	
Name of the respondent		Member No.(**MID Code**)	

Mobile No. of the respondent (On request No. if personal no. is unavailable):

Q No.	Household Identification	Code	Code
A1	Household Identification Number (from the list)		Name and Code of the Interviewer (from the list)
A2	Name of Village (from the list)		Date of the interview: Day / Month / Year
A3	Code of the Union Parishad (from the list)		Signature and Code of the Supervisor (from the list)
A4	Upazila Code (from the list)		Date of Data verification by Supervisor: Day / Month / Year
A5	District Code (from the list)		**A8** Ethnicity Code: **Code A8: 1**.Not ethnic minority, **2**.Ethnic minority
A6	What religion do you belong to? **1**. Muslim, **2**. Hindu, **3**. Christian, **4**. Buddha **5**. Others (specify)		**A9** If Ethnic minority **Code A9: 1**. Chakma, **2**. Santal, **3**. Garo, **4**. Monipuri, **99**. Other (specify)
A7	What is your mother tongue? **1**. Bangla, **2**. Ethnic, **99**. Other (specify)		

Module B: Household Members Information (Information of Household members)

Household member identification number	Name	Relation with HH Head	Sex	Age	Education	Can you read or write?	Marital Status	Ocupation		If any member live outside house, where does he/she live?	Earning member	Training related info(could be more than one)		
								Main	Secondary					
		CodeB01	Code B02		CodeB04	CodeB05	CodeB06	CodeB07	CodeB08	Code B09	Code B10	Code B11-13		
MID	Name	B01	B02	B03	B04	B05	B06	B07	B08	B09	B010	B11	B12	B13
01 HH Head														
02														
03														
04														
05														
06														
07														
08														
09														

10														

Code for Module B: Household Members Information

Relation CodeB01	**Sex Code B02**	**Education CodeB04**	***Can read or write* CodeB05**	**Marital status CodeB06**	**Ocupation CodeB07 (Main)** Ges **B08 (Secondary)**	***Where does live outside house?* Code B09**	***Earning member* Code B10**	***Training related infos* Code B11-13**
<u>Relation with HH Head:</u> **1**. HH Head **2**. Husband/wife **3**. Son/Daughter/Son in law/Daughter in law **4**. Father/mother **5**. Brother/sister **6**. Grandchild **7**. Father in law/mother in law **8**. Brother in law/sister in law **9**. Nephew/niece **10**. Uncle/Aunt **11**. Employee/domestic worker **12**.	**1.** Male **2.** Female **3.** Common	**1.** No formal education **2.** Illitarate **3.** Under class V **4.** Primary (Class V pass)) **5.** JSC (pass) **6.** SSC/Dakhil (pass) **7.** HSC/Alim/Diploma Engineer (pass) **8.** Graduation/Fazil/MBBS/BSc Engineer (pass) **9.** Masters/Kamil (pass) **10.** Not applicable **99.** Others (specify)	**1.** Can read **2.** Can write **3.** Can read and write **4.** Not applicable	**1.** Unmarried **2.** Married **3.** Separated **4.** Divorced **5.** Widowed **99.** Others (specify)	**1.** Day labor (works for others) **2.** Labor (work for himself) like Weaver, Blacksmith, Potter, Riksha driver etc. **3.** Agriculture **4.** Small business **5.** Service **6.** Student **7.** Housewife **8.** Unemployed	**1**. lives in house **2**. lives outside house but in the country **3**. lives abroad	**1.**Earning member **2**. Non-earning **3**. Not Applicable	**1.** Vegetables cultivation **2.** Health **3.** Nutrition **4.** Family Planning **5.** Maternal health **6.** Income generating activity **7.** Accounting **8.** Adult literacy **9.** Did not get any training **99**. Others (specify)

Relation CodeB01	**Sex Code B02**	**Education CodeB04**	***Can read or write* CodeB05**	**Marital status CodeB06**	**Ocupation CodeB07 (Main)** Ges **B08 (Secondary)**	***Where does live outside house?* Code B09**	***Earning member* Code B10**	***Training related infos* Code B11-13**
Homeless/Displaced **13**. Lodging **99**. Others (specify)					**9.** Retired **10.** Expatriat (Specify, like write the job he or she does, if not known what he/she does, please write- not known) **11.** Fisher **12.** Village Doctor **13.** No occupation **14.** Not applicable **99.** Others (specify)			

Module C: Housing Types

µ.bs	Housing Types		Code
C1	Do you live in your own house? **Code C1:** 1. Yes, **2**. No, (Question **C2** is not applicable if the answer is YES), **3**. Don't know/ does not answer	**C1**	
C2	If the answer of C1 is NO, what is your housing settlement? **Code C2: 1**. Rent, **2**. Khas, **3**. Other places without rent, **4**.Common (Ezmali), **99**. Others (specify)	**C2**	
C3	How many rooms are there in your house? (without Kitchen, Toilet and open Cow-shed)	**C3**	
C4	What are the Wall Material of your house? **Code C4: 1**. Brick cement **2**. Tin **3**. Bamboo, **4**. Mud **99**. Others (specify)	**C4**	
C5	Source of your drinking water **Code C5: 1**. Water supply, **2**. Tubewell, **3**. Pond/river/streams, **4**. well, **5**. Rain water, **6**. PSF, **99**. Others (specify)	**C5**	
C6	What type of sanitation/toilet do you have? **Code C6: 1**. Water sealed, **2**. Not water sealed, **3**. Open, **99**. Others (specify)	**C6**	
C7	Do you have electricity in your house? **Code C7: 1**. Yes**, 2**.No	**C7**	
C8	Do you have solar elecricity in your house? **Code C8: 1**. Yes, **2**.No	**C8**	
C9	How many member of your HH have Mobile pone? Write the number. (If one member have more than one mobile, count 1)	**C9**	

Module D: Household Asset

Sl No.	Description of Asset		Number
Electronic/Electric (number)			
1.	Radio	**D1**	
2.	TV	**D2**	
3.	Computer	**D3**	
4.	Fridge	**D4**	
5.	Swing Machine	**D5**	
99.	Others (specify)	**D6**	
Transport			**Number**
6.	Bicycle	**D7**	
7.	Motor Cycle	**D8**	
8.	Private Car	**D9**	
9.	Riksha/Riksha Van	**D10**	
10.	Batery powered Riksha	**D11**	
11.	CNG/Baby Taxi	**D12**	
12.	Easy Byke	**D13**	
13.	Pickup/Truck	**D14**	
14.	Bus	**D15**	
15.	Boat	**D16**	
16.	Engin boat	**D17**	
99.	Others (specify)	**D18**	

Sl. No.	Household Animal		Number
17.	Cow	**D19**	
18.	Bull	**D20**	
19.	Buffalo	**D21**	
20.	Goat	**D22**	
21.	Sheep	**D23**	
22.	Boar	**D24**	
99.	Others (specify)	**D25**	
Poultry			**Number**
23.	Hen	**D26**	
24.	Duck	**D27**	
25.	Swan	**D28**	
26.	Pegion	**D29**	
99.	Others (specify)	**D30**	
Fishery asset land quantity (Decimal)			**Decimal**
27.	Pond fishery	**D31**	
28.	Gher's Fishery (Shrimp)	**D32**	
29.	Gher's Fishery (Fish)	**D33**	
30.	Pagar/well	**D34**	
31.	Pan culture	**D35**	
99.	Others (specify)	**D36**	

Sl. No.	Tree Asset		Number
32.	Fruit Tree	**D37**	
33.	Timber Tree	**D38**	
34.	Medicinal Tree	**D39**	
99.	Others (specify)	**D40**	
Agriculture Equipment			**Number**
35.	Tructor	**D41**	
36.	Power tiller	**D42**	
37.	Irrigation Pump	**D43**	
38.	Mowing machine	**D44**	
99.	Others (specify)	**D45**	

Module E: Agricultural Practices

Sl.	Description	E1.1 Single Crop	E1.2 Double Crop		E1.3 Triple crop
1.	How much land did you cropped last year? (1 July 2016 to 30 June 2017) (in **Decimal**)				
2.	What is your agricultural land settlement? (Write in decimal)	**E2.1 Own**	**E2.2 Share Cropping**	**E2.3 Khas**	**E2.4 Mortgaged**
3.	Did you grow vegetables last year? **Code** E**3: 1**. Yes, **2**. No (**Modelue F and question 4 is not applicable if the answer is NO)**			**E3**	
4.	How many decimal in your homestead did you grow vegetables last year? (in decimal)			**E4**	
5.	Do you grow fruits? **Code E5: 1**. Yes, **2**.No (**Question 6 and Modelue G is not required if answer is No**)			**E5**	
6.	In how many decimal in your homestead do you grow fruits? **(in Decimal)**			**E6**	
7.	What vegetables are in great demand in your HH/Village **(Code E7)**				
8.	What fruits are in great demand in your HH/Village **(Code E8)**				

Module F: Vegetables Related Information (1 July 2016 to 30 June 2017)

Sl. No.	Last year what vegetables did you grow	For how many years do you grow this vegetable	Land used to grow veg. last year (without homestead and in **decimal)**	Production of veg. last year (KG/Decimal and with homestead)	Variety of vegetables	Do you follow Safe Veg. production process (GAP)	How many season/year do you grow vegetables?	Usage of vegetables (answer may be more than one)			How much money have you made by selling Veg.?	Where do you sell vegetables? (may be more than one answer)		
	Code F01				**CodeF05**	**Code F06**	**Code F07**	**Code F08-10**				**Code F12-14**		
	F01	**F02**	**F03**	**F04**	**F05**	**F06**	**F07**	**F08**	**F09**	**F10**	**F11**	**F12**	**F13**	**F14**
1.														
2.														
3.														
4.														
5.														
6.														
7.														

Code for Module F: Vegetables Related Information

Code for F01 and E07 Name of Vegetables			**Code for F05 Variety of vegetables**	**Code for F06 Do you follow GAP?**	**Code for F07 How many times/year**	**Code for F08-F10 Usage of Veg.**	**Code for F12- F14 Where do you sell?**
1. Cabbage **2.** Cauliflower	**24.** Bitter gourd **25.** Teasle	**46.** Water spinach **47.** Kangkong **48.** Sweet potato	**1.** Local **2.** High yeild	**1.** Yes **2.** No **3.** Don’	**1.** Summer / Rainy Season	**1.** Own consumption	**1.** Sale in local market

3. Broccoli **4.** Kholrabi **5.** Petsai **6.** Mustard green **7.** Turnip **8.** Radish **9.** Pea **10.** Hyacinth bean **11.** yard long bean **12.** French bean **13.** soybean **14.** Tripatri leaves **15.** Yam bean **16.** Sweet gourd **17.** Bottle gourd **18.** Wax gourd **19.** Cucumber **20.** Cucumber (short) **21.** Ribbed gourd **22.** Sponse gourd **23.** Bitter gourd (small)	gourd **26.** Pointed gourd **27.** Snake gourd **28.** Squash **29.** Muskmelon **30.** Snap melon **31.** Potato **32.** Brinjal **33.** Tomato **34.** Sweet pepper **35.** Okra **36.** Stem amaranth **37.** Red amaranth **38.** Spiny amaranth **39.** Leaf amaranth **40.** Indian spinach (green) **41.** Indian spinach (red) **42.** Spinach **43.** Bathua **44.** Helencha **45.** Lettuce	**49.** Carrot **50.** Thankuni **51.** White yam **52.** Eddoe **53.** Taro **54.** Tannia (Dudkachu) **55.** Tannia (Moulavikachu) **56.** Giant taro **57.** Elephant foot aroid/yam **58.** Drumstick **59.** Plantain **60.** Green papaya **61.** Asparagus **62.** Jute leaf **63.** Baby corn **64.** Malencha **65.** Amrul shak **66.** Nunia **67.** Fern **68.** Taro leaf **99**.OthersSpecify)	**3.** Hybrid **4.** Don't know	t know	**2.** Winter **3.** In the middle of summer and winter **4.** Whole year **5.** Not fixed	**2.** Gift to relatives **3.** Sale **4.** Get wasted **99**. Others (specify)	**2.** People buy from house **3.** Sale to neighbors **99.** Others (specify)

Module G: Fruit Related Information (in Last year)

Sl. No.	Last year what Fruits did you grow?	For how many years do you grow this Fruit?	Land used to grow Fruit last year (without homestead and in decimal)	*Production of fruit last year (KG or number/Decimal and including homestead)		Variety of Fruit	Do you follow Safe Fruit Production process (GAP)	How many season/year do you grow fruit?	Usage of fruits (answer may be more than one)			What % of your fruit have you sold?	Tatal income from fruit sale last year?	Where did you sell your fruits? (answer may be more than one)		
	Code G01			Number	KG	**Code G06**	**Code G07**	**Code G08**	**Code G09-G11**					**Code G14-G16**		
	G01	**G02**	**G03**	**G04**	**G05**	**G06**	**G07**	**G08**	**G09**	**G10**	**G11**	**G12**	**G13**	**G14**	**G15**	**G16**
1.																
2.																
3.																
4.																
5.																
6.																
7.																
8.																
9.																

10.																
11.																

***If orchard is sold, please note: for mango-approximate KG and for Licci approximate number (note Tree/decimal also at the end of this page)**

Code for Module G: Fruit Related Information

Code G01 and E08 : Fruit Name			**Code G06: Fruit Variety**	**Code G07: Do you follow Safe Fruit Production process (GAP)**	**Code G08: How many season/year do you grow fruit?**	**Code G09-G11: Usage of fruit**	**Code G14-G16: Fruit sale**
1. Jara lemon **2.** Lemon **3.** Satkara **4.** Lime **5.** Taikar **6.** Pummelo **7.** Jackfruit **8.** Hogplum **9.** Golden Apple **10.** Guava **11.** Jamun	**12.** Wax Apple **13.** Wood apple **14.** Litchi **15.** Elephant Foot Apple **16.** Elephant's Foot Apple **17.** Langsat **18.** Carambola **19.** Pineapple **20.** Jujube **21.** Olives **22.** Tamarind	**23.** Karonda **24.** Elephant Apple **25.** Custard Apple **26.** Kauphal **27.** Aonla **28.** Monkey Jack **29.** Mango **30.** Banana **31.** Coconut **32.** Battle leaf **33.** Betel nut **99**. Others (specify)	**1.** Local **2.** High yeild **3.** Hybrid **4.** Don't know	**1.** Yes **2.** No **3.** Don't know	**1.** Summer/Rainy Season **2.** Winter **3.** In the middle of summer and winter **4.** Whole year **5.** Not fixed	**1.** Own consumption **2.** Gift to relatives **3.** Sale **4.** Get wasted **99.** Others (specify)	**1.** Sale in local market **2.** People buy from house **3.** Sale to neighbors **99.** Others (specify)

Module H: Vegetables and Fruits Consumption related Information

Sl.No.	Question						
1.	Do you eat adequate vegetables? **Code H1**						
		MID	**MID**	**MID**	**MID**	**MID**	**MID**
2.	Which of your HH member do not want to eat vegetables? (MID No.)						
3.	Why they don't want to eat vegetables? **Code H3** (answer may be more than one)						
4.	What vegetables your family don't like? **Code H4** (Use vegetables' code) (answer may be more than one)						
5.	What are the reason for disliking these vegetables? **Code H5** (answer may be more than one)						
6.	Do you eat adequate fruits? **Code H6**						
		MID	**MID**	**MID**	**MID**	**MID**	**MID**
7.	Which of your HH member do not want to eat fruits? MID No.						
8.	Why they don't want to eat fruits? **Code H8** (answer may be more than one)						
9.	What are the reason for disliking these fruit? **Code H9 (**Code of fruits, answer may be more than one)						
10.	What are the reason for disliking these fruits? **Code H10** (answer may be more than one)						

Code H1 I H6 (Eat adequate or not) 1. Yes, **2**. No, 3**.** Don't know whether it is adequate or not, **4**. Eat very small amount**, 5**. Eat somewhat**, 6.** Eat in season, **7**. Not applicable**, 99.** Others (specify)

Code H3, H5 I H8, and H10 (Why they don't want to eat fruits? And what are the reason for disliking these fruits) 1. Not safe, **2**. Mix pesticide/poison, **3**. Quality is not good, **4**. Not available, **5**. Costly, **6**.children don't want to eat, **7**. HH head don't want to eat, **8**. Not tasty, **10**. No need to eat, **11**. It's not good to eat it heavily, **12**. Forbidden to eat (for illness or other reason), **13**. Not applicable, **99**. Others (specify)

Module I: NCD Related Information

	Question		Code **I**
1.	Do cholera, pox, and tuberculosis communicable diseases? **Code I1**	**I.1**	
2.	Do high blood pressure and diabetes? **Code I2**	**I.2**	
3.	Which foods contributes to high blood pressure? **Code I3 (**Code of foods)	**I.3**	
4.	Do you think that physical exercise help to decrease high blood pressure? **Code I4**	**I.4**	
5.	Do you think that physical labor help to decrease high blood pressure? **Code I5**	**I.5**	

Code I.: (I.1, **I**.2, **I**.4, **I**.5: Code: **1**.Yes**, 2**. No, **3**. don't know

Code I.: (I.3 Code for foods) 1. Fast food (pizza, burger, chicken fry), **2**. Red meat (Beef, pork), **3**. Fat riched food (Mutton, Polao, Biriyani), **4**. Sweet food (Kadma, Goja, Khurma, Coconut cake etc.), **5**. Soft drinks, **6**. Energy drink, **7**. Big fish, **9**. Shrimp/crab, **10**. Fruits, **11.**Fried snaks (Chanachur, Peyaju, Beguni etc.), **12**. Smoking, **13**. Alcohol, **14**. Carbohydrate (rice/bread), **15**. Salt with food, **16**. Pickle, **17**. Pulse, **18**. Beans, **19**. Biscuit, **20.** Skin of chicken, **21**. Nuts, **22**. Egg, **23**. Coffee, **24**. Tea, **25**. Cake, **26**. Chinese food, **27**. Milk, **28**. Excessive oil, ghee, butter, margarin **29**. Kabab, **30**. Junk food (pastry, Shigara, samucha), **31**. Noodles, **32**. Chocolate, **33**. Dairy food, **34**. Fruits, **35**. Vegetables, **36**. Leafy vegetables, **37**. Green vegetables, **38**. Don't know, **99**. Others (specify)

Module J: NCD Status of the Respondent: [Questions from STEP-1, WHO]

w	Description		Code J
1.	Are you suffering from any disease now? **Code: J1: 1**. Yes, **2**. No (Question 2 & 3 is not applicable if the answer is No)	**J1**	
2.	If yes, please name the diseases **Code: J2**: (answer may be more than one)	**J2**	
3.	Which of these diseases have been identified by doctors? Code: J3: (answer may be more than one)	**J3**	
4.	Have you ever measured blood pressure by doctor or health worker? **Code: J4: 1**. Yes, **2**. No, **3**. Cant remember	**J4**	
5.	Have any doctor or health worker informed you that you have high blood pressur? (if answer is no, go to question no 7) **Code: J5**: **1**. Yes, **2**. No, **3**. Cant remember	**J5**	
6.	If you are informed that you have high blood pressure, are you maintaining doctor's advice?		
6.1	A) Regular medication **Code: J6.1: 1**. Yes, **2**. No, **3**. sometime	**J6.1**	
6.2	B) Decrease excess salt consumption **Code: J6.**2: **1. Yes, 2. No, 3. sometime**	**J6.2**	
6.3	C) Change the food habit **Code: J6.3**: **1. Yes, 2. No, 3. sometime**	**J6.3**	
6.4	D) Trying to decrease weight **Code: J6.4**: **1. Yes, 2. No, 3. sometime**	**J6.4**	
6.5	E) Avoid smoking **Code: J6.5: 1. Yes, 2. No, 3. sometime**	**J6.5**	
6.6	F) Regular physical exercise **Code: J6.6**: **1**. Yes, **2**. No, **3**. sometime	**J6.6**	
7.	Have you ever counted your blood sugar by any doctor of health worker? **Code: J7**: **1**. Yes, **2**. No, **3**. Cant remember	**J7**	
8.	Have any doctor or health worker told you that you have diabetes? **Code: J8: 1**. Yes, **2**. No, **3**. Cant remember	**J8**	
9.	If you have diabetes, are you following doctor's advice? (Question **9.1-9.5** are not applicable if the answer is no)		
9.1	A) Regular medication **Code: J9.1:** 1. **1**. Yes, **2**. No, **3**. sometime	**J9.1**	
9.2	B) Change the food habit **Code: J9.2: 1**. Yes, **2**. No, **3**. sometime	**J9.2**	
9.3	C) Trying to decrease weight **Code: J9.3**: **1**. Yes, **2**. No, **3**. sometime	**J9.3**	
9.4	D) Avoid smoking **Code: J9.4**: **1**. Yes, **2**. No, **3**. sometime	**J9.4**	
9.5	E) Regular physical exercise **Code: J9.5**: **1**. Yes, **2**. No, **3**. sometime a¨	**J9.5**	

Code: J2 and J3: (Name of the disease): 1. Infection, **2**. Fever, **3**. Cancer, **4**. Influenza, **5**. Ache, **6**. Animea, **7**. Diabetes, **8**. Congenital disorder, **9**. Inflammation, **10**. Catching cold, **11**. HIV/AIDS, **12**. Arthurites, **13**. Tuberculosis, **14**. Encephalitis, **15**. Cardiovascular Disease, **16**. Immunodeficiency, **17**. Rabies, **18**. Ebola Virus disease, **19**. Lyme isease, **20**. Cutaneous condition, **21**. Cyst, **22**. Hypertension, **23**. Pneumonia, **24**. Alergy, **25**. Dengui, **26**. Hepatitis, **27**. Meningitis, **28**. Chicken Pox, **29**. Paralysis, **30**. Injury, **31**. Diarrhea, **32**. STD, **33**. Pregnency related, **34**. Fatigue, **35**. Death, **36**. Malaria, **37**. Skin Ulcer, **38.** Anthrux, **39**. Epilesy, **40**. Measles **41.** Headache, **42**. Cholera, **43**. Systemic Disease, **44**. Genetic Disorder, **45**. Salmonellosis, **46**. Type 2 Diabetes, **47**. Azthma, **48**. Tyroid, **49**. Neurological Disorder, **50**. Chronic Obstructive Pulmonary Disease, **51**. Herpes simplex, **52**. Do not kno

Module K: Physical Measurenent of the respondents
(Information of HH Head/Adult male and wife of HH Head/ Adult female)

w							
Sl. No.	**Description**		**Male member of HH**			**Female member of HH**	
1.	**MID** of HH member	**K1**			**K1.1**		
2.	Height (in centimeter and upto decimal places)	**K2**			**K2.1**		
3.	Weight (In KG and three times, upto decimal places)	**K3**			**K3.1**		
Pressure:							
4.	Now I want to measure your Blood Pressure						
4.1	**gvc 1:** (Note: respondent takes 15 minutes rest) mmHg	**K4.1**			**K4.1.1**		
4.2	**gvc 2:** (Note: After 3 minutes of first count) mmHg	**K4.2**			**K4.2.2**		
4.3	**gvc 3:** (Note: After 3 minutes of second count) mmHg	**K4.3**			**K4.3.3**		
5.	**Diabetes:**						
Now I want to measure your Blood Sugar:							
5.1	Blood sugar level (Glucometer) mmol/L (upto decimal places) **Reading**	**K5.1**			**K5.1**		

MUAC (Only for pregnant women)

w	**MID No.** of HH member	**K6**	
6.1	Are you pregnant? **Code K6.1: 1.** Yes, **2**. No	**K6.1**	
6.2	If yes, for how many months? **Months**	**K6.2**	
6.3	MUAC in centimeter **Reading**	**K6.3**	

Module L: Dietary Habit (Ask the female HH member

MID No. of respondent:

1. w				2. Ata				3. Flour				4. Beef/Pork				5. Mutton			
Plain rice without oil		Fried		Without oil		Fried		Limited Oil/Vegetable		High oil/Fried		Limited Oil/Vegetable		High oil/Fried		Limited Oil/Vegetable		High oil/Fried	
Unit	frequency	Unit	frequency	Unit	frequency	Unit	frequency	Unit	frequency	Unit	frequency	Unit	frequency	Unit	frequency	Unit	frequency	Unit	frequency
Code: L01		Code: L03		Code: L05		Code: L07		Code: L09		Code: L11		Code: L13		Code: L15		Code: L17		Code: L19	
L01	**L02**	**L03**	**L04**	**L05**	**L06**	**L07**	**L08**	**L09**	**L10**	**L11**	**L12**	**L13**	**L14**	**L15**	**L16**	**L17**	**L18**	**L19**	**L20**

6. Chicken				7. Fish				8. Pulse				9. Leafy Vegetables				10. Vegetables			
Limited Oil/Vegetabe		High oil/Fried		Limited oil		High oil/Fried		Limited oil		High oil/Fried		Limited oil		High oil/Fried		Limited oil		High oil/Fried	
Unit	frequency	Unit	frequency	Unit	frequency	Unit	frequency	Unit	frequency	Unit	frequency	Unit	frequency	Unit	frequency	Unit	frequency	Unit	frequency
Code: L21		Code: L23		Code: L25		Code: L27		Code: L29		Code: L31		Code: L33		Code: L35		Code: L37		Code: L39	
L21	**L22**	**L23**	**L24**	**L25**	**L26**	**L27**	**L28**	**L29**	**L30**	**L31**	**L32**	**L33**	**L34**	**L35**	**L36**	**L37**	**L38**	**L39**	**L40**

11. w		12. Egg		13. Fruit		14. Milk		15. Dairy food	
Limited oil	Fried/Sma	Boiled/Veg	Fried/Sma	Without oil	With oil	Without oil	With oil	Without oil	With oil

		shed		etables		shed													
Unit	frequency	Unit	frequency	Unit	frequency	Unit	frequency	Unit	frequency	Unit	frequency	Unit	frequency	Unit	frequency	Unit	frequency	Unit	frequency
Code: L41		Code: L43		Code: L45		Code: L47		Code: L49		Code: L51		Code: L53		Code: L55		Code: L57		Code: L59	
L41	**L42**	**L43**	**L44**	**L45**	**L46**	**L47**	**L48**	**L49**	**L50**	**L51**	**L52**	**L53**	**L54**	**L55**	**L56**	**L57**	**L58**	**L59**	**L60**

16. Sweet foods				**17. Ghee**				**18. Butter**				**19. Oil**			
Without oil		With oil													
Unit	frequency	Unit	frequency	Unit	frequency			Unit	frequency			Unit	frequency		
Code:L 61		**Code:L 63**		**Code:L 65**				**Code:L 67**				**Code:L 69**			
L61	**L62**	**L63**	**L64**	**L65**	**L66**			**L67**	**L68**			**L69**	**L70**		

Code for L: Dietary Habit (Code L01-L69) (Unit Code): **1.** Days, **2**. week, **3**. Two weeks, **4**. Month, **5**. Three months, **6**. Six month**, 7**. Year, **8**. Do not know, **9**. Not applicable

Module M: Physical Exercise

Sl. No.	Questions		Code
1.	Do you play, exercise or take part in entertainment (like dance) other than your regular/occupational work? (At a stretch ten minutes which sweats you)? **Code: M1: 1. Yes, 2. No, 3**. Sometimes (Question 2 & 3 are not applicable if the answer is No)	**M1**	
2.	How many days in a week do you perform these exercise/work other than your regular work? (Day)	**M2**	
3.	How many minutes per day do you do these exercise/work? (minutes/day)	**M3**	
4.	Do you walk or Cycle at a stretch ten minutes for commuting? **Code: M4: 1. Yes, 2. No, 3. Sometimes**	**M4**	

5.	How many days in a week do you walk or cycle ten minutes for commuting?	**M5**	
6.	How many minutes do you relax (without sleep) in a day? (1 Hour=60 minutes, 2 Hours=120 minutes)	**M6.1**	
7.	How many hours do you sleep in a day (24 hours)? Hour	**M7.1**	
8.	How many hours do you sleep in a weekend day (24 hours)? Hour	**M8.1**	
9.	How many hours do you sit at a stretch?	**M9.1**	
10.	Do you need to walk to go to your workplace? **Code: M10: 1**. Yes, **2**. No**, 3**. Sometimes	**M10.1**	
11.	If yes, how many minutes it takes? (in Minutes)	**M11.1**	
12.	How many hours do you need for physical work at your workplace? (in hour/day)	**M12.1**	

Module N: Marriage and Women Empowerment

(Information of this section will be collected only from the wife of HH Head, Female HH Head or Adult female member of HH)
As a female HH member, can you take own decisions in the following matters? **MID No**. of respondent:

N1	Study of daughter	
N2	Study of son	
N3	Savings	
N4	Expenditure of own savings	
N5	Taking loan	
N6	Go outside for work	
N7	Sale of HH asset (like chicken, duck)	

N8	Sale of egg or milk	
N9	Family planning	
N10	Expenditure in Eid/Puja/Christmas	
N11	Sale of land	
N12	Go to your father's home	
N13	To see any leadership character	
N14	Give asset to daughter's wedding	

Code for N1 to N14: 1. Always, **2**. Most of the time, 3. Sometimes, **4**. Never, **5**. Not applicable

N15	Is there any woman in this area who is obeyed by all? **Code N15:** (**1**. Yes, **2**.No, **3**. Do not know*)* (Question **N16- N25** are not applicable if the answer is No or Do not know)	
N16	If there is any woman like that, is she called by any title out of honor? **Code N16** (**1**. Yes, **2**.No, **3**.Do not know*)*	

If the answer is Yes, by which title is she called?

	Title	Please tick		Title	Please tick		Title	Please tick
N17	Teacher		**N20**	Hujuran		**N23**	Wife of Huzur/Matabbar	
N18	Dai (Nurse who help during delivery)		**N21**	Wife of teacher		**N24**	Sage (Pir/Jogi/Hrishi)	
N19	NGO group leader		**N22**	Member/ Chairman/ commissioner		**N25**	Others (specify)	

(Questions N26- N28 are not applicable if there is no married girl in this family)
(Questions N29- N31 are not applicable if there is no married girl in this family)

Sl. No.	Question		Answer
N26	In which year you last got your family's girl married?	Year	
N27	What is the amount of gift you gave in that marriage as assets and cash?	Taka	
N28	At the time of the marriage which was her age?	Age	
N29	In which year you last got your family's boy married?	Year	
N30	What is the amount of Mohrana you fixed in that marriage?	Taka	
N31	At the time of the marriage which was his age?	Age	

Module O: Consumer Preference

Sl.	Question		Code O

No.			
1.	In your knowledge, people of the area/country consume	**O1**	
2.	My family eat leafy vegetables, fiber riched foods, green and other vegetables in every serving	**O2**	
3.	Half of my family's total daily food is vegetables	**O3**	
4.	Vegetables should be hervested some days after using pesticides	**O4**	
5.	Indiginous vegetables is better for health	**O5**	
6.	Vegetables are safe for consumption if organic pesticide is used	**O6**	
7.	Use of organic pesticide is promoted in media	**O7**	
8.	Adequate vegetable consumption is promoted in media	**O8**	

Code for: O: 1. Yes, 2. No, 3. Do not know

Module P: Communication

Sl. No.	Questions (only for the female members of the HH) MID No.		Code P			
1.	Do you watch TV? **Code P1: 1.** Yes, **2**. No (Question **2, 3, 4** &5 is not applicable if the answer is No) (Answer would be Yes if watch TV occationally)	**P**1				
2.	Which channels are available where you watch TV? **Code P2: 1**. BTV, **2**. Channel-i, **3**. GTV, **4**. ATN Bangla, **5**. NTV, **6**. RTV, **7**. Other Bangladeshi TV, **8**. Indian Bangla Channel, **9**. Indian Hindi Channel, **10**. Other foreign channels, **11**. Local Dish Channel (answer may be more than one)	**P**2				
3.	Do you watch any special kind of program? **Code P3: 1**. Drama, **2**.Cinema, **3**. Drama Serial, **4**. News, **5**. Cooking show, **6**. Agricultural show, **7**. Song**, 8**. Other entertainment show (like fashion show and others), **9**. Sports, 99. Others (specify) (answer may be more than one)	**P3**				
4.	Do you like cooking show? **Code P4: 1**. Yes**, 2.** No**, 3.** Do not know	**P4**				
5.	Do you or other members of your family watch agricultural show? **Code P5: 1**. Yes**, 2.** No**, 3.** Do not know	**P5**				
6.	Do you/others of your family enjoy Radio, FM radio or mobile Radio? **Code P6**: **1**. Yes**, 2.** No**, 3.** Do not	**P6**				

	know		
7.	If yes, what type of program do you enjoy? **Code P7**: **1**. News of disaster, **2**. News, **3**. Drama, **4**. Song, **5.** Agricultural program, **6.** Cooking program, **7**. Sports, **8.** Entertainment program, **9**. Do not know, **99**. Others (specify) (answer may be more than one)	**P7**	
8.	Do you have any community radio in your area which you listen to? **Code P8**: **1**. Yes**, 2.** No**, 3.** Do not know	**P8**	
9.	Have you heard any pot song or Jari gaan or street drama staged in and around your village? **Code P9: 1**. Yes**, 2.** No**, 3.** Do not know (Question 10 & 11 is not applicable if answer is No)	**P9**	
10.	Have you seen that street drama or pot song? **Code P10: 1**. Have seen, **2**. Have not seen	**P10**	
11.	What was the subject of that drama or song? **Code P11: 1**. Social, **2.** Historical, **3**.Women empowerment, **4**. Health, **5**. Family planning, **6**. Sanitation, **7**. Agriculture, **8**. Nutrition, **99.** Others (specify)	**P11**	
12.	Can you go to watch drama or jari gaan which is performed in or around your village? **Code P12: 1**. Yes**, 2.** No**, 3.** Do not know	**P12**	
13.	Which media do you prefer most to get any information? **Code P13: 1. TV**, **2**. Radio, **3**. Poster, **4**. Leaflet, **5**. Mobile phone, **6**. Street drama, **7**. Any govt. office/Union Parishad, **8**. Personal Communication (NGO worker, Health worker, Councilor etc.), **9**. Video (answer may be more than one)	**P13**	
14.	Do you read Mobile phone messeges or make someone read you your messeges? **Code P14: 1**. Yes, **2.** No, **3**. Do not know, **4**. Not applicable	**P14**	
15.	Is TV commercial or messeges capable of bringing about changes in your behavior? **Code P5: 1**. Yes**, 2.** No**, 3.** Do not know	**P15**	
16.	In your opinion, which is the most effective medium to get information? **Code P16: 1**. TV, **2**. Radio, **3**. Mobile, **4**. Street Drama**, 5**. NGO worker, **6**. Govt. official, **7**. Union Parishad, **8**. Neighbor, **9**. Printed material (Newspaper, leaflet, poster), **10**. Video, **11**. School/School teacher, **12.** Loud speaker of mosque, **99**. Others (specify)	**P16**	
17.	Where do you go generally for Hypertension, Diabetes, Obesity, Malnutrition etc.? **Code P17: 1**. Medicine seller, **2**. Village Doctor, **3**. Govt. Doctor (Community Clinic, Upazila/Zila Hospital), **4**. Private Doctor, **5**. Clinic **99**. Others (specify)	**P17**	
18.	Do you have any arrangement for exercise or walking**? Code P18: 1**. Yes**, 2**. No, **3**. Do not know, **4**. Do not want to go, **5**. Not applicable	**P18**	
19.	Is there any arrangement for you or your family to walk? **Code P19: 1**. Yes**, 2.** No**, 3.** Do not know	**P19**	
20.	Is there any play ground for you or your children? **Code P20: 1**. Yes, **2.** No, **3**. Do not know, **4**. Not applicable	**P20**	
21.	How much time do your children can play in and outside school) (Minutes/Day)	**P21**	
22.	Is there any club for children/youths in your area/village? **Code P22: 1**. Yes**, 2.** No**, 3.** Do not know	**P22**	
23.	Have you ever get any information regarding non-communicable disease like Heart disease, Diabetes	**P23**	

	etc.? **Code P23: 1** Have got, **2.** Have not got**, 3**. Can not remember		
24.	If yes, from where did you get that? **Code P24: 1**. Hospital, **2**. Community clinic, **3.** Drug seller, **4**. NGO worker, **5**. Media, **99**. Others (specify) (answer may be more than one)	**P24**	
25.	(Ask this question to Children) Have you ever get any information from school regarding non-communicable disease? **Code P25: 1**. Have got, **2**. Have not got, **3**. Do not remember, **4**.Not applicable **MID No.**	**P25**	
26.	If yes, from whom did you get that information? **Code P26: 1.** Teacher, **2**. Young doctor, **3**. NGO Worker, **4**. Govt. initiative, **5**. Did not get any, **99**. Others (specify)	**P26**	
27.	If you have got this from young doctor then how frequently does this program happen in your school? **Code P28: 1**. monthly, **2**. quarterly, **3**. Once in six month, **4**. Yearly, **5**. Irregular, **6**. Do not know, **7**. Does not happen, **99**. Others (specify)	**P27**	
28.	(Ask this question to Children) Have you ever get any information from school regarding the benefit of consuming vegetables? **Code P25: 1**. Have got, **2**. Have not got, **3**. Do not remember, **4**. Not applicable **MID No.**	**P28**	
29.	Do your school going children get tiffin from school**? Code P29: 1**. Yes, **2**. No, **3**. Do not know, **4**. Not applicable	**P29**	
30.	Do your school going children take tiffin from home? **Code P30: 1.** Yes**, 2.** No, **3.** Do not know**, 4.** Not applicable	**P30**	
31.	If yes, then what is that? **Code P31:** (answer may be more than one)	**P31**	
32.	If they buy tiffin from shop, what is that? **Code P32:** (answer may be more than one)	**P32**	
33.	Who take the dicision of what will be cooked in your house? **MID No.**	**P33**	
34.	What is the main consideration to take that dicision? **Code P34**	**P34**	
35.	Who shops for your house? (Use **MID No.**)	**P35**	
36.	Who take dicision about the items for cooking to be shopped? **MID No.**	**P36**	
37.	Do you know what healthy food is? **Code P37**	**P37**	
38.	What is the problem about eating healthy food? **Code P38**	**P38**	

Code for P: Communication

Code for P29 and P30: 1. Rice and curry **2**. Fried rice, **3**. Sandwitch, **4**. Burger, **5**. Noodles, **6**. Cheaps, **7**. Cake, **8**. Bread, **9**. Parota, **10**. Egg, **11**. Sausage, **12**. Nugget, **13**. Pickle, **14**. Chatpati, **15**. Fuska, **16**. Jhalmuri, **17**. Biscuit, **18**. Pastry, **19**. Chicken fry, **20**. Cream roll/bun, **21**. Bread/bun**, 22.** Not applicable, **99**. Others (specify) (answer may be more than one)

Code P32: **1**Taste, **2**. Price, **3**. Safe food, **4**. Time (fast cooking), **5**. Opinion of husband/HH head**, 6**. Opinion of children, **8**. Healthy food, **9**. Opinion of mother in law**, 10**. Own opinion**, 11**. Opinion of all family members, **12**. Do not know/not sure, **99**. Others (specify)
Code P37: 1. Know, **2**. Do not know, **3**. No answer
Code P38: 1. every member of the family has different opinion, **2**. Opinion of Family head, **3**. Opinion of male family members**, 4**. Opinion of mother in law, **5**. Opinion of father in law, **6**. Unavailable in local bazar , **7**. Price is high, **8**. Do not know what is healthy, **9**. We eat what we grow, **10**. We eat what is available in our area/village, **11**. Opinion of children/Children do not want to eat healthy foods, **12**. Healthy foods are poisonous, **13**. We can't afford healthy foods, **14**. Not applicable, **99**. Others (specify)

Module Q: Consumption of Tobacco (Information should be taken from one Male and one female member of the HH. For male-HH Head or Adult male member and for female- the wife of HH Head or adult female member of the HH)

Sl. No	Question	Male				Female			
1.	MID of respondents **MID No.**	**Q**1				**Q**1.**1**			
2.	Which members of your HH smoke? **MID No.**	**Q**2				**Q**2.**1**			
3.	Which members of your HH use chewing tobacco/Jarda/Sadapata? **MID No.**	**Q3**				**Q3.1**			
4.	Which members of your HH use tobacco powder (Gul/Nashshi) **MID No.**	**Q4**				**Q4.1**			
5.	(if the respondent is a smoker) How many sticks do you smoke in a day? **(Number)**	**Q5**				**Q5.1**			
6.	How many times do you use chewing tobacco/Jarda? **(Number)**	**Q6**				**Q6.1**			
7.	How many times do you use tobacco powder/Gul? **(Number)**	**Q7**				**Q7.1**			
8.	For how many years do you smoke? **(Year)**	**Q8**				**Q8.1**			
9.	For how many years do you use Chewing tobacco/jarda? **(Year)**	**Q9**				**Q9.1**			
10.	For how many years do you use tobacco powder/Gul? **(Year)**	**Q10**				**Q10.1**			