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Cohort profile: The BangladEsh Longitudinal Investigation of Emerging Vascular and nonvascular Events (BELIEVE) cohort study

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Abstract

Purpose Bangladesh has experienced a rapid epidemiological transition from communicable to non-communicable diseases (NCDs) in recent decades. There is, however, limited evidence about multi-dimensional determinants of NCDs in this population. The BangladEsh Longitudinal Investigation of Emerging Vascular and nonvascular Events *(*BELIEVE) study is a household-based prospective cohort study established to investigate biological, behavioural, environmental, and broader determinants of NCDs.

Participants Between January 2016 and March 2020, 73,883 participants (aged 11 years or older) were recruited from 30,817 households across urban, urban-poor ("slum") and rural settings in Bangladesh. An structured questionnaire was administered by trained personnel recording participants' demographic, socioeconomic, behavioural, medical, environmental and other factors. Anthropometric measurements and blood pressure were recorded for each participant. Biological specimens were collected and aliquoted for long-term storage and analysis.

Findings to date Of the 73,883 study participants (mean [SD] baseline age: 39 [15] years), 43,470 (59%) were females, and 38,848 (52%) had no or only primary-level education. Focusing only on the 65,822 adults participants aged 20 to 79 years at baseline, 15,411 (23%) reported being diagnosed with hypertension; 10,578 (16%) with type 2 diabetes; and 7,624 (12%) with hypercholesterolaemia. Age and sex standardised prevalences of these conditions were much higher in urban than slum and rural settings. Overall, mean (SD) body mass index (BMI) was 25 (5) kg/m^2, with 10,442 (16%) participants aged 20 to 79, classified as obese (i.e., BMI$\geq$30 kg/m^2). Mean BMI was also higher in urban than slum and rural areas.

Future plans Longitudinal follow-up for ascertainment and adjudication of a range of fatal and non-fatal health outcomes among participants in this cohort will provide a powerful resource to investigate multi-dimensional determinants of incident NCDs across diverse settings in Bangladesh, helping to advance scientific discovery and public health action.

STRENGTHS AND LIMITATIONS OF THIS STUDY

- Largest bioresource for non-communicable diseases (NCDs) and related traits in Bangladesh, configured to investigate multi-dimensional determinants of NCDs across urban, slum and rural settings.

- Comprehensive recording of questionnaire-based data, including demographic, socioeconomic, behavioural, medical, environmental and other factors, as well as physical measurements.

- Collection of a range of biological samples ─ including serum, plasma, whole blood, and nail samples ─ stored in long-term repositories.

- Use of stored biological samples to enable the study of many genomic and molecular factors together with other information, laying foundations to advance scientific discovery and public health action.

- The study is not necessarily representative of the general Bangladesh population and could be limited by misclassification of disease outcomes and by loss of contact with some participants during follow-up.

Introduction

Non-communicable diseases (NCDs) – including cardiovascular diseases, diabetes, cancer, and chronic respiratory diseases – are the leading causes of premature death in low- and middle-income countries (LMICs) (1,2). In particular, South Asia has recorded a higher number of life-years lost due to premature NCDs than any other global region, a situation which reflects both the region's large population and the relatively young age at which NCD deaths tend to occur in this region (1,3). Furthermore, while NCD mortality rates have decreased during recent decades in most countries, they remain at high level in the South East Asia region (4,5). Better understanding of the multi-dimensional determinants of NCDs in South Asia should, therefore, inform development of appropriately tailored strategies for disease prevention and control.

There is, however, limited evidence available on NCD determinants for many South Asian populations (2,6). For example, Bangladesh, a country with 170 million people, is one of the least studied most densely-populated countries with regard to NCDs, despite steep and sustained increases in NCDs risk factors and incidence during recent decades (7,8). In 2021, 74% of all adult deaths in Bangladesh were attributed to NCDs (9-11). The high burden of NCDs in Bangladesh is not just of local public health concern, as mortality due to NCDs has been reported to be more than two times higher among Bangladeshis living in western regions compared to host populations (12). An important challenge is, therefore, to establish informative epidemiological resources in a rigorous manner to evaluate risk factors among Bangladeshis.

The present report provides a description of the methods used in the establishment of the BangladEsh Longitudinal Investigation of Emerging Vascular and nonvascular Events (BELIEVE) study. It also describes the baseline characteristics of the study population recruited so far, and outlines the rationale for the study's further development.

Cohort description

Study design and participants

Between January 2016 and March 2020, the BELIEVE prospective cohort study recruited 73,883 participants from 30,817 households across three different settings in Bangladesh: urban (Mirpur-Dhaka), rural (Matlab-Chandpur), and urban-poor ("slum"; Bauniabadh-Dhaka), (**Figure 1**). Households were initially identified through complete surveys that had previously mapped households' information across the three study sites. Individuals living in the identified households were eligible for enrolment into the study if they: 1) were aged 11 years or older; 2) had lived in their current household for at least 3 years; 3) were intending to reside in the study site for at least a further 5 years; and 4) were willing to provide written informed consent and prospective follow-up information. For all participants, the recruitment procedure firstly involved trained study personnel visiting all identified households to provide written and verbal information about the study. Upon completion of the household visit, all eligible household members were invited to attend a local study clinic to complete an individual-level baseline assessment (**Figure 2**).

Questionnaire administration and physical measurements at baseline assessment

During the household visit, trained personnel administered a structured questionnaire to collect household-level information and family structure characteristics (**Table 1**) using a bespoke Android interface operated through handheld touchscreen tablet devices. During the clinic visit, trained personnel used a computer-based pre-piloted epidemiological questionnaire to collect self-reported information on >300 items related to socioeconomic and demographic characteristics, consanguinity, behaviours (e.g., tobacco and alcohol consumption, dietary intake, physical activity), females health, self-reported personal and family medical history, and medication use (**Table 1**; a copy of the study questionnaire is available upon request). Self-reported information on medical history and medication use was supplemented by medical records, drugs prescriptions, and by asking participants to bring their medications to the clinic visit. To assess local dietary patterns, benchmark food-frequency questionnaires previously developed and validated in Bangladesh were adapted for BELIEVE.(13) This questionnaire estimated standard portion size assigned to each food item and drinking water source. Participants' phone numbers (or, for participants younger than 18 years, a contact number of a legal parent, guardian or caretaker) were routinely collected at the baseline visit for future contact and to collect follow-up information.

Standardised procedures and equipment were used to assess height, weight, waist and hip circumference, body composition, systolic and diastolic blood pressure, heart rate, and upper body strength (**Supplementary Table 1**). Briefly, blood pressure was measured using an

automated device (Omron HEM 7130) on the right arm twice with a 3-minute interval between each measurement, with the patient remaining in a sitting position for at least 5 minutes before the first evaluation. Height was measured using the ShorrBoard ICA Measuring Board to within 1cm and weight was measured using the Tanita HD-661 scale to within 0.1kg. Waist circumference was assessed using a non-stretchable soft standard measuring tape over the abdomen at the widest diameter between the costal margin and the iliac crest, and hip circumference at the level of the greater trochanters (i.e., the widest diameter around the buttocks). Anthropometric measurements were performed in a standing position. Body composition was assessed by bio-impedance using the Tanita MC-780MA analyser and handgrip strength using a Jamar Plus Digital Hand Dynamometer.

To enhance consistency in the collection of data, we trained staff extensively and adopted standardised approaches, validated instruments, and electronic data collection methods with built-in validity checks and queries. For example, the paper-free digital data collection platform involved extensive computerised checks to restrict missing values, duplications, inconsistencies, and outliers. Information was transferred daily in a secure manner to the study's central database at Cambridge University, with a copy also kept at the local recruitment centres for additional checks and queries. Reports were generated by data managers and reviewed by study PIs and coordinators on a regular basis.

Collection, storage, and initial use of biological samples

Participants provided non-fasting blood samples for research with the time of last meal recorded. Up to 23 ml of non-fasted whole blood samples was collected from each participant aged 18 years and above in two tubes (11 ml EDTA, and 12 ml serum). For participants aged 11-17 years, 12 ml of non-fasted whole blood samples was collected in two tubes (6 ml EDTA and 6 ml serum). Samples were centrifuged within 45 minutes of venipuncture (at 6,000 rpm for 15 minutes). Isolated serum, EDTA plasma and whole blood samples were stored at −20°C before being transferred to a -86°C freezer at the end of each working day (**Supplementary Figure 1**). To enable the measurement of additional potential risk factors (e.g., metal contaminants), finger- and toe-nail clippings were collected in a subset of participants, kept separately in plastic bottles, and stored at room temperature. Biological samples have been stored in long-term dual repositories located in Bangladesh and the UK to enable further assays. A range of biochemical and genomic analyses on the stored samples is currently ongoing.

Follow-up procedure and outcome ascertainment

Study participants are being actively followed-up indefinitely for cause-specific mortality and incidence of selected non-fatal health outcomes (**Figure 2**). Follow-up involves contact with participants by the study team at regular intervals, during which trained personnel use an electronic questionnaire to collect information on medical events reported since the last contact. Based on the responses to the questionnaire (or if phone contact is unsuccessful), a household visit is scheduled to collect additional information and medical documents. During the household visit, trained personnel collect further information for selected major categories of non-fatal events (including myocardial infarction, diabetes, stroke, common cancers) using a structured questionnaire and a bespoke Android electronic interface operated through handheld touchscreen tablet devices.

As the majority of individuals in the study settings who have received medical attention tend to have paper copies of medical documents in their homes, study personnel visiting households collect digital photographs of any relevant medical documents available (including discharge summaries, diagnostic test reports, medications, and death certificates) using tablet devices. If medical documents are unavailable, written informed consent is obtained to retrieve these from the relevant hospitals. Nearly all deaths in the study areas will have involved some form of medical attention, with their underlying causes being certified by a medical doctor. A validated verbal autopsy is conducted in all deaths by trained personnel to help determine the most likely cause from symptoms or signs described by family members.(14) To help adjudicate and classify health outcomes (e.g., into definite, probable and possible categories), the information collected described above is periodically reviewed by medically-trained personnel.

The quality and completeness of both mortality and morbidity follow-up data in each study site is checked regularly during the study period by the study coordinating centres. This involves monitoring the number of people who have died or are lost to follow-up, assessment of overall mortality patterns in the study cohort, levels of diagnostic criteria for individual diseases, and the proportion of deaths with unknown cause.

Ethical approval and informed consent

The BELIEVE study has received approvals from the relevant institutional review boards of the Bangladesh Medical Research Council, the National Heart Foundation Hospital and Research Institute, icddr,b and Bangabandhu Sheikh Mujib Medical University (BMRC/NREC/2013-2016/390; BMRC/NREC/2016-2019/243; BSMMU/2019/1184; BSMMU/2019/1185; PR-18051; HBREC.2019.09). Written informed consent has been obtained from each participant (or by a parent or guardian for participants under the age of

18), including for future use of data and stored samples and invitation to further research studies. The data collected in this research are subject to the core data protection principles and requirements of the United Kingdom Data Protection Act 1998. The investigators and institutional review boards are committed to ensure that research is conducted according to the latest version of the Declaration of Helsinki, Universal Declaration on the Human Genome and Human Rights adopted by the United Nations Educational, Scientific and Cultural Organization (UNESCO), and other legislation.

Patient and public involvement

In keeping with this study's principles of co-creation and community engagement, we have implemented a participatory strategy, collaborating closely with local residents and key stakeholders (some of whom were study participants). Community consultations were conducted in communal spaces to communicate the study's objectives and actively seek feedback from community members. Invitations were extended to local leaders for these sessions, facilitating a deeper understanding of the community's needs and concerns, allowing us to tailor the study accordingly. In addition, we employed local community members as field team personnel, who were trained to collect data and assist study participants. This approach not only provided employment opportunities for local people but also enhanced the cultural appropriateness of the study approaches we used. As well as co-creating the study design, study participants were provided information about the study's purpose, with the assurance that their information would be exclusively used for research purposes.

Sample size considerations and statistical analysis

Sample size considerations have been guided by a combination of pragmatic constraints (e.g., the availability of resources) and statistical power calculations. Assuming 5% of the population develop a disease condition during follow-up, a study of 70,000 individuals should provide 80% power to detect a hazard ratio (HR) of about 1.1 per 1 SD higher value at 5% significance level. In this report, continuous variables were summarised as mean (SD) or median and interquartile range (IQR), and categorical variables were summarised as frequencies and percentages. Variables were summarised and compared across relevant population subgroups (e.g., study site, sex, and age-group) using the t-test for continuous variables and chi-square test for categorical variables. The prevalences of chronic conditions at baseline were summarised as overall crude prevalences, and by site, sex and 20-year age group. To make comparisons between sites analysis was conducted restricted to data from participants aged between 20 and 79 years to compare prevalences of conditions standardised according to the Bangladesh 2022 population structure.(15) All statistical tests were 2-sided, and the significance level was set at $P<0.05$. Robust standard errors were estimated to allow for

clustering of participants by household. Analyses were performed using STATA (version 16, StataCorp, TX, USA) and R (version 4.0.1, R Foundation for Statistical Computing). Future statistical analyses will be developed following relevant guidelines for cohort data with household clustering (e.g., Strengthening the Reporting of Observational Studies) (16) and will be presented elsewhere.

Findings to date

Demographic, behavioural and physical characteristics in the overall study population

Overall, 59,846 (81%) participants were recruited from Mirpur-Dhaka (urban site), 5,332 (7%) from Bauniabadh-Dhaka (slum site), and 8,705 (12%) from Matlab-Chandpur (rural site). 43,470 (59%) participants were female; the mean [SD] age at recruitment was 39 [15] years; 4,122 participants (5.6%) were aged between 11-17 years inclusive (**Table 2**). At the time of the baseline survey 38,848 (52%) participants had either no formal education or primary level education only; 17% were current smokers; 23% were current users of chewable tobacco products; and only 1.3% of the participants reported consuming alcohol regularly.

Several characteristics varied by study site. For example, 55% of participants in the urban site had secondary or higher level of education compared with only 16% and 18% in slum and rural sites, respectively (**Supplementary Table 2**). Whereas the percentage of participants self-reporting as current smokers was similar across the sites (17%, 17% and 13% in urban, slum and rural sites, respectively), reported use of chewable tobacco and alcohol was higher in the slum site (62% and 12.2% respectively, vs 18% and 0.4% in the urban site, and 34% and 0.4% in the rural site). Additional conventional risk factor values differed by study site (**Table 2**), with a tendency towards more adverse risk factor profiles in urban participants (**Supplementary Table 2**). For example, mean (SD) systolic blood pressure was 125 (21) mmHg in participants from the urban site versus 112 (20) and 120 (20) mmHg in the slum and rural sites, respectively. Mean (SD) BMI was 26 (5) kg/m^2, 23 (5) kg/m^2 and 23 (5) kg/m^2 in participants from the urban, slum and rural sites respectively, with other measures of adiposity (including, waist-to-hip ratio and body fat percentage) following a similar trend. As the trend towards urbanisation accelerates in Bangladesh, such differences in risk factor profiles portend implications for striking increases in NCDs (17,18). This contrast in risk factor profiles across settings also suggests the need for context-specific solutions to help better prevent and control NCDs. We plan to contribute toward this goal through longitudinal surveillance of

risk factors and NCD incidence in the BELIEVE cohort, as well as the re-purposing the cohort framework to support applied health research studies.

Certain baseline characteristics also differed between males and females (**Supplementary Table 3**). Females were, on average, younger (38 [15] vs 41[16] years), had spent fewer years in education (45% vs 50% had secondary or higher level of education), were less likely to report any tobacco smoking (<1% vs 41%) and consuming alcohol (<1% vs 3%). Systolic blood pressure was higher among males (127 [20] vs 121 [21] mmHg), whereas females had a higher BMI (26 [5] vs 24 [4] kg/m^2).

Overweight, obesity and chronic health conditions in adults aged 20 to 79

Among adult participants aged between 20 and 79 years (**Supplementary Table 4-6**) and using WHO-defined BMI categories, 39% of individuals were considered overweight (BMI 25-29 kg/m^2) and 16% obese (i.e., BMI≥30 kg/m^2, **Supplementary table 4**). After standardisation to the sex and age distribution of the Bangladeshi population for the same age range, the corresponding proportions were 37% and 14%, respectively (**Supplementary Figure 2**). Proportions of overweight and obese participants were higher in the urban site, compared to the slum and rural sites, and also higher in females compared to males (**Supplementary Figure 2-3**). There are likely to be multiple factors contributing to excess adiposity, including dietary patterns, sedentary lifestyles, and urbanisation (1,19). Additionally, socio-economic disparities and lack of awareness regarding the importance of diet and physical activity may play roles. As overweight and obesity are associated with multiple chronic health conditions, including cardiovascular diseases, diabetes, and certain cancers (20–22), addressing this challenge is necessary to improve the health of the Bangladeshi population and alleviate healthcare system burdens (23,24).

The most prevalent self-reported chronic health conditions at baseline that were recorded among adults aged 20-79 were hypertension, type 2 diabetes and hypercholesterolaemia (**Supplementary Table 6**), with standardised prevalences of 21%, 15% and 11%, respectively (**Figure 3**). Prevalence of these conditions was higher among participants recruited in the urban site compared to those in slum and rural sites. For example, the standardised prevalence of hypertension was 23%, 16% and 14% in urban, slum and rural sites, respectively. Corresponding prevalences were 16%, 10% and 5.7% for type 2 diabetes, and 12%, 8% and 1.5% for hypercholesterolaemia. The overall prevalence of type 2 diabetes in this study was higher than those previously reported for Bangladesh (17), and varied by age and sex, with the highest prevalences were among older participants and females (**Supplementary Figures 4-6**). These findings may suggest potential age and sex-specific

differences in susceptibility to type 2 diabetes or disparities in healthcare access and management or both. We plan to contribute toward understanding of such potential age and sex-specific differences in determinants of chronic diseases, as it should inform development of targeted preventive measures, and tailored interventions to address the specific risk factors affecting different populations.

Strengths and limitations

Although Bangladesh is experiencing substantial increases in NCDs (10), there is limited evidence about the multi-dimensional risk factors and drivers of NCDs in the country, thereby preventing deeper understanding of the web of causation for NCDs and limiting development of optimal prevention and control approaches. The BELIEVE study has been established as a long-term epidemiological bioresource to help address this gap, including investigation of Bangladesh's contrasting urban and rural settings. Configured to investigate biological, behavioural, environmental, and broader determinants of NCDs, the BELIEVE study is a household-based prospective cohort study that spans urban, slum and rural settings. To our knowledge, it represents the largest bioresource for NCDs and related traits in Bangladesh, involving active longitudinal follow-up of participants for new-onset health outcomes.

The BELIEVE study has demonstrated the feasibility of employing modern epidemiological methods at scale in a population-based study located across multiple different settings in Bangladesh. The study has used electronic data collection methods, utilising study forms implemented through bespoke software applications ("apps"), allowing comprehensive recording of questionnaire-based data, as well as physical measurements. The study has also collected a range of biological samples, including serum, plasma, whole blood, and nail samples stored in long-term repositories. Assay of these samples is enabling study of many molecular factors, laying foundations to advance understanding of disease pathways and potential therapeutic targets for treatment and prevention of NCDs in Bangladesh and beyond.

The potential limitations of the BELIEVE study merit consideration. Within each of the three study settings, every household was invited to participate in the cohort. As the household participation rates have been high (>80%), they suggest that study participants should be broadly representative of the source population in the participating sites. However, the participants, households and sites included in the study were not necessarily representative of the general Bangladesh population. Nevertheless, it should be reasonable to infer that findings from this cohort can be generalised to other similar settings in Bangladesh because the study involves participants with a wide range of diverse characteristics (e.g., in relation to

age, sex, socio-economic status, education level, occupation etc), recruited from a variety of different settings (urban, slum, and rural areas) characteristic of contemporary Bangladesh.

A further potential limitation relates to the scope for misclassification of risk factors and health outcomes recorded at baseline and during study follow-up because of inaccuracies in participant self-report. To help limit the effects for such potential misclassification, the BELIEVE study is supplementing self-reported data with use of objective measurements (e.g., assay of LDL-cholesterol, HbA1c, arsenic metabolites), inspection of health records kept by participants during household follow-up visits, use of previously validated "verbal autopsy" methods, and exploration of emerging potential linkages of study participants with digital health records kept at community healthcare and hospital levels.

Finally, there is potential in this prospective study for underestimation of the strength of the associations observed between risk factors and incident health outcomes due to fluctuations in risk factor levels within individuals over time (i.e., "regression dilution" bias). To help limit such bias, the BELIEVE study plans to conduct periodic serial re-surveys of risk factor levels in randomly selected subsets of the study participants.

Conclusion

By providing a powerful resource to investigate multi-dimensional determinants of NCDs across diverse settings in Bangladesh, the BELIEVE study should help advance scientific understanding and inform public health action in an archetypal low-middle-income country with pressing public health needs.

Data availability statement

Data are available upon application to the study's Steering and Data Access Committee.

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Tables and Figures

Figure 1. Location of the BELIEVE study sites

Figure 2: Study recruitment and follow-up procedures

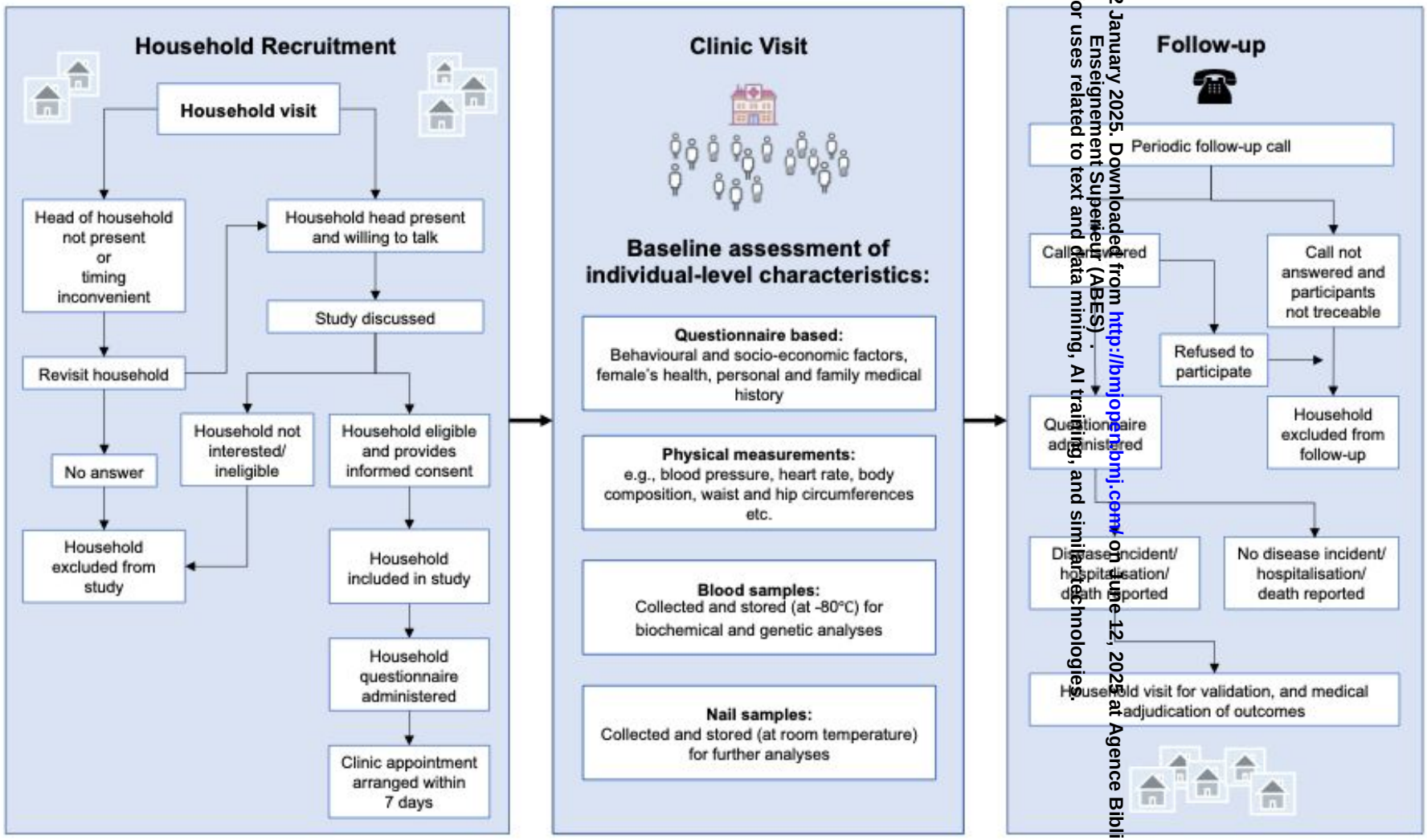
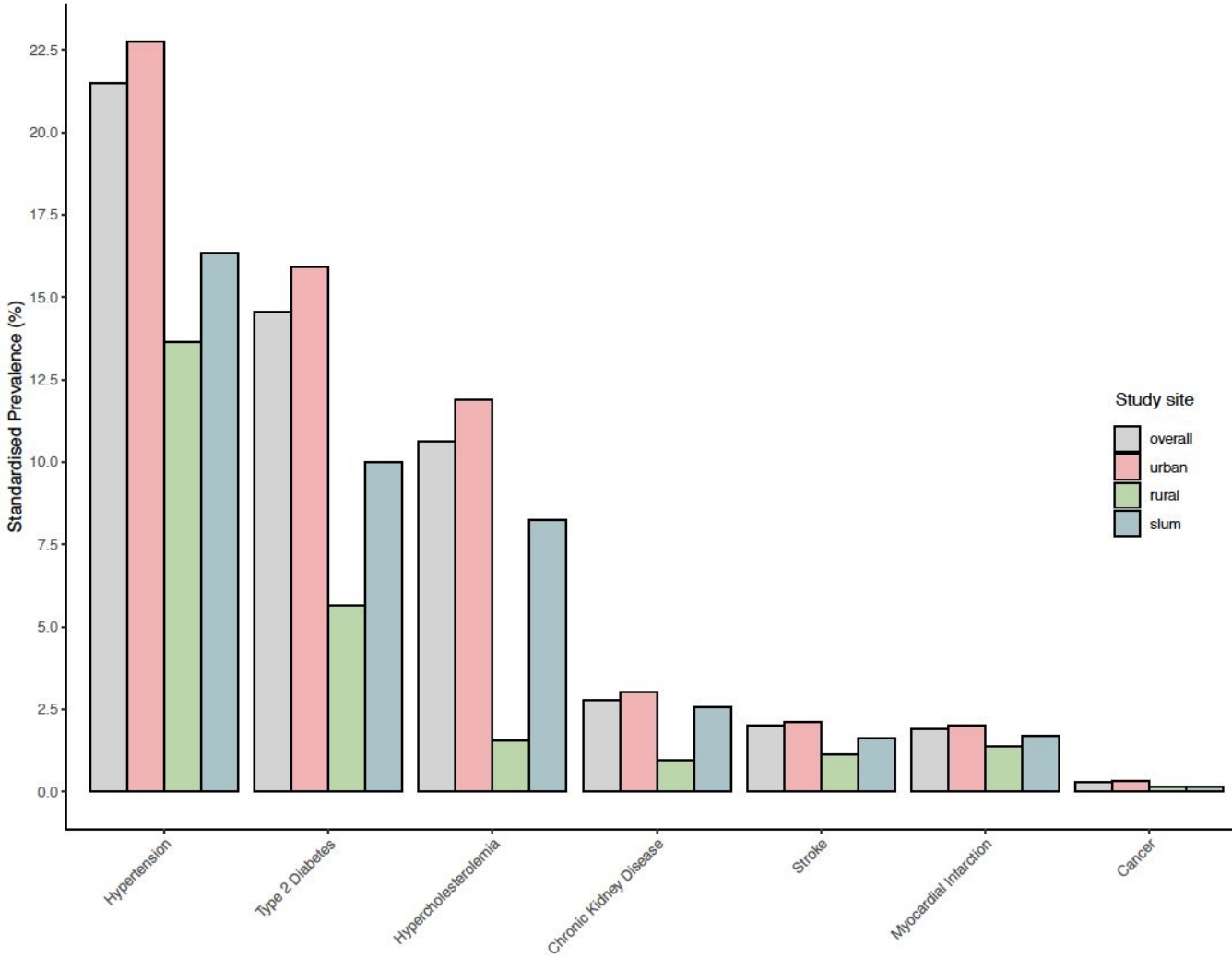


Figure 3. Standardised prevalences of selected chronic conditions at recruitment in BELIEVE for participants aged 20-79



MI: myocardial infraction
Prevalence was standardised using the sex and age distribution of the Bangladesh 2022 population aged 20-79.

Table 1. Questionnaire-based information, physical measurements and biological samples collected at baseline in the BELIEVE study

Characteristics	Description
House and household	
House information	Location, type of accommodation, house construction materials, number of bedrooms, cooking source, sanitation, water source, indoor and outside environment
Household information	Number of occupants, contact details, family size
Individual	
Demographics	Age, sex, ethnicity, religion, marital status, consanguinity
Behavioural factors	Tobacco consumption (cigarette and non-cigarette), passive tobacco exposure, cooking habits, food frequency assessment, alcohol consumption, physical activity, sleeping habits, mobile phone usage
Socioeconomic factors	Education, occupation, income, remittances, loans, assets ownership (including mobile phone, television, refrigerator, Digital Versatile Disc (DVD) player, Air Conditioning, bicycle, motorcycle, car, livestock, land, bank account)
Psychosocial factors	Stress at work and at home, social support, Center for Epidemiological Studies Depression symptoms score, Generalized Anxiety Disorder score, sleeping habits, life events
Females health	Age at menarche, hormonal contraceptive usage, menstrual and pregnancy history
Personal and family medical history	Myocardial infarction, angina, hypertension, other vascular diseases, type 2 diabetes mellitus, atrial fibrillation, cancers, hypercholesterolemia, chronic liver disease, chronic kidney disease, chronic obstructive respiratory disease, mental disorders, neurological diseases, infectious diseases, childhood disorders, major surgery, chest and limb pain, current medication usage
Physical measurements	Blood pressure, heart rate, respiratory rate, height, weight, body composition, upper body strength, waist and hip circumferences.
Biological samples	Serum, plasma and whole blood samples, finger and toe-nail clippings

Table 2. Baseline characteristics of the 73,833 BELIEVE study participants

Key characteristics	Mean (SD) or Number (%)
Demographic and behavioural characteristics	
Age (years)	39 (15)
Individuals aged <18 years	4122 (5.6)
Female	43470 (59)
Study site of residence	
Urban site	59846 (81)
Urban slum site	5332 (7.2)
Rural site	8705 (12)
Married	54386 (74)
Education level	
None/pre-primary	16594 (22)
Primary	22254 (30)
Secondary	21367 (29)
Bachelors or higher degree	13105 (18)
Current smoker	12450 (17)
Current chewable tobacco user	16982 (23)
Current alcohol consumer	927 (1.3)
Physical measurements	
Systolic blood pressure (mmHg)	123 (21)
Diastolic blood pressure (mmHg)	77 (12)
Body Mass Index (BMI, kg/m^2)	25 (5)
Waist circumference (cm)	86 (12)
Waist to hip ratio	0.92 (0.08)
Body fat percentage (%)	27 (9)

Missing data by variable: Married (n=3), Education (n=563), smoking/chewable tobacco use (n=4), Alcohol consumption (n=42), systolic blood pressure (n=23), diastolic blood pressure (n=22), BMI (n=45), waist circumference (n=26), waist to hip ratio (n=30).

Body fat percentage was not measured in the early stages of recruitment and therefore was not available in 15,049 participants.

Supplementary Material

Supplementary Table 1. A detailed description of physical measurements in the BELIEVE study

Test	Description
Blood Pressure and Heart Rate	Blood pressure and heart rate were measured using an automated upper arm device. Measurements were taken after a period of 5 minutes during which the participant was sitting quietly; i) in a seated position with legs uncrossed and feet flat on the floor; ii) with the appropriate cuff size placed snugly around the upper arm, leaving a space for a finger between the participant and cuff; iii) ensuring that the cuff was appropriately aligned with the brachial artery following the instructions in the equipment manual. Two measurements of blood pressure and heart rate were taken.
Height	Standing height was measured using a stadiometer standardised across all study sites to the nearest 1cm. Participants were asked to remove their shoes before the measurement being taken and to stand upright with heels and shoulders against the measuring rod, knees and back straight and looking forward. The evaluating arm was pushed down to lightly touch the participant's head. Two measurements of height were taken.
Weight	Weight was measured using a device standardised across all study sites to the nearest 1kg. The scales were standardised to 0 before each use. Weight was measured in light clothing; participants were asked to remove their outer garments (e.g., coats) and shoes. Participants were asked to stand on the centre of the scales, arms to the side, looking forward. Two measurements of weight were taken.
Waist Circumference	Waist circumference was measured with the participant standing, using equipment standardised across study sites. This was measured to the nearest 0.1 cm using a non-stretchable standard tape measure. Subject was relaxed with arms held loosely at sides. Waist circumference was measured over the abdomen at the widest diameter between the costal margin and the iliac crest over light clothing. Two measurements were taken for waist circumference.
Hip Circumference	Hip circumference was measured, with the participant standing, using equipment standardised across study sites. This was measured to the nearest 0.1 cm using a non-stretchable standard tape measure. Subject should relax with arms held loosely at sides. Hip circumference was measured at the widest diameter around the buttocks. The tape measure must be kept horizontal for standing measurement. Two measurements were taken for hip circumference.
Respiratory Rate	Respiratory rate was measured with the participant seated. The Field Research Assistant counted the number of breaths per minute by careful observations without the participant being aware. This was timed with for 60seconds with a watch.
Body Composition	Body Composition was calculated by measuring bio-impedance using the Tanita MC-780MA body composition analyser. Participants were directed and monitored during use of this machine by trained study clinic nurses following the standard operating procedures (appendix 5).
Upper Body Strength	Upper body strength was measured using a Jamar Plus Digital Hand Dynamometer. Trained FRA's monitored and directed participants in the correct usage of the handgrip dynamometer (detailed in appendix 7).

Supplementary Table 2: Baseline characteristics of the BELIEVE study participants by site

Characteristics	Urban		Urban Slum		Rural	
	Number of available observations	Mean (SD) or Number (%)	Number of available observations	Number (%)	Number of available observations	Mean (SD) or Number (%)
Demographic and behavioural characteristics						
Age (years)	59846	40 (15)	5332	32 (15)	8705	37 (18)
Individuals aged <18 years		968 (1.6)		1232 (23)		1922 (22)
Females	59846	34780 (58)	5332	3372 (63)	8705	5318 (61)
Married	59844	45332 (76)	5331	3309 (62)	8705	5745 (66)
Education level	59368		5310		8642	
None/pre-primary		9808 (17)		2831 (53)		3955 (46)
Primary		17449 (29)		1630 (31)		3175 (37)
Secondary		19319 (33)		771 (15)		1277 (15)
Bachelors or higher degree		12792 (22)		78 (1)		235 (3)
Current smoker	59844	10363 (17)	5331	913 (17)	8704	1174 (13)
Current chewable tobacco user	59843	10734 (18)	5331	3322 (62)	8705	2926 (34)
Current alcohol consumer	59820	244 (0.4)	5324	650 (12)	8697	33 (0.4)
Physical measurements						
Systolic blood Pressure (mmHg)	59831	125 (21)	5324	112 (20)	8705	120 (20)
Diastolic blood Pressure (mmHg)	59832	78 (11)	5324	70 (12)	8705	74 (12)
Body Mass Index (BMI, kg/m^2)	59815	26 (5)	5323	23 (5)	8700	23 (5)
Waist circumference (cm)	59828	87 (12)	5324	83 (14)	8705	80 (13)
Waist to hip ratio	59824	0.93 (0.08)	5324	0.91 (0.08)	8705	0.91 (0.08)
Body fat percentage (%)	45432	28 (9)	5140	27 (9)	8262	24 (9)

Supplementary Table 3: Baseline characteristics of the BELIEVE study participants by sex

Characteristics	Females		Males	
	Number of available observations	Mean (SD) or Number (%)	Number of available observations	Mean (SD) or Number (%)
Demographic and behavioural characteristics				
Age (years)	43470	38 (15)	30413	41 (16)
Individuals aged <18 years	43470	2307 (5.3)	30413	1815 (6.0)
Study site of residence				
Urban		34780 (80)		25066 (82)
Urban slum		3372 (7.8)		1960 (6.4)
Rural		5318 (12)		3387 (11)
Married	43467	32082 (74)	30413	22304 (73)
Education level	43129		30191	
None/pre-primary		10412 (24)		6182 (20)
Primary		13406 (31)		8848 (29)
Secondary		12334 (29)		9033 (30)
Bachelors or higher degree		6977 (16)		6128 (20)
Current Smoker	43466	63 (0)	30413	12387 (41)
Current Chewable tobacco user	43467	10376 (24)	30412	6606 (22)
Current Alcohol consumer	43442	122 (0.3)	30399	805 (2.6)
Physical measurements				
Systolic Blood Pressure (mmHg)	43458	121 (21)	30402	127 (20)
Diastolic Blood Pressure (mmHg)	43458	76 (12)	30403	78 (12)
Body Mass Index (BMI, kg/m^2)	43447	26 (5)	30391	24 (4)
Waist Circumference (cm)	43457	87 (13)	30400	86 (12)
Waist to hip ratio	43455	0.91 (0.08)	30398	0.94 (0.07)
Body Fat Percentage (%)	34735	32 (7)	24099	20 (6)

Supplementary Table 4. Baseline characteristics of the BELIEVE study participants aged 20-79, excluding pregnant females

Characteristics	Number of available observations	Mean (SD) or Number (%)
Demographic and behavioural characteristics		
Age (years)	65199	42 (14)
Females	65199	38196 (59)
Study site of residence	65199	
Urban site		54833 (84)
Urban slum site		3901 (6.0)
Rural site		6465 (9.9)
Married	65196	52459 (80)
Education level	64709	
None/pre-primary		13888 (21)
Primary		19268 (30)
Secondary		19260 (30)
Bachelors or higher degree		12293 (19)
Current smoker	65195	11767 (18)
Current chewable tobacco user	65195	15962 (24)
Current alcohol consumer	65167	722 (1.1)
Physical measurements		
Systolic blood pressure (mmHg)	65181	125 (21)
Diastolic blood pressure (mmHg)	65182	78 (11)
Body Mass Index (BMI, kg/m^2)	65163	26 (5)
Waist circumference (cm)	65179	88 (11)
Waist to hip ratio	65175	0.93 (0.07)
Body fat percentage (%)	51846	28 (9)
WHO-defined BMI categories		
Underweight (<18.5 kg/m^2)		3145 (4.8)
Normal weight (18.5-24.9 kg/m^2)		26074 (40)
Overweight (25.0-29.9 kg/m^2)		25502 (39)
Obese (≥30 kg/m^2)		10442 (16)

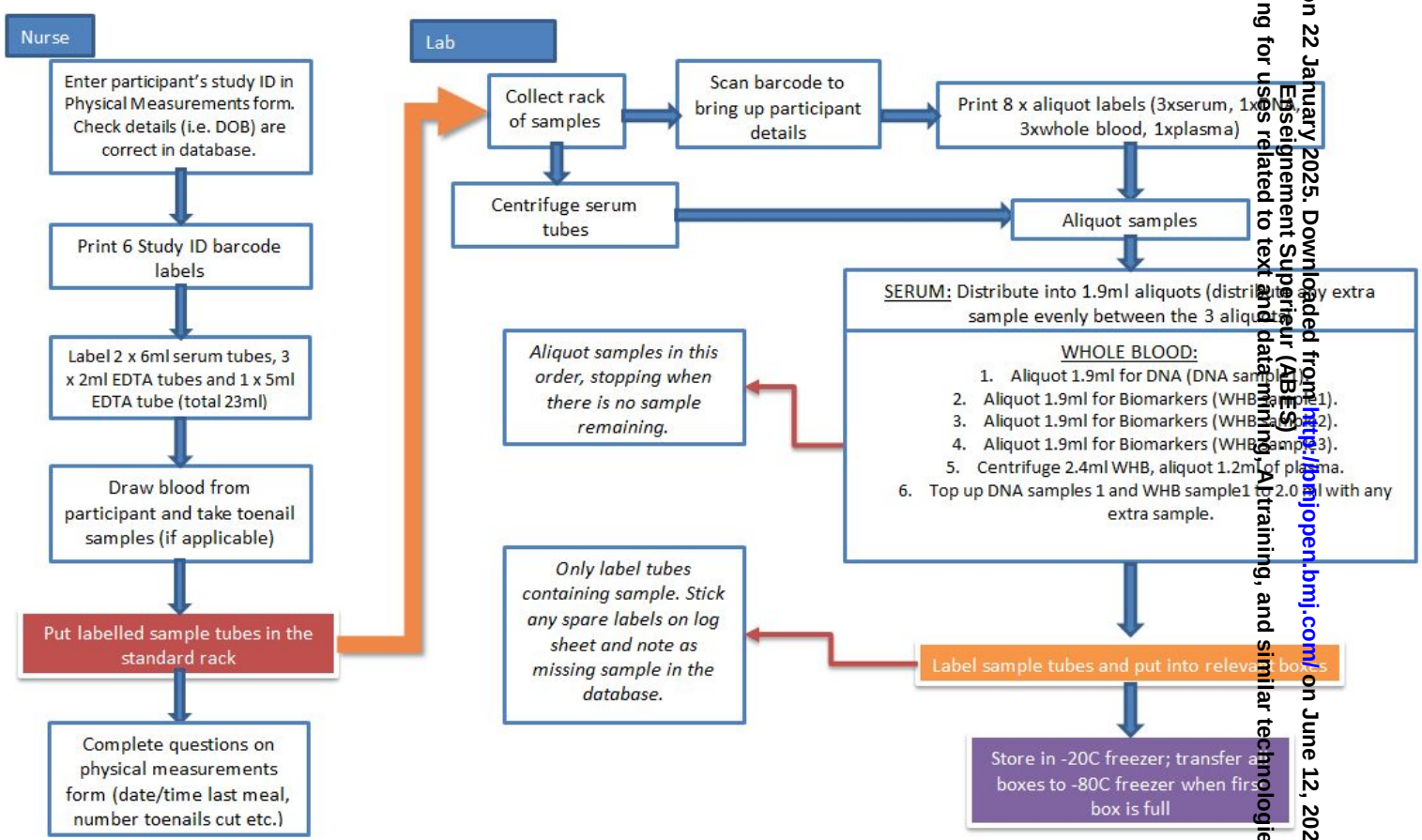
Supplementary Table 5: Baseline characteristics of the BELIEVE study participants by age

Characteristics	Age 11-19 years		Age 20-39 years		Age 40-59 years		Age 60-79 years		Age >=80years	
	Number of available observations	Mean (SD) or Number (%)	Number of available observations	Mean (SD) or Number (%)	Number of available observations	Mean (SD) or Number (%)	Number of available observations	Mean (SD) or Number (%)	Number of available observations	Mean (SD) or Number (%)
Demographic and behavioural characteristics										
Age (years)	7744	16 (3)	32780	30 (6)	25258	49 (6)	7744	66 (5)	317	84 (4)
Females	7744	4546 (59)	32780	20943 (64)	25258	14442 (57)	7744	3434 (44)	317	105 (33)
Married	7744	1127 (15)	32779	25072 (76)	25257	22449 (89)	7743	5558 (71)	317	180 (57)
Education level	7680		32541		25077		7741		311	
None/pre-primary		2499 (33)		6543 (20)		5718 (23)		1748 (23)		86 (28)
Primary		2711 (35)		10544 (32)		7133 (28)		1784 (23)		82 (26)
Secondary		1818 (24)		10008 (31)		7313 (29)		2138 (28)		90 (29)
Bachelors or higher degree		652 (8)		5446 (17)		4913 (20)		2041 (26)		53 (17)
Current Smoker	7744	653 (8)	32778	6258 (19)	25257	4504 (18)	7743	1006 (13)	317	29 (9)
Current Chewable tobacco user	7744	823 (11)	32778	4146 (13)	25257	8300 (33)	7743	3552 (46)	317	161 (51)
Current Alcohol consumer	7735	205 (2.7)	32763	516 (1.6)	25249	191 (0.8)	7737	15 (0.2)	317	0 (0.0)
Physical measurements										
Systolic Blood Pressure (mmHg)	7739	107 (13)	32771	116 (15)	25251	131 (21)	7742	143 (23)	317	152 (24)
Diastolic Blood Pressure (mmHg)	7739	66 (9)	32771	75 (10)	25252	82 (11)	7742	81 (11)	317	79 (12)
Body Mass Index (BMI, kg/m^2)	7735	21 (4)	32763	25 (5)	25244	26 (4)	7739	25 (4)	317	23 (4)
Waist Circumference (cm)	7738	71 (11)	32770	85 (11)	25250	91 (10)	7742	91 (11)	317	89 (11)
Waist to hip ratio	7738	0.84 (0.06)	32768	0.90 (0.07)	25248	0.96 (0.06)	7742	0.98 (0.07)	317	0.99 (0.07)
Body Fat Percentage (%)	6742	23 (8)	25884	27 (9)	20082	29 (9)	5858	27 (9)	228	25 (8)

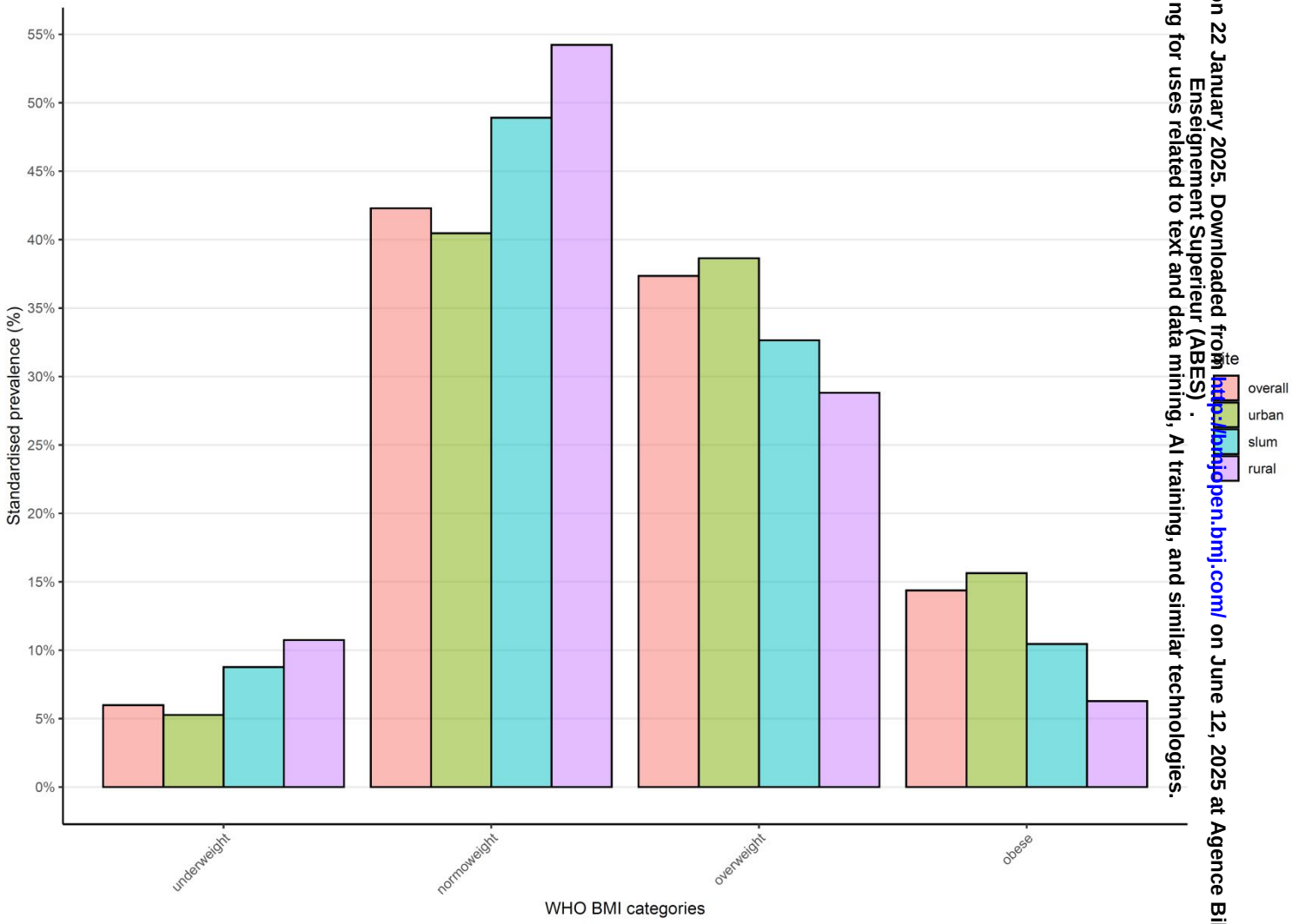
Supplementary Table 6. Crude prevalence of selected chronic conditions at recruitment in BELIEVE participants aged 20-79, overall and by site

Chronic condition present at baseline	Overall		Urban		Urban Slum		Rural	
	Number of available observations	Number (%) with condition	Number of available observations	Number (%) with condition	Number of available observations	Number (%) with condition	Number of available observations	Number (%) with condition
Hypertension	65819	15411 (23)	55378	13795 (25)	6541	1046 (16)	3900	552 (14)
Type 2 diabetes	65821	10578 (16)	55379	9776 (18)	6541	452 (7)	3901	350 (9)
Hypercholesterolemia	65820	7624 (12)	55379	7241 (13)	6541	110 (2)	3900	273 (7)
Stroke	65820	1371 (2.1)	55379	1232 (2.2)	6541	90 (1.4)	3900	49 (1.3)
Myocardial infarction	65820	1332 (2.0)	55379	1178 (2.1)	6541	109 (1.7)	3900	45 (1.2)
Chronic kidney disease	65819	1928 (2.9)	55378	1764 (3.2)	6541	66 (1.0)	3900	98 (2.5)
Cancer	65818	220 (0.33)	55379	204 (0.37)	6540	10 (0.15)	3899	6 (0.15)

Supplementary Figure 1. Standard Operating Procedures – Blood Sample Collection, Labelling and Processing

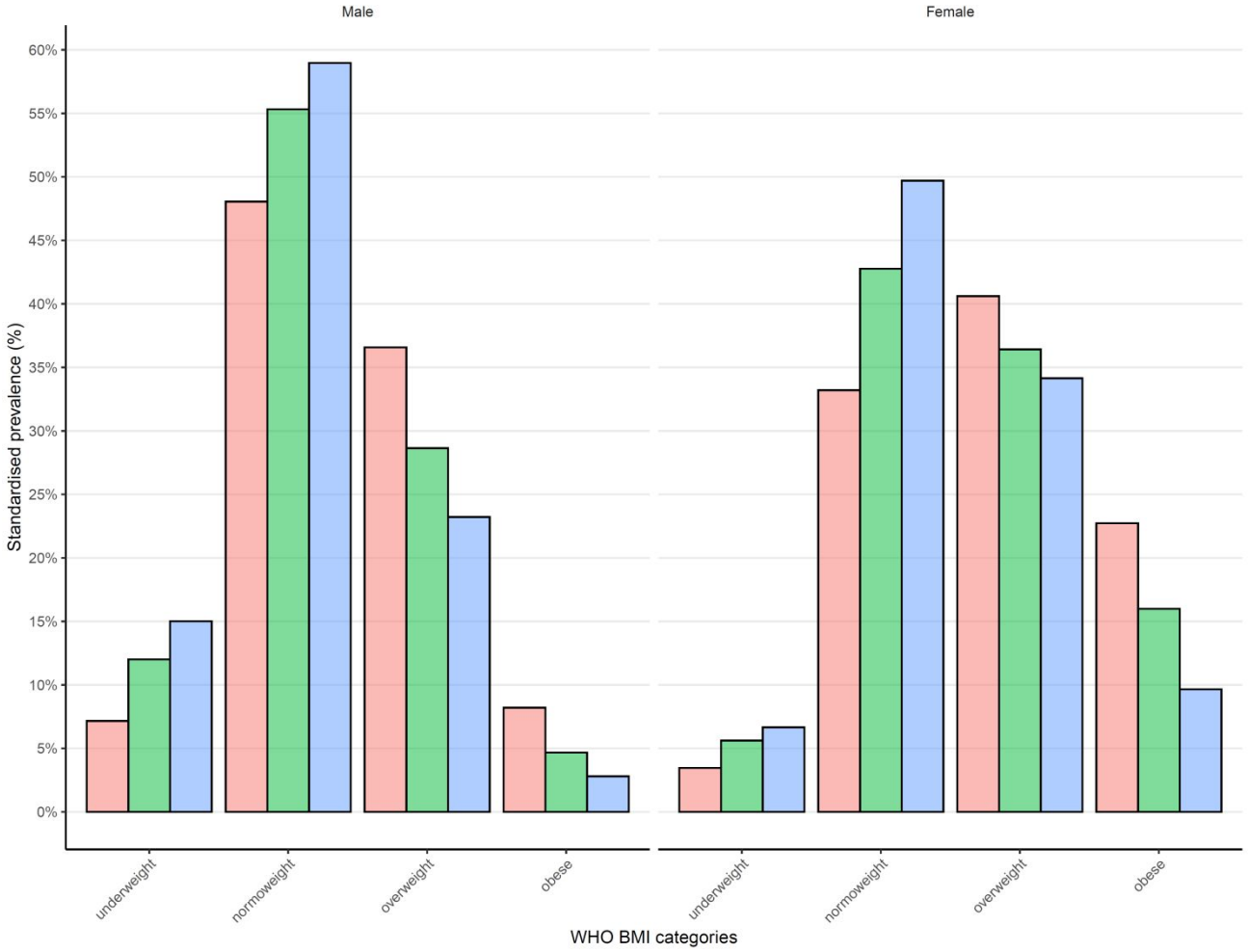


Supplementary Figure 2. Standardised prevalences of WHO-defined BMI categories in BELIEVE participants aged 20-79, overall and by site



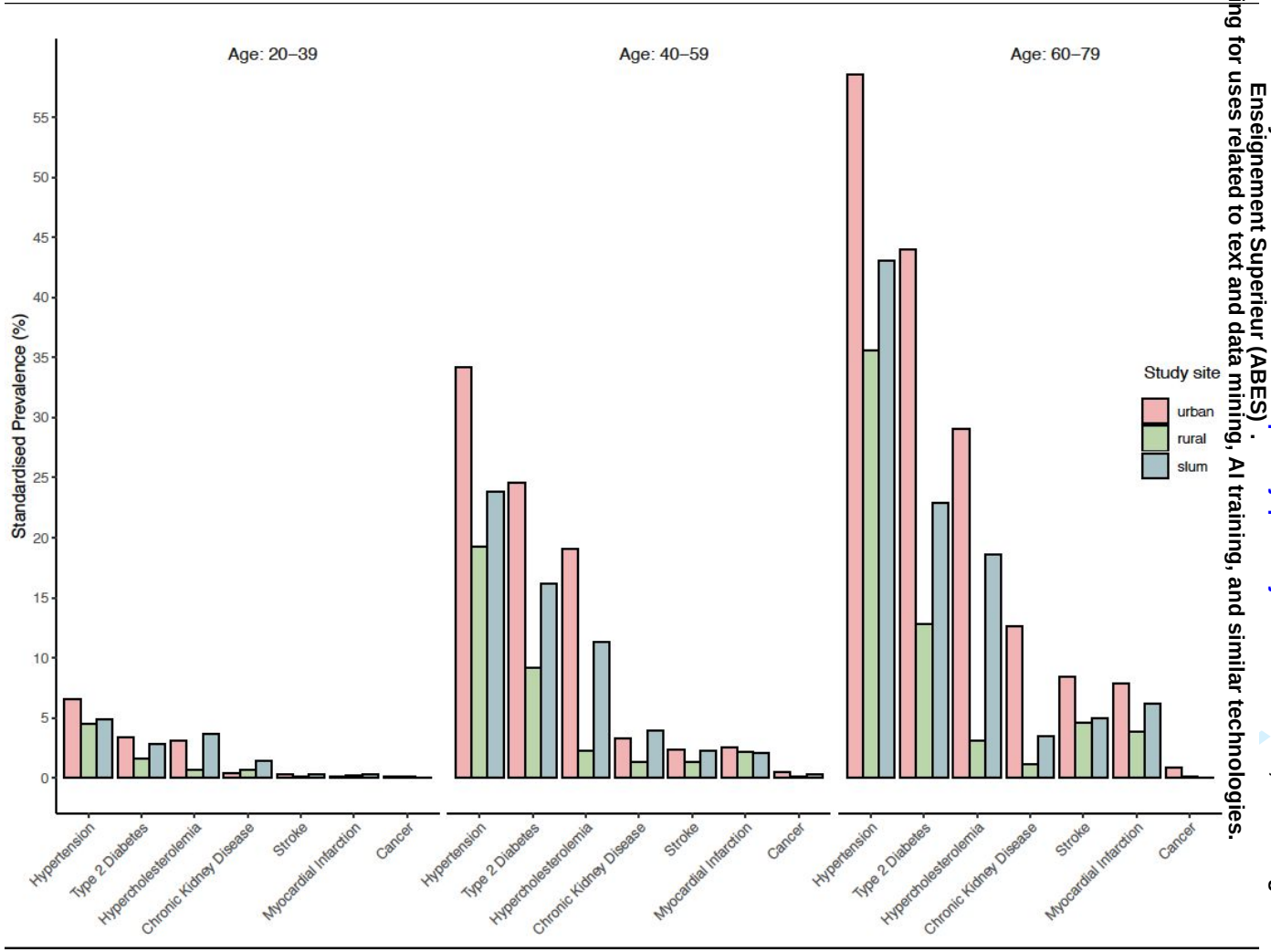
Prevalence is standardised using the sex and age distribution of the Bangladesh 2022 population aged 20-79

Supplementary Figure 3. Standardised prevalences of WHO-defined BMI categories in BELIEVE participants aged 20-79, by sex and site



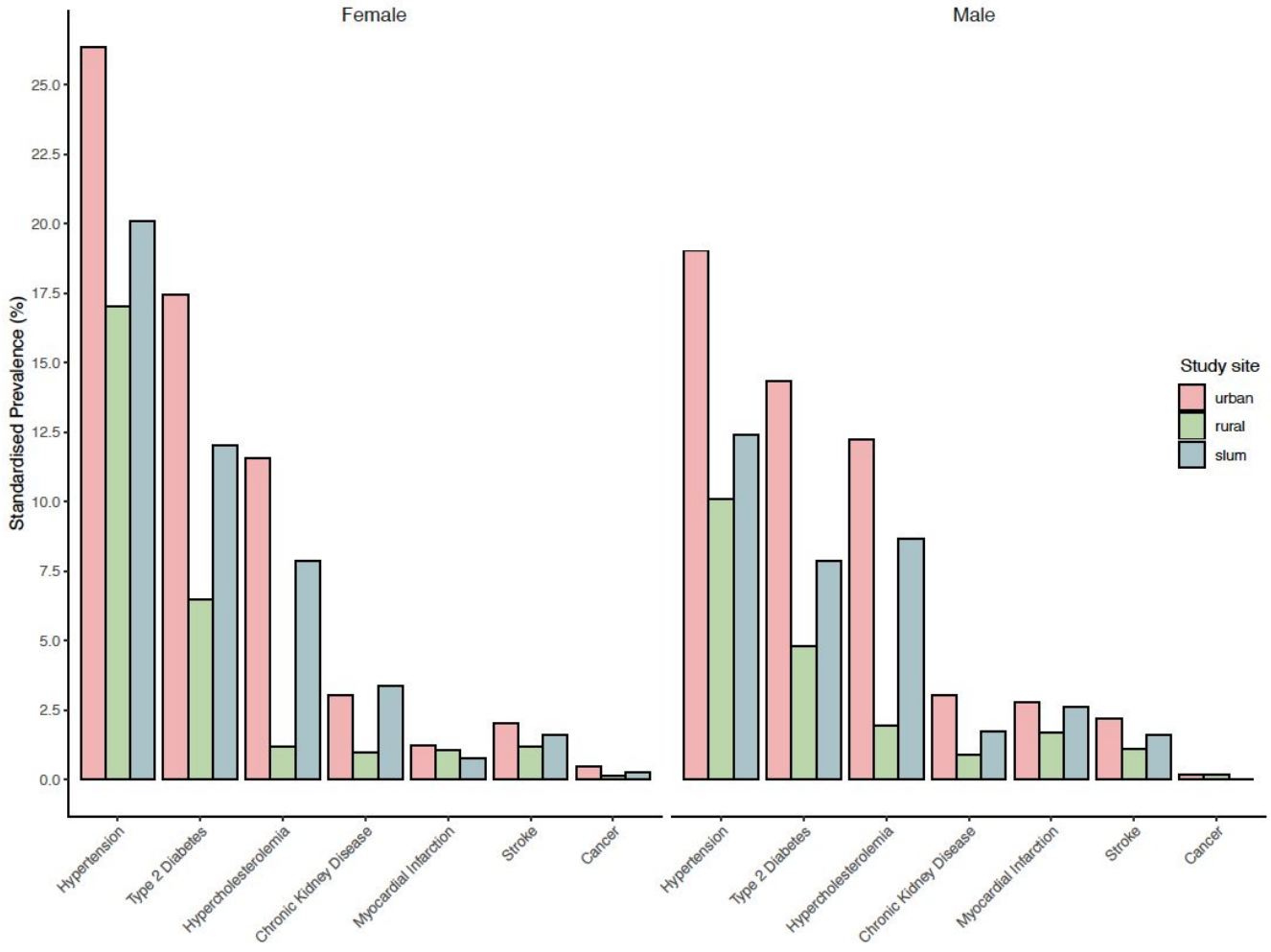
Prevalence was standardised using the sex and age distribution of the Bangladesh 2022 population aged 20-79.

Supplementary Figure 4. Standardised prevalence of selected chronic conditions in participants aged 20-79, by age and site



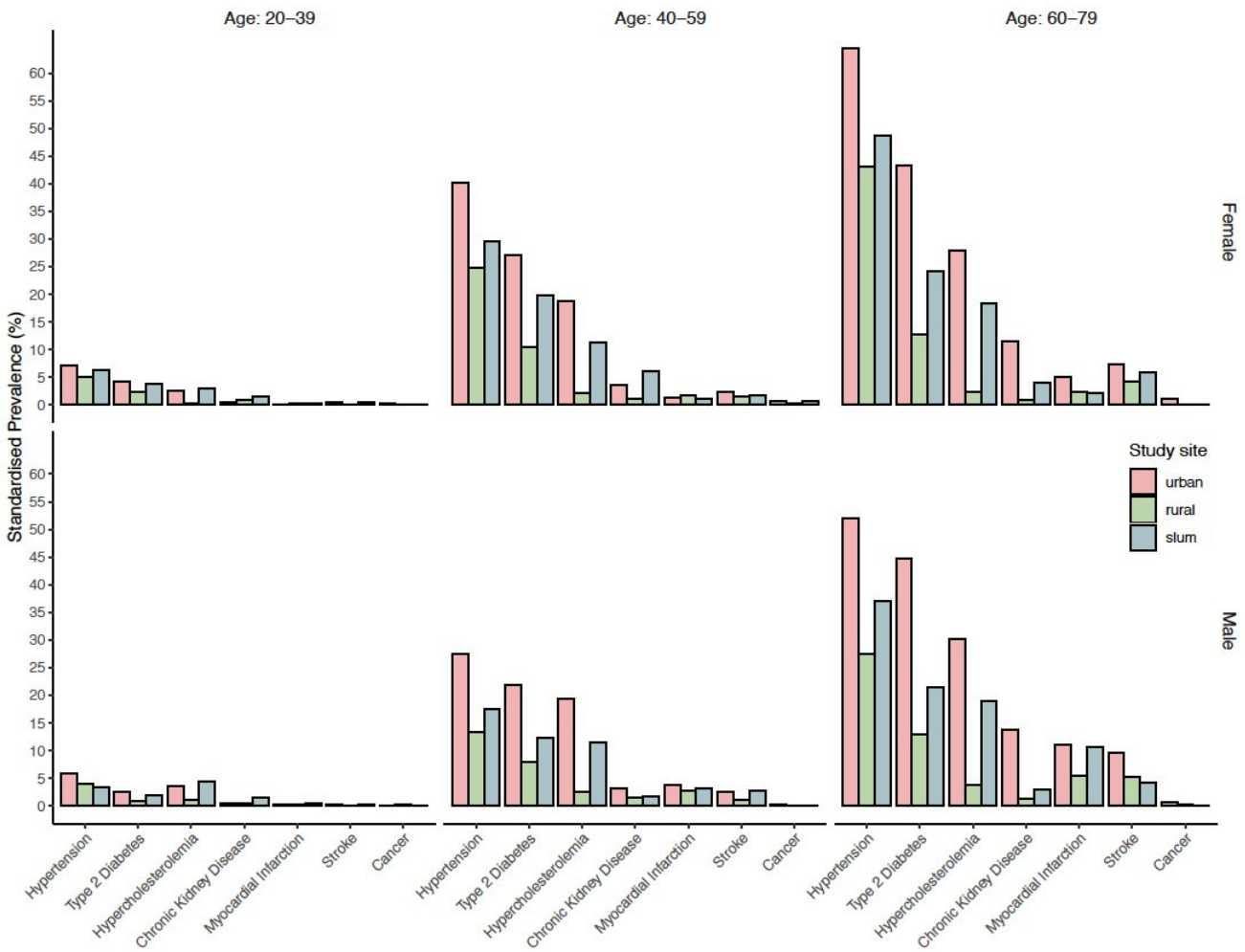
MI: myocardial infraction
Prevalence was standardised using the sex and age distribution of the Bangladesh 2022 population aged 20-79.

Supplementary Figure 5. Standardised prevalences of selected chronic conditions in participants aged 20-79, by sex and site



MI: myocardial infraction
Prevalence was standardised using the sex and age distribution of the Bangladesh 2022 population aged 20-79.

Supplementary Figure 6. Standardised prevalences of selected chronic conditions in participants aged 20-79, by sex, age and site



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Cohort profile: The BangladEsh Longitudinal Investigation of Emerging Vascular and nonvascular Events (BELIEVE) cohort study

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Cohort profile:
The BangladEsh Longitudinal Investigation of Emerging Vascular and nonvascular Events (BELIEVE) cohort study

The BELIEVE study group*

*authors are listed at the end of the paper

Keywords: cohort study, global health, non-communicable disease

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2 Tables and 3 Figures, 12 Supplementary Tables and Figures

Abstract

Purpose Bangladesh has experienced a rapid epidemiological transition from communicable to non-communicable diseases (NCDs) in recent decades. There is, however, limited evidence about multi-dimensional determinants of NCDs in this population. The BangladEsh Longitudinal Investigation of Emerging Vascular and nonvascular Events (BELIEVE) study is a household-based prospective cohort study established to investigate biological, behavioural, environmental, and broader determinants of NCDs.

Participants Between January 2016 and March 2020, 73,883 participants (aged 11 years or older) were recruited from 30,817 households across urban, urban-poor ("slum") and rural settings in Bangladesh. An structured questionnaire was administered by trained personnel recording participants' demographic, socioeconomic, behavioural, medical, environmental and other factors. Anthropometric measurements and blood pressure were recorded for each participant. Biological specimens were collected and aliquoted for long-term storage and analysis.

Findings to date Of the 73,883 study participants (mean [SD] baseline age: 39 [15] years), 43,470 (59%) were females, and 38,848 (52%) had no or only primary-level education. Focusing only on the 65,822 adults participants aged 20 to 79 years at baseline, 15,411 (23%) reported being diagnosed with hypertension; 10,578 (16%) with type 2 diabetes; and 7,624 (12%) with hypercholesterolaemia. Age and sex standardised prevalences of these conditions were much higher in urban than slum and rural settings. Overall, mean (SD) body mass index (BMI) was 25 (5) kg/m^2, with 10,442 (16%) participants aged 20 to 79, classified as obese (i.e., BMI$\geq$30 kg/m^2). Mean BMI was also higher in urban than slum and rural areas.

Future plans Collection of information at baseline visit was completed in 2020. Regular longitudinal follow-up is ongoing for ascertainment and adjudication of a range of fatal and non-fatal health outcomes among participants. This cohort will provide a powerful resource to investigate multi-dimensional determinants of incident NCDs across diverse settings in Bangladesh, helping to advance scientific discovery and public health action in an archetypal low-middle-income country with pressing public health needs.

STRENGTHS AND LIMITATIONS OF THIS STUDY

- Largest bioresource for non-communicable diseases (NCDs) and related traits in Bangladesh, configured to investigate multi-dimensional determinants of NCDs across urban, slum and rural settings.

- Comprehensive recording of questionnaire-based data, including demographic, socioeconomic, behavioural, medical, environmental and other factors, as well as physical measurements.

- Collection of a range of biological samples ─ including serum, plasma, whole blood, and nail samples ─ stored in long-term repositories.

- Use of stored biological samples to enable the study of many genomic and molecular factors together with other information, laying foundations to advance scientific discovery and public health action.

- The study is not necessarily representative of the general Bangladesh population and could be limited by misclassification of disease outcomes and by loss of contact with some participants during follow-up.

Introduction

Non-communicable diseases (NCDs) – including cardiovascular diseases, diabetes, cancer, and chronic respiratory diseases – are the leading causes of premature death in low- and middle-income countries (LMICs).[1,2] In particular, South Asia has recorded a higher number of life-years lost due to premature NCDs than any other global region, a situation which reflects both the region's large population and the relatively young age at which NCD deaths tend to occur in this region.[1,3] Furthermore, while NCD mortality rates have decreased during recent decades in most countries, they remain at high level in the South East Asia region.[4,5] Better understanding of the multi-dimensional determinants of NCDs in South Asia should, therefore, inform development of appropriately tailored strategies for disease prevention and control.

There is, however, limited evidence available on NCD determinants for many South Asian populations.[2,6] For example, Bangladesh, a country with 170 million people, is one of the least studied most densely-populated countries with regard to NCDs, despite steep and sustained increases in NCDs risk factors and incidence during recent decades.[7,8] In 2021, 74% of all adult deaths in Bangladesh were attributed to NCDs.[9-11] The high burden of NCDs in Bangladesh is not just of local public health concern, as mortality due to NCDs has been reported to be more than two times higher among Bangladeshis living in western regions compared to host populations.[12] An important challenge is, therefore, to establish informative epidemiological resources in a rigorous manner to evaluate risk factors among Bangladeshis.

The present report provides a description of the methods used in the establishment of the BangladEsh Longitudinal Investigation of Emerging Vascular and nonvascular Events (BELIEVE) study. It also describes the baseline characteristics of the study population recruited so far and outlines the rationale for the study's further development.

Cohort description

Study design and participants

Between January 2016 and March 2020, the BELIEVE prospective cohort study recruited 73,883 participants from 30,817 households across three different settings in Bangladesh: urban (Mirpur-Dhaka), rural (Matlab-Chandpur), and urban-poor ("slum"; Bauniabadh-Dhaka), (**Figure 1**). Households were initially identified through complete surveys that had previously mapped households' information across the three study sites. Individuals living in the identified households were eligible for enrolment into the study if they: 1) were aged 11 years or older; 2) had lived in their current household for at least 3 years; 3) were intending to reside in the study site for at least a further 5 years; and 4) were willing to provide written informed consent and prospective follow-up information. For all participants, the recruitment procedure firstly involved trained study personnel visiting all identified households to provide written and verbal information about the study. Upon completion of the household visit, all eligible household members were invited to attend a local study clinic to complete an individual-level baseline assessment (**Figure 2**).

Questionnaire administration and physical measurements at baseline assessment

The study questionnaire was adapted to the Bangladesh context based on validated questionnaires used in previous large-scale studies.[13-15] The initial version of the structured questionnaire underwent preliminary testing with a small group of individuals from the target population to evaluate clarity, relevance, and cultural appropriateness. Following this, a larger group of individuals was involved for further validation and refinements, and adjustments were made to enhance readability and ensure logical flow, before finalising the questionnaire for the main study. To ensure both linguistic accuracy and cultural relevance, the questionnaire was translated into Bengali using a rigorous translation and back-translation process. During the household visit, trained personnel administered the structured questionnaire to collect household-level information and family structure characteristics (**Table 1**) using a bespoke Android interface operated through handheld touchscreen tablet devices. During the clinic visit, trained personnel used a computer-based pre-piloted epidemiological questionnaire to collect self-reported information on >300 items related to socioeconomic and demographic characteristics, consanguinity, behaviours (e.g., tobacco and alcohol consumption, dietary intake, physical activity), females health, self-reported personal and family medical history, and medication use (**Table 1**; a copy of the study questionnaire is available in the **Appendix**). Direct computer entry by participants, rather than interviews, was employed to enhance privacy when answering sensitive questions, with the option to skip these questions if preferred.

Self-reported information on medical history and medication use was supplemented by medical records, drugs prescriptions, and by asking participants to bring their medications to the clinic visit. To assess local dietary patterns, benchmark food-frequency questionnaires previously developed and validated in Bangladesh were adapted for BELIEVE.[16] This questionnaire estimated standard portion size assigned to each food item and drinking water source. Participants' phone numbers (or, for participants younger than 18 years, a contact number of a legal parent, guardian or caretaker) were routinely collected at the baseline visit for future contact and to collect follow-up information.

Standardised procedures and equipment were used to assess height, weight, waist and hip circumference, body composition, systolic and diastolic blood pressure, heart rate, and upper body strength (**Supplementary Table 1**). Briefly, blood pressure was measured using an automated device (Omron HEM 7130) on the right arm twice with a 3-minute interval between each measurement, with the patient remaining in a sitting position for at least 5 minutes before the first evaluation. Height was measured using the ShorrBoard ICA Measuring Board to within 1cm and weight was measured using the Tanita HD-661 scale to within 0.1kg. Waist circumference was assessed using a non-stretchable soft standard measuring tape over the abdomen at the widest diameter between the costal margin and the iliac crest, and hip circumference at the level of the greater trochanters (i.e., the widest diameter around the buttocks). Anthropometric measurements were performed in a standing position. Body composition was assessed by bio-impedance using the Tanita MC-780MA analyser and handgrip strength using a Jamar Plus Digital Hand Dynamometer.

To enhance consistency in the collection of data, we trained staff extensively and adopted standardised approaches, validated instruments, and electronic data collection methods with built-in validity checks and queries. For example, the paper-free digital data collection platform involved extensive computerised checks to restrict missing values, duplications, inconsistencies, and outliers. Information was transferred daily in a secure manner to the study's central database at Cambridge University, with a copy also kept at the local recruitment centres for additional checks and queries. Reports were generated by data managers and reviewed by study PIs and coordinators on a regular basis.

Collection, storage, and initial use of biological samples

Participants provided non-fasting blood samples for research with the time of last meal recorded. Up to 23 ml of non-fasted whole blood samples was collected from each participant aged 18 years and above in two tubes (11 ml EDTA, and 12 ml serum). For participants aged 11-17 years, 12 ml of non-fasted whole blood samples was collected in two tubes (6 ml EDTA

and 6 ml serum). Samples were centrifuged within 45 minutes of venipuncture (at 6,000 rpm for 15 minutes). Isolated serum, EDTA plasma and whole blood samples were stored at −20°C before being transferred to a -86°C freezer at the end of each working day (**Supplementary Figure 1**). To enable the measurement of additional potential risk factors (e.g., metal contaminants), finger- and toe-nail clippings were collected in a subset of participants, kept separately in plastic bottles, and stored at room temperature. Biological samples have been stored in long-term dual repositories located in Bangladesh and the UK to enable further assays. A range of biochemical and genomic analyses on the stored samples is currently ongoing.

Follow-up procedure and outcome ascertainment

Study participants are being actively followed-up indefinitely for cause-specific mortality and incidence of selected non-fatal health outcomes (**Figure 2**). Follow-up involves contact with participants by the study team at regular intervals (e.g, every 18-24 months), during which trained personnel use an electronic questionnaire to collect information on medical events reported since the last contact. Based on the responses to the questionnaire (or if phone contact is unsuccessful), a household visit is scheduled to collect additional information and medical documents. During the household visit, trained personnel collect further information for selected major categories of non-fatal events (including myocardial infarction, diabetes, stroke, common cancers) using a structured questionnaire and a bespoke Android electronic interface operated through handheld touchscreen tablet devices.

As the majority of individuals in the study settings who have received medical attention tend to have paper copies of medical documents in their homes, study personnel visiting households collect digital photographs of any relevant medical documents available (including discharge summaries, diagnostic test reports, medications, and death certificates) using tablet devices. If medical documents are unavailable, written informed consent is obtained to retrieve these from the relevant hospitals. Nearly all deaths in the study areas will have involved some form of medical attention, with their underlying causes being certified by a medical doctor. A validated verbal autopsy is conducted in all deaths by trained personnel to help determine the most likely cause from symptoms or signs described by family members.[17] To help adjudicate and classify health outcomes (e.g., into definite, probable and possible categories), the information collected described above is periodically reviewed by medically-trained personnel.

The quality and completeness of both mortality and morbidity follow-up data in each study site is checked regularly during the study period by the study coordinating centres. This involves

monitoring the number of people who have died or are lost to follow-up, assessment of overall mortality patterns in the study cohort, levels of diagnostic criteria for individual diseases, and the proportion of deaths with unknown cause.

Ethical approval and informed consent

The BELIEVE study has received approvals from the relevant institutional review boards of the Bangladesh Medical Research Council, the National Heart Foundation Hospital and Research Institute, icddr,b and Bangabandhu Sheikh Mujib Medical University (BMRC/NREC/2013-2016/390; BMRC/NREC/2016-2019/243; BSMMU/2019/1184; BSMMU/2019/1185; PR-18051; HBREC.2019.09). Written informed consent has been obtained from each participant (or by a parent or guardian for participants under the age of 18), including for future use of data and stored samples and invitation to further research studies. The data collected in this research are subject to the core data protection principles and requirements of the United Kingdom Data Protection Act 1998. The investigators and institutional review boards are committed to ensure that research is conducted according to the latest version of the Declaration of Helsinki, Universal Declaration on the Human Genome and Human Rights adopted by the United Nations Educational, Scientific and Cultural Organization (UNESCO), and other legislation.

Patient and public involvement

In keeping with this study's principles of co-creation and community engagement, we have implemented a participatory strategy, collaborating closely with local residents and key stakeholders (some of whom were study participants). Community consultations were conducted in communal spaces to communicate the study's objectives and actively seek feedback from community members. Invitations were extended to local leaders for these sessions, facilitating a deeper understanding of the community's needs and concerns, allowing us to tailor the study accordingly. In addition, we employed local community members as field team personnel, who were trained to collect data and assist study participants. This approach not only provided employment opportunities for local people but also enhanced the cultural appropriateness of the study approaches we used. As well as co-creating the study design, study participants were provided information about the study's purpose, with the assurance that their information would be exclusively used for research purposes.

Sample size considerations and statistical analysis

Sample size considerations have been guided by a combination of pragmatic constraints (e.g., the availability of resources) and statistical power calculations. Assuming 5% of the population develop a disease condition during follow-up, a study of 70,000 individuals should provide

80% power to detect a hazard ratio (HR) of about 1.1 per 1 SD higher value at 5% significance level. In this report, continuous variables were summarised as mean (SD) or median and interquartile range (IQR), and categorical variables were summarised as frequencies and percentages. A complete case analysis was used to handle missing data. Variables were summarised and compared across relevant population subgroups (e.g., study site, sex, and age-group) using the t-test for continuous variables and chi-square test for categorical variables. The prevalences of chronic conditions at baseline were summarised as overall crude prevalences, and by site, sex and 20-year age group. To make comparisons between sites analysis was conducted restricted to data from participants aged between 20 and 79 years to compare prevalences of conditions standardised according to the Bangladesh 2022 population structure.[18] All statistical tests were 2-sided, and the significance level was set at P<0.05. Robust standard errors were estimated to allow for clustering of participants by household. Analyses were performed using STATA (version 16, StataCorp, TX, USA) and R (version 4.0.1, R Foundation for Statistical Computing). Future statistical analyses will be developed following relevant guidelines for cohort data with household clustering (e.g., Strengthening the Reporting of Observational Studies) [19] and will be presented elsewhere.

Findings to date

Demographic, behavioural and physical characteristics in the overall study population

Overall, 59,846 (81%) participants were recruited from Mirpur-Dhaka (urban site), 5,332 (7%) from Bauniabadh-Dhaka (slum site), and 8,705 (12%) from Matlab-Chandpur (rural site). 43,470 (59%) participants were female; the mean (SD) age at recruitment was 39 (15) years; 4,122 participants (5.6%) were aged between 11-17 years inclusive (**Table 2**). At the time of the baseline survey 38,848 (52%) participants had either no formal education or primary level education only; 17% were current smokers; 23% were current users of chewable tobacco products; and only 1.3% of the participants reported consuming alcohol regularly.

Several characteristics varied by study site. For example, 55% of participants in the urban site had secondary or higher level of education compared with only 16% and 18% in slum and rural sites, respectively (**Supplementary Table 2**). Whereas the percentage of participants self-reporting as current smokers was similar across the sites (17%, 17% and 13% in urban, slum and rural sites, respectively), reported use of chewable tobacco and alcohol was higher in the slum site (62% and 12.2% respectively, vs 18% and 0.4% in the urban site, and 34% and 0.4% in the rural site). Additional conventional risk factor values differed by study site (**Table 2**), with a tendency towards more adverse risk factor profiles in urban participants (**Supplementary Table 2**). For example, mean (SD) systolic blood pressure was 125 (21)

mmHg in participants from the urban site versus 112 (20) and 120 (20) mmHg in the slum and rural sites, respectively. Mean (SD) BMI was 26 (5) kg/m^2, 23 (5) kg/m^2 and 23 (5) kg/m^2 in participants from the urban, slum and rural sites respectively, with other measures of adiposity (including, waist-to-hip ratio and body fat percentage) following a similar trend. As the trend towards urbanisation accelerates in Bangladesh, such differences in risk factor profiles portend implications for striking increases in NCDs.[20,21] This contrast in risk factor profiles across settings also suggests the need for context-specific solutions to help better prevent and control NCDs. We plan to contribute toward this goal through longitudinal surveillance of risk factors and NCD incidence in the BELIEVE cohort, as well as the re-purposing the cohort framework to support applied health research studies.

Certain baseline characteristics also differed between males and females (**Supplementary Table 3**). Females were, on average, younger (38 vs 41 years), had spent fewer years in education (45% vs 50% had secondary or higher level of education), were less likely to report any tobacco smoking (<1% vs 41%) and consuming alcohol (<1% vs 3%). Systolic blood pressure was higher among males (127 vs 121 mmHg), whereas females had a higher BMI (26 vs 24 kg/m^2).

Overweight, obesity and chronic health conditions in adults aged 20 to 79

Among adult participants aged between 20 and 79 years (**Supplementary Table 4-6**) and using WHO-defined BMI categories, 39% of individuals were considered overweight (BMI 25-29 kg/m^2) and 16% obese (i.e., BMI≥30 kg/m^2, **Supplementary table 4**). After standardisation to the sex and age distribution of the Bangladeshi population for the same age range, the corresponding proportions were 37% and 14%, respectively (**Supplementary Figure 2**). Proportions of overweight and obese participants were higher in the urban site, compared to the slum and rural sites, and also higher in females compared to males (**Supplementary Figure 2-3**). There are likely to be multiple factors contributing to excess adiposity, including dietary patterns, sedentary lifestyles, and urbanisation.[1,22] Additionally, socio-economic disparities and lack of awareness regarding the importance of diet and physical activity may play roles. As overweight and obesity are associated with multiple chronic health conditions, including cardiovascular diseases, diabetes, and certain cancers,[23-25] addressing this challenge is necessary to improve the health of the Bangladeshi population and alleviate healthcare system burdens.[26-27]

The most prevalent self-reported chronic health conditions at baseline that were recorded among adults aged 20-79 were hypertension, type 2 diabetes and hypercholesterolaemia (**Supplementary Table 6**), with standardised prevalences of 21%, 15% and 11%, respectively

(**Figure 3**). Prevalence of these conditions was higher among participants recruited in the urban site compared to those in slum and rural sites. For example, the standardised prevalence of hypertension was 23%, 16% and 14% in urban, slum and rural sites, respectively. Corresponding prevalences were 16%, 10% and 5.7% for type 2 diabetes, and 12%, 8% and 1.5% for hypercholesterolaemia. The overall prevalence of type 2 diabetes in this study was higher than those previously reported for Bangladesh,[20] and varied by age and sex, with the highest prevalences were among older participants and females (**Supplementary Figures 4-6**). These findings may suggest potential age and sex-specific differences in susceptibility to type 2 diabetes or disparities in healthcare access and management or both. We plan to contribute toward understanding of such potential age and sex-specific differences in determinants of chronic diseases, as it should inform development of targeted preventive measures, and tailored interventions to address the specific risk factors affecting different populations.

Strengths and limitations

Although Bangladesh is experiencing substantial increases in NCDs (10), there is limited evidence about the multi-dimensional risk factors and drivers of NCDs in the country, thereby preventing deeper understanding of the web of causation for NCDs and limiting development of optimal prevention and control approaches. The BELIEVE study has been established as a long-term epidemiological bioresource to help address this gap, including investigation of Bangladesh's contrasting urban and rural settings. Configured to investigate biological, behavioural, environmental, and broader determinants of NCDs, the BELIEVE study is a household-based prospective cohort study that spans urban, slum and rural settings. To our knowledge, it represents the largest bioresource for NCDs and related traits in Bangladesh, involving active longitudinal follow-up of participants for new-onset health outcomes.

The BELIEVE study has demonstrated the feasibility of employing modern epidemiological methods at scale in a population-based study located across multiple different settings in Bangladesh. The study has used electronic data collection methods, utilising study forms implemented through bespoke software applications ("apps"), allowing comprehensive recording of questionnaire-based data, as well as physical measurements. The study has also collected a range of biological samples, including serum, plasma, whole blood, and nail samples stored in long-term repositories. Assay of these samples is enabling study of many molecular factors, laying foundations to advance understanding of disease pathways and potential therapeutic targets for treatment and prevention of NCDs in Bangladesh and beyond.

The potential limitations of the BELIEVE study merit consideration. Within each of the three study settings, every household was invited to participate in the cohort. As the household participation rates have been high (>80%), they suggest that study participants should be broadly representative of the source population in the participating sites. However, the participants, households and sites included in the study were not necessarily representative of the general Bangladesh population. Nevertheless, it should be reasonable to infer that findings from this cohort can be generalised to other similar settings in Bangladesh because the study involves participants with a wide range of diverse characteristics (e.g., in relation to age, sex, socio-economic status, education level, occupation etc), recruited from a variety of different settings (urban, slum, and rural areas) characteristic of contemporary Bangladesh.

A further potential limitation relates to the scope for misclassification of risk factors and health outcomes recorded at baseline and during study follow-up because of inaccuracies in participant self-report. To help limit the effects for such potential misclassification, the BELIEVE study is supplementing self-reported data with use of objective measurements (e.g., assay of LDL-cholesterol, HbA1c, arsenic metabolites), inspection of health records kept by participants during household follow-up visits, use of previously validated "verbal autopsy" methods, and exploration of emerging potential linkages of study participants with digital health records kept at community healthcare and hospital levels.

Finally, there is potential in this prospective study for underestimation of the strength of the associations observed between risk factors and incident health outcomes due to fluctuations in risk factor levels within individuals over time (i.e., "regression dilution" bias). To help limit such bias, the BELIEVE study plans to conduct periodic serial re-surveys of risk factor levels in randomly selected subsets of the study participants.

Collaboration

We welcome potential collaboration with other researchers. Data are available upon application to the study's Steering and Data Access Committee.

Conclusion

By providing a powerful resource to investigate multi-dimensional determinants of NCDs across diverse settings in Bangladesh, the BELIEVE study should help advance scientific understanding and inform public health action in an archetypal low-middle-income country with pressing public health needs.

Data availability statement

Data are available upon application to the study's Steering and Data Access Committee.

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Competing interest statement

Adam Butterworth reports institutional grants from AstraZeneca, Bayer, Biogen, BioMarin, Bioverativ, Novartis, Regeneron and Sanofi. John Danesh holds a British Heart Foundation Professorship and an NIHR Emeritus Senior Investigator Award [*]. John Danesh serves on scientific advisory boards for AstraZeneca, Novartis, Our Future Health and UK Biobank, and has received multiple grants from academic, charitable and industry sources outside of the submitted work. Emanuele Di Angelantonio holds an NIHR Senior Investigator Award [*]. Simon Griffin has received honoraria from Astra Zeneca and Eli Lilly for contributions to postgraduate education for health professionals in the United Kingdom. Stephen Sutton holds an Emeritus NIHR Senior Investigator Award [*]. Angela Wood is part of the BigData@Heart Consortium, funded by the Innovative Medicines Initiative-2 Joint Undertaking under grant agreement No 116074.

*The views expressed are those of the authors and not necessarily those of the NIHR or the Department of Health and Social Care.

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Tables and Figures

Figure 1. Location of the BELIEVE study sites

Figure 2: Study recruitment and follow-up procedures

Figure 3. Standardised prevalences of selected chronic conditions at recruitment in BELIEVE for participants aged 20-79

Prevalence was standardised using the sex and age distribution of the Bangladesh 2022 population aged 20-79.

Table 1. Questionnaire-based information, physical measurements and biological samples collected at baseline in the BELIEVE study

Characteristics	Description
House and household	
House information	Location, type of accommodation, house construction materials, number of bedrooms, cooking source, sanitation, water source, indoor and outside environment
Household information	Number of occupants, contact details, family size
Individual	
Demographics	Age, sex, ethnicity, religion, marital status, consanguinity
Behavioural factors	Tobacco consumption (cigarette and non-cigarette), passive tobacco exposure, cooking habits, food frequency assessment, alcohol consumption, physical activity, sleeping habits, mobile phone usage
Socioeconomic factors	Education, occupation, income, remittances, loans, assets owned (including mobile phone, television, refrigerator, Digital Versatile Disc (DVD) player, Air Conditioning, bicycle, motorcycle, car, livestock, land, bank account)
Psychosocial factors	Stress at work and at home, social support, Center for Epidemiological Studies Depression symptoms score, Generalized Anxiety Disorder score, sleeping habits, life events
Females health	Age at menarche, hormonal contraceptive usage, menstrual and pregnancy history
Personal and family medical history	Myocardial infarction, angina, hypertension, other vascular diseases, type 2 diabetes mellitus, atrial fibrillation, cancers, hypercholesterolemia, chronic liver disease, chronic kidney disease, chronic obstructive respiratory disease, mental disorders, neurological diseases, infectious diseases, childhood disorders, major surgery, chest and limb pain, current medication usage
Physical measurements	Blood pressure, heart rate, respiratory rate, height, weight, body composition, upper body strength, waist and hip circumferences.
Biological samples	Serum, plasma and whole blood samples, finger and toe-nail clippings

Table 2. Baseline characteristics of the 73,833 BELIEVE study participants

Key characteristics	Mean (SD) or Number (%)
Demographic and behavioural characteristics	
Age (years)	39 (15)
Individuals aged <18 years	4122 (5.6)
Female	43470 (59)
Study site of residence	
Urban site	59846 (81)
Urban slum site	5332 (7.2)
Rural site	8705 (12)
Married	54386 (74)
Education level	
None/pre-primary	16594 (22)
Primary	22254 (30)
Secondary	21367 (29)
Bachelors or higher degree	13105 (18)
Current smoker	12450 (17)
Current chewable tobacco user	16982 (23)
Current alcohol consumer	927 (1.3)
Physical measurements	
Systolic blood pressure (mmHg)	123 (21)
Diastolic blood pressure (mmHg)	77 (12)
Body Mass Index (BMI, kg/m^2)	25 (5)
Waist circumference (cm)	86 (12)
Waist to hip ratio	0.92 (0.08)
Body fat percentage (%)	27 (9)

Missing data by variable: Married (n=3), Education (n=563), smoking/chewable tobacco use (n=4), Alcohol consumption (n=42), systolic blood pressure (n=23), diastolic blood pressure (n=22), BMI (n=45), waist circumference (n=26), waist to hip ratio (n=30).

Body fat percentage was not measured in the early stages of recruitment and therefore was not available in 15,049 participants.


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NEPAL
INDIA
INDIA
MYANMAR
BAY OF BENGAL
Mouths of the Ganges
Sundarbans
BANGLADESH
Urban site:
Mirpur, Dhaka
Slum site:
Bauniabadh, Dhaka
Rural site:
Matlab
Dhaka
(Dacca)
Kolkata
(Calcutta)
Rangpur
Rajshahi
Khulna
Barisal
Chittagong
Sylhet
Comilla
Jessore
Jalpaiguri
Koch Bihar
Dinajpur
Bogra
Jamalpur
Mymensingh
Tangail
Pabna
Faridpur
Madaripur
Gopalganj
Noakhali
Feni
Cox's Bazar
Maungdaw
Brahmaputra
Ganges (Padma)
Meghna
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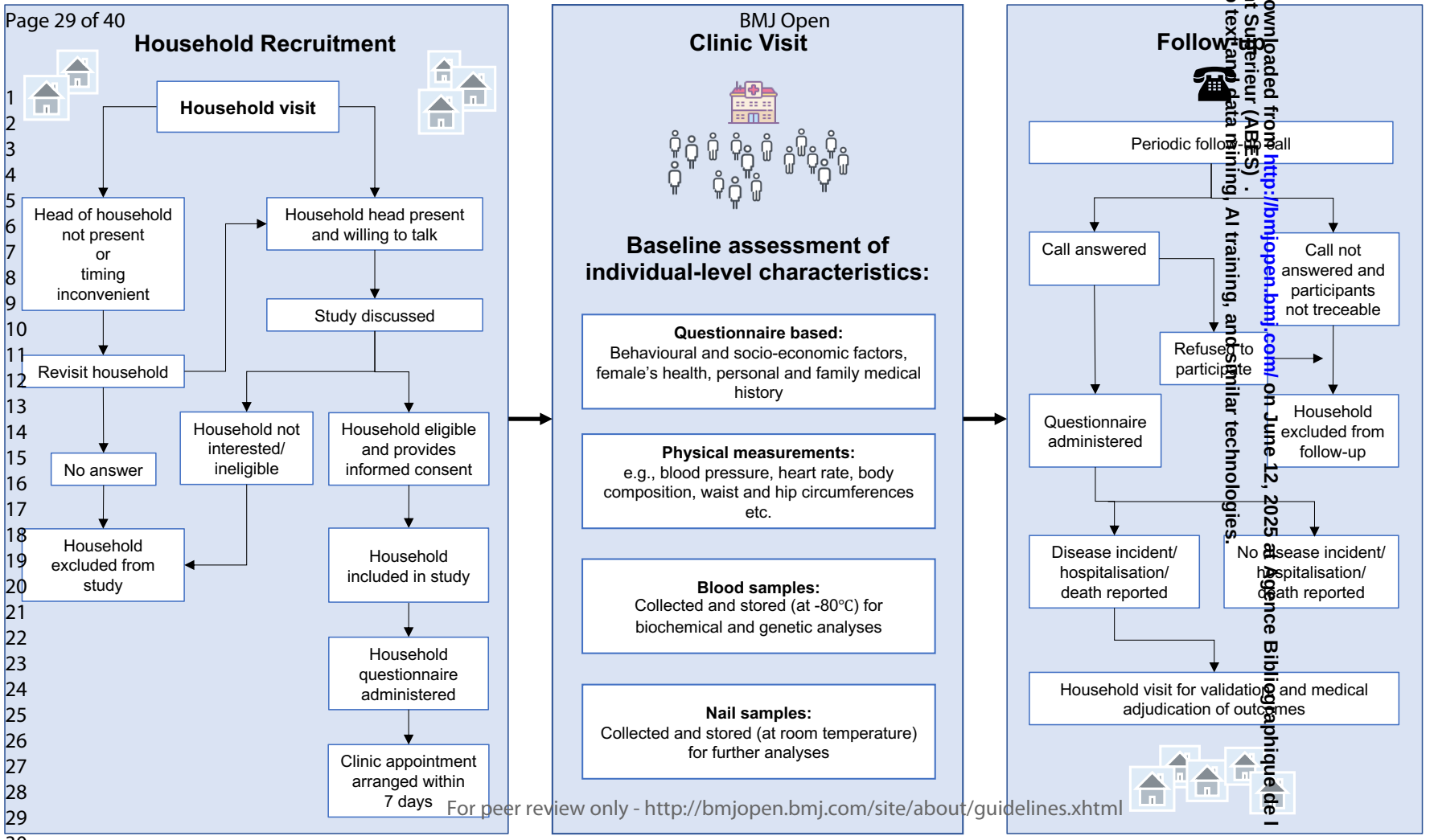
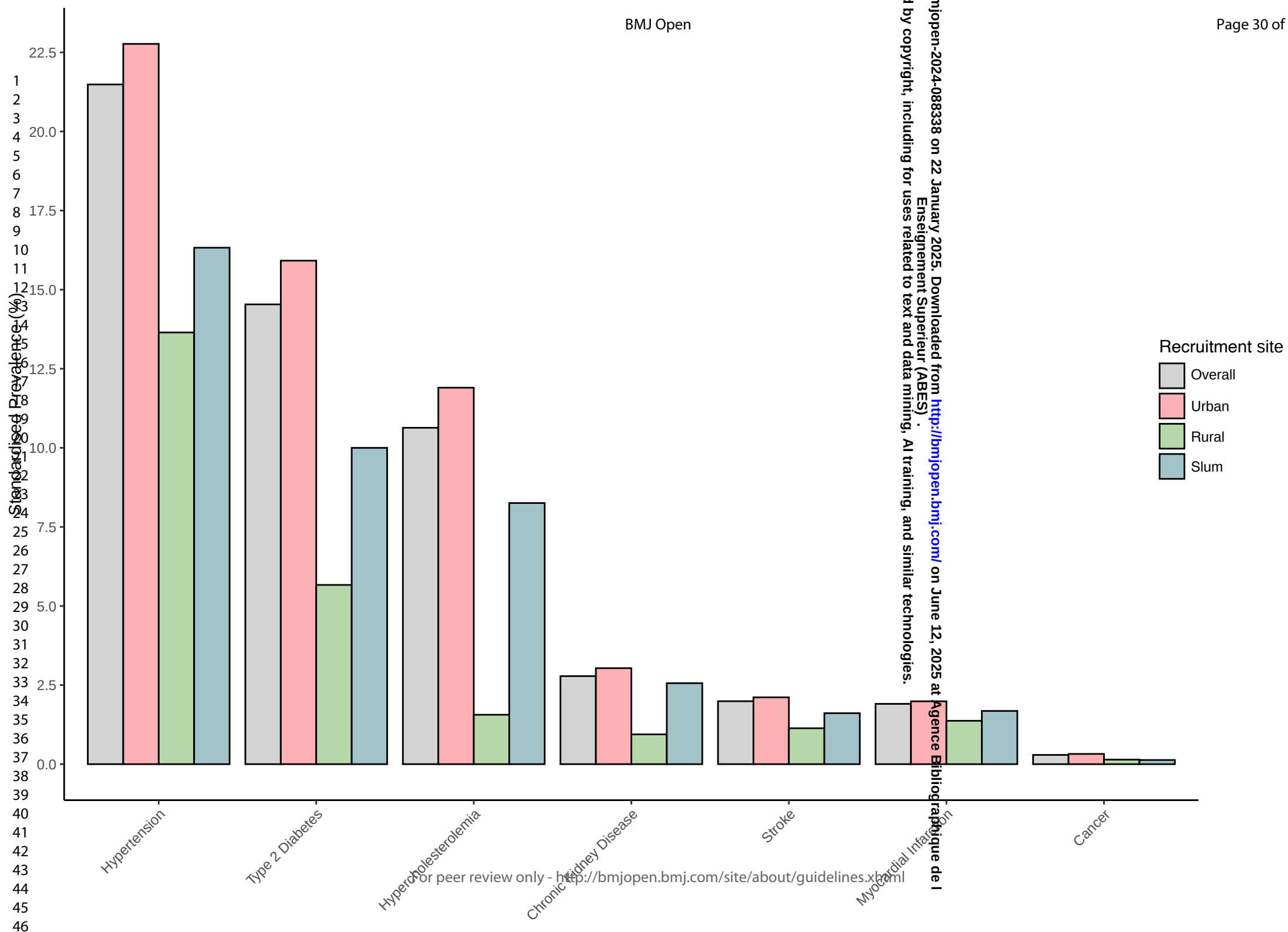




Supplementary Material

Supplementary Table 1. A detailed description of physical measurements in the BELIEVE study

Test	Description
Blood Pressure and Heart Rate	Blood pressure and heart rate were measured using an automated upper arm device. Measurements were taken after a period of 5 minutes during which the participant was sitting quietly; i) in a seated position with legs uncrossed and feet flat on the floor; ii) with the appropriate cuff size placed snugly around the upper arm, leaving a space for a finger between the participant and cuff; iii) ensuring that the cuff was appropriately aligned with the brachial artery following the instructions in the equipment manual. Two measurements of blood pressure and heart rate were taken.
Height	Standing height was measured using a stadiometer standardised across all study sites to the nearest 1cm. Participants were asked to remove their shoes before the measurement being taken and to stand upright with heels and shoulders against the measuring rod, knees and back straight and looking forward. The evaluating arm was pushed down to lightly touch the participant's head. Two measurements of height were taken.
Weight	Weight was measured using a device standardised across all study sites to the nearest 1kg. The scales were standardised to 0 before each use. Weight was measured in light clothing; participants were asked to remove their outer garments (e.g., coats) and shoes. Participants were asked to stand on the centre of the scales, arms to the side, looking forward. Two measurements of weight were taken.
Waist Circumference	Waist circumference was measured with the participant standing, using equipment standardised across study sites. This was measured to the nearest 0.1 cm using a non-stretchable standard tape measure. Subject was relaxed with arms held loosely at sides. Waist circumference was measured over the abdomen at the widest diameter between the costal margin and the iliac crest over light clothing. Two measurements were taken for waist circumference.
Hip Circumference	Hip circumference was measured, with the participant standing, using equipment standardised across study sites. This was measured to the nearest 0.1 cm using a non-stretchable standard tape measure. Subject should relax with arms held loosely at sides. Hip circumference was measured at the widest diameter around the buttocks. The tape measure must be kept horizontal for standing measurement. Two measurements were taken for hip circumference.
Respiratory Rate	Respiratory rate was measured with the participant seated. The Field Research Assistant counted the number of breaths per minute by careful observations without the participant being aware. This was timed with for 60seconds with a watch.
Body Composition	Body Composition was calculated by measuring bio-impedance using the Tanita MC-780MA body composition analyser. Participants were directed and monitored during use of this machine by trained study clinic nurses following the standard operating procedures (appendix 5).
Upper Body Strength	Upper body strength was measured using a Jamar Plus Digital Hand Dynamometer. Trained FRA's monitored and directed participants in the correct usage of the handgrip dynamometer (detailed in appendix 7).

Supplementary Table 2: Baseline characteristics of the BELIEVE study participants by site

Characteristics	Urban		Urban Slum		Rural	
	Number of available observations	Mean (SD) or Number (%)	Number of available observations	Number (%)	Number of available observations	Mean (SD) or Number (%)
Demographic and behavioural characteristics						
Age (years)	59846	40 (15)	5332	32 (15)	8705	37 (18)
Individuals aged <18 years		968 (1.6)		1232 (23)		1922 (22)
Females	59846	34780 (58)	5332	3372 (63)	8705	5318 (61)
Married	59844	45332 (76)	5331	3309 (62)	8705	5745 (66)
Education level	59368		5310		8642	
None/pre-primary		9808 (17)		2831 (53)		3955 (46)
Primary		17449 (29)		1630 (31)		3175 (37)
Secondary		19319 (33)		771 (15)		1277 (15)
Bachelors or higher degree		12792 (22)		78 (1)		235 (3)
Current smoker	59844	10363 (17)	5331	913 (17)	8704	1174 (13)
Current chewable tobacco user	59843	10734 (18)	5331	3322 (62)	8705	2926 (34)
Current alcohol consumer	59820	244 (0.4)	5324	650 (12)	8697	33 (0.4)
Physical measurements						
Systolic blood Pressure (mmHg)	59831	125 (21)	5324	112 (20)	8705	120 (20)
Diastolic blood Pressure (mmHg)	59832	78 (11)	5324	70 (12)	8705	74 (12)
Body Mass Index (BMI, kg/m^2)	59815	26 (5)	5323	23 (5)	8700	23 (5)
Waist circumference (cm)	59828	87 (12)	5324	83 (14)	8705	80 (13)
Waist to hip ratio	59824	0.93 (0.08)	5324	0.91 (0.08)	8705	0.91 (0.08)
Body fat percentage (%)	45432	28 (9)	5140	27 (9)	8262	24 (9)

Supplementary Table 3: Baseline characteristics of the BELIEVE study participants by sex

Characteristics	Females		Males	
	Number of available observations	Mean (SD) or Number (%)	Number of available observations	Mean (SD) or Number (%)
Demographic and behavioural characteristics				
Age (years)	43470	38 (15)	30413	41 (16)
Individuals aged <18 years	43470	2307 (5.3)	30413	1815 (6.0)
Study site of residence				
Urban		34780 (80)		25066 (82)
Urban slum		3372 (7.8)		1960 (6.4)
Rural		5318 (12)		3387 (11)
Married	43467	32082 (74)	30413	22304 (73)
Education level	43129		30191	
None/pre-primary		10412 (24)		6182 (20)
Primary		13406 (31)		8848 (29)
Secondary		12334 (29)		9033 (30)
Bachelors or higher degree		6977 (16)		6128 (20)
Current Smoker	43466	63 (0)	30413	12387 (41)
Current Chewable tobacco user	43467	10376 (24)	30412	6606 (22)
Current Alcohol consumer	43442	122 (0.3)	30399	805 (2.6)
Physical measurements				
Systolic Blood Pressure (mmHg)	43458	121 (21)	30402	127 (20)
Diastolic Blood Pressure (mmHg)	43458	76 (12)	30403	78 (12)
Body Mass Index (BMI, kg/m^2)	43447	26 (5)	30391	24 (4)
Waist Circumference (cm)	43457	87 (13)	30400	86 (12)
Waist to hip ratio	43455	0.91 (0.08)	30398	0.94 (0.07)
Body Fat Percentage (%)	34735	32 (7)	24099	20 (6)

Supplementary Table 4. Baseline characteristics of the BELIEVE study participants aged 20-79, excluding pregnant females

Characteristics	Number of available observations	Mean (SD) or Number (%)
Demographic and behavioural characteristics		
Age (years)	65199	42 (14)
Females	65199	38196 (59)
Study site of residence	65199	
Urban site		54833 (84)
Urban slum site		3901 (6.0)
Rural site		6465 (9.9)
Married	65196	52459 (80)
Education level	64709	
None/pre-primary		13888 (21)
Primary		19268 (30)
Secondary		19260 (30)
Bachelors or higher degree		12293 (19)
Current smoker	65195	11767 (18)
Current chewable tobacco user	65195	15962 (24)
Current alcohol consumer	65167	722 (1.1)
Physical measurements		
Systolic blood pressure (mmHg)	65181	125 (21)
Diastolic blood pressure (mmHg)	65182	78 (11)
Body Mass Index (BMI, kg/m^2)	65163	26 (5)
Waist circumference (cm)	65179	88 (11)
Waist to hip ratio	65175	0.93 (0.07)
Body fat percentage (%)	51846	28 (9)
WHO-defined BMI categories		
Underweight (<18.5 kg/m^2)		3145 (4.8)
Normal weight (18.5-24.9 kg/m^2)		26074 (40)
Overweight (25.0-29.9 kg/m^2)		25502 (39)
Obese (≥30 kg/m^2)		10442 (16)

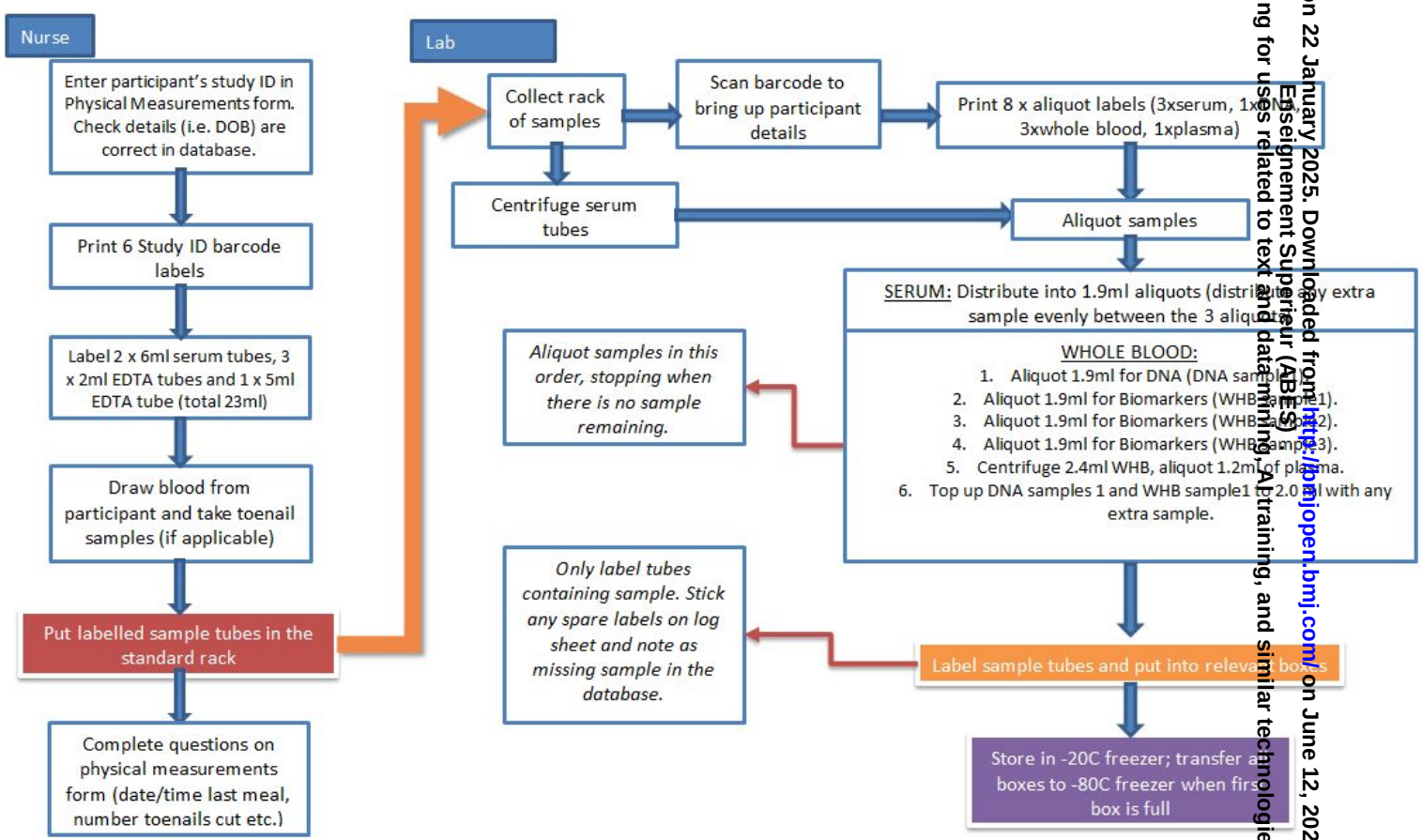
Supplementary Table 5: Baseline characteristics of the BELIEVE study participants by age

Characteristics	Age 11-19 years		Age 20-39 years		Age 40-59 years		Age 60-79 years		Age >=80years	
	Number of available observations	Mean (SD) or Number (%)	Number of available observations	Mean (SD) or Number (%)	Number of available observations	Mean (SD) or Number (%)	Number of available observations	Mean (SD) or Number (%)	Number of available observations	Mean (SD) or Number (%)
Demographic and behavioural characteristics										
Age (years)	7744	16 (3)	32780	30 (6)	25258	49 (6)	7744	66 (5)	317	84 (4)
Females	7744	4546 (59)	32780	20943 (64)	25258	14442 (57)	7744	3434 (44)	317	105 (33)
Married	7744	1127 (15)	32779	25072 (76)	25257	22449 (89)	7743	5558 (71)	317	180 (57)
Education level	7680		32541		25077		7741		311	
None/pre-primary		2499 (33)		6543 (20)		5718 (23)		1748 (23)		86 (28)
Primary		2711 (35)		10544 (32)		7133 (28)		1784 (23)		82 (26)
Secondary		1818 (24)		10008 (31)		7313 (29)		2138 (28)		90 (29)
Bachelors or higher degree		652 (8)		5446 (17)		4913 (20)		2041 (26)		53 (17)
Current Smoker	7744	653 (8)	32778	6258 (19)	25257	4504 (18)	7743	1006 (13)	317	29 (9)
Current Chewable tobacco user	7744	823 (11)	32778	4146 (13)	25257	8300 (33)	7743	3552 (46)	317	161 (51)
Current Alcohol consumer	7735	205 (2.7)	32763	516 (1.6)	25249	191 (0.8)	7737	15 (0.2)	317	0 (0.0)
Physical measurements										
Systolic Blood Pressure (mmHg)	7739	107 (13)	32771	116 (15)	25251	131 (21)	7742	143 (23)	317	152 (24)
Diastolic Blood Pressure (mmHg)	7739	66 (9)	32771	75 (10)	25252	82 (11)	7742	81 (11)	317	79 (12)
Body Mass Index (BMI, kg/m^2)	7735	21 (4)	32763	25 (5)	25244	26 (4)	7739	25 (4)	317	23 (4)
Waist Circumference (cm)	7738	71 (11)	32770	85 (11)	25250	91 (10)	7742	91 (11)	317	89 (11)
Waist to hip ratio	7738	0.84 (0.06)	32768	0.90 (0.07)	25248	0.96 (0.06)	7742	0.98 (0.07)	317	0.99 (0.07)
Body Fat Percentage (%)	6742	23 (8)	25884	27 (9)	20082	29 (9)	5858	27 (9)	228	25 (8)

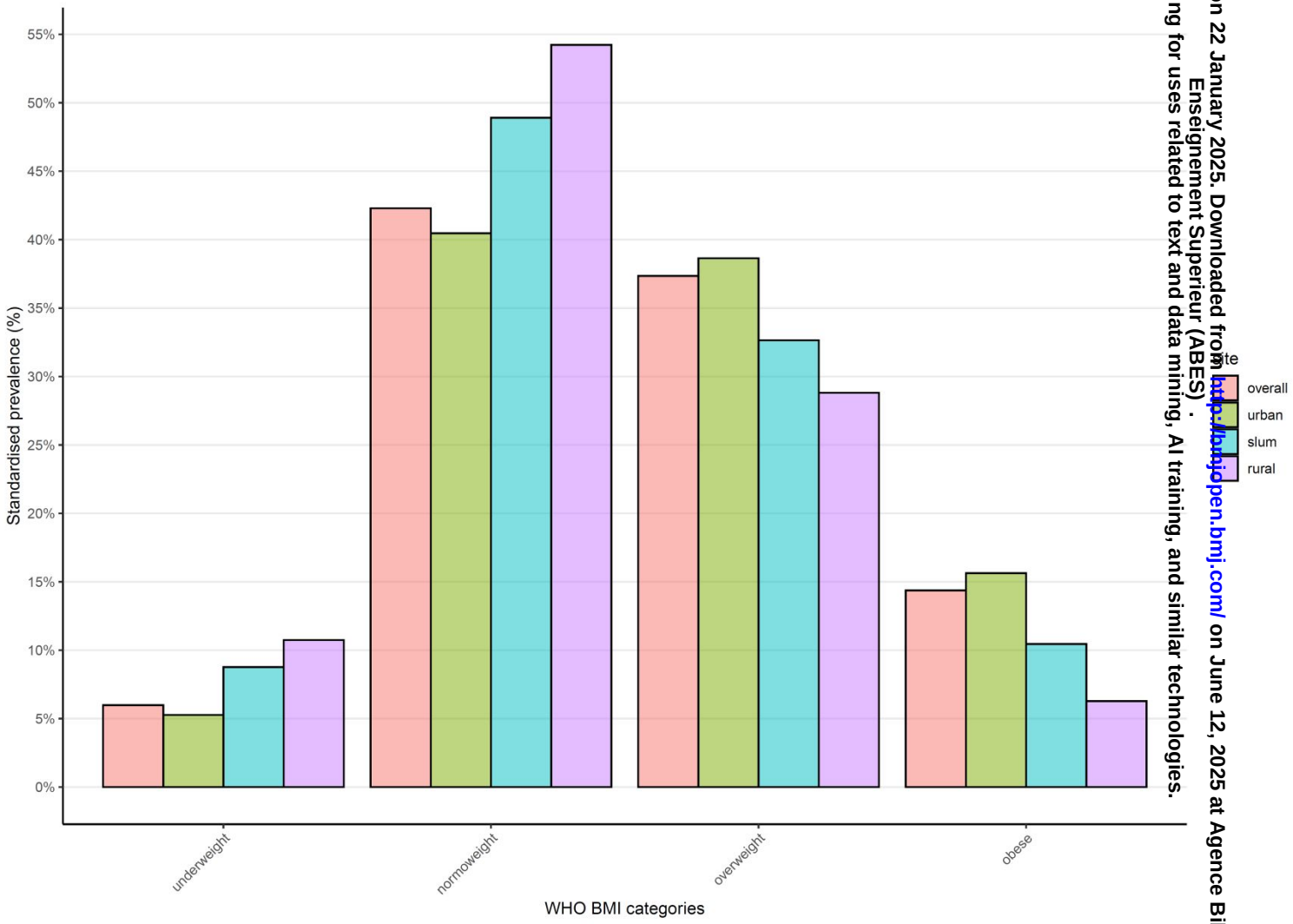
Supplementary Table 6. Crude prevalence of selected chronic conditions at recruitment in BELIEVE participants aged 20-79, overall and by site

Chronic condition present at baseline	Overall		Urban		Urban Slum		Rural	
	Number of available observations	Number (%) with condition	Number of available observations	Number (%) with condition	Number of available observations	Number (%) with condition	Number of available observations	Number (%) with condition
Hypertension	65819	15411 (23)	55378	13795 (25)	6541	1 (16)	3900	552 (14)
Type 2 diabetes	65821	10578 (16)	55379	9776 (18)	6541	4 (7)	3901	350 (9)
Hypercholesterolemia	65820	7624 (12)	55379	7241 (13)	6541	(2)	3900	273 (7)
Stroke	65820	1371 (2.1)	55379	1232 (2.2)	6541	4)	3900	49 (1.3)
Myocardial infarction	65820	1332 (2.0)	55379	1178 (2.1)	6541	1.7)	3900	45 (1.2)
Chronic kidney disease	65819	1928 (2.9)	55378	1764 (3.2)	6541	66 .0)	3900	98 (2.5)
Cancer	65818	220 (0.33)	55379	204 (0.37)	6540	0 (0.15)	3899	6 (0.15)

Supplementary Figure 1. Standard Operating Procedures – Blood Sample Collection, Labelling and Processing

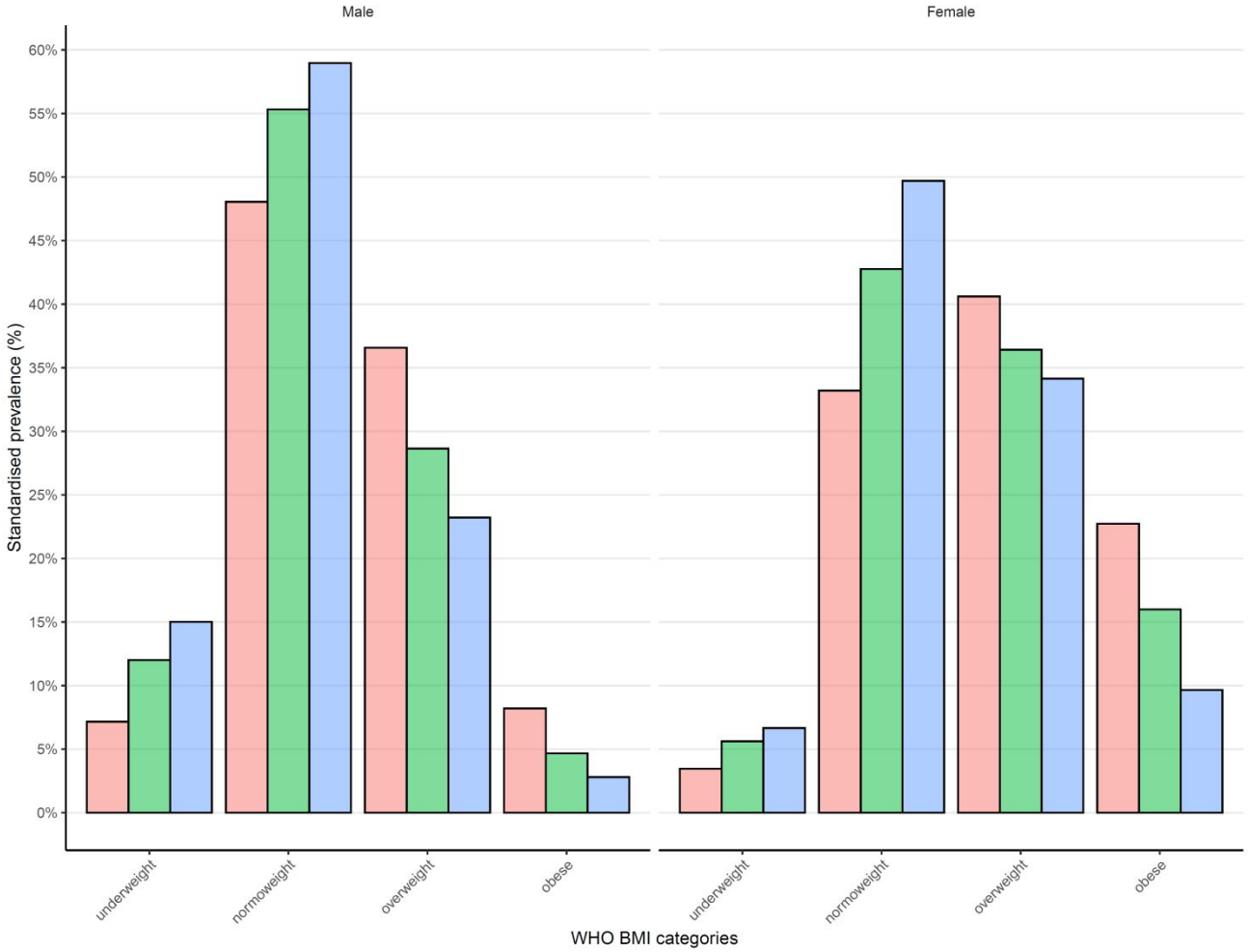


Supplementary Figure 2. Standardised prevalences of WHO-defined BMI categories in BELIEVE participants aged 20-79, overall and by site



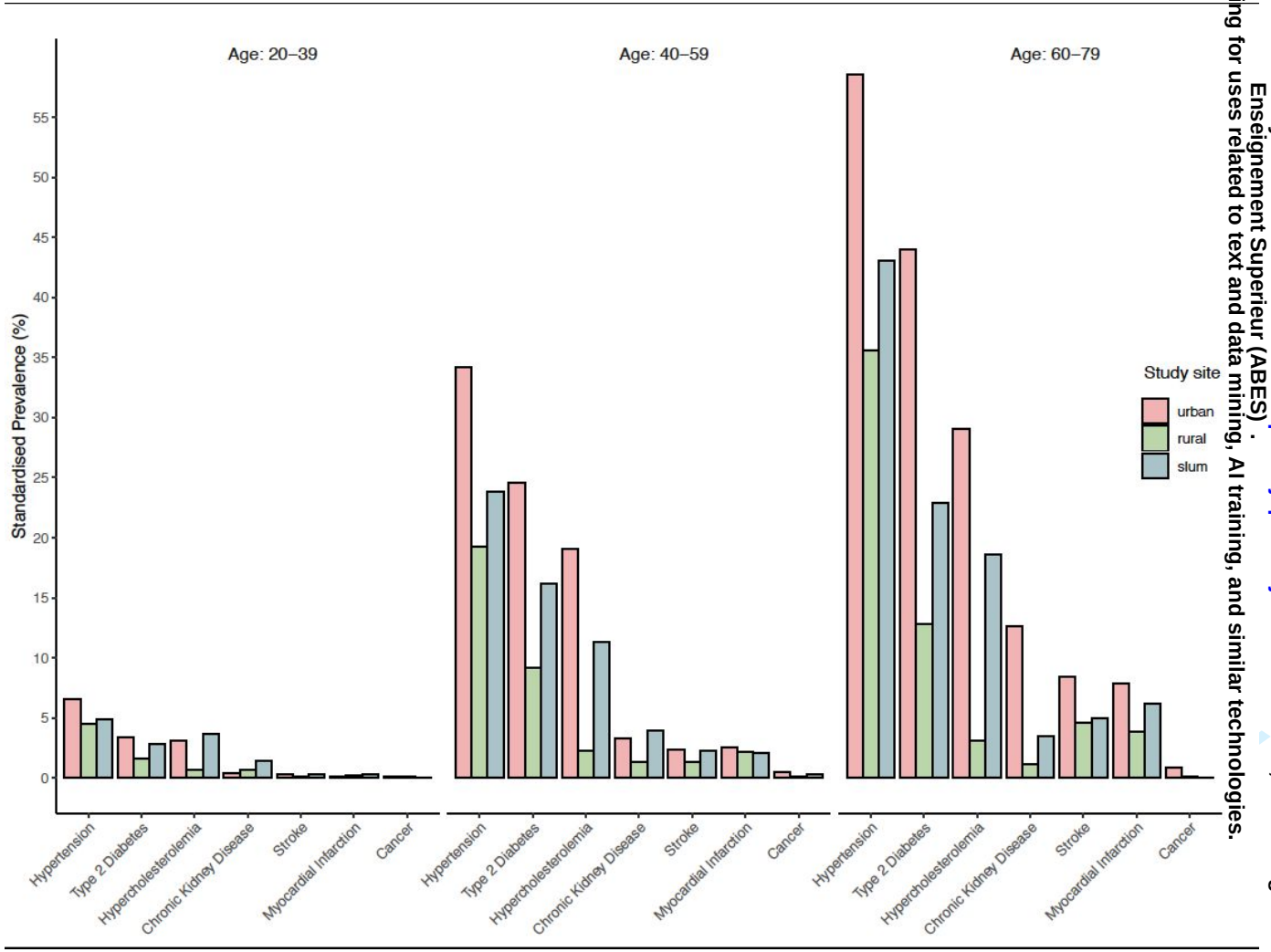
Prevalence is standardised using the sex and age distribution of the Bangladesh 2022 population aged 20-79

Supplementary Figure 3. Standardised prevalences of WHO-defined BMI categories in BELIEVE participants aged 20-79, by sex and site



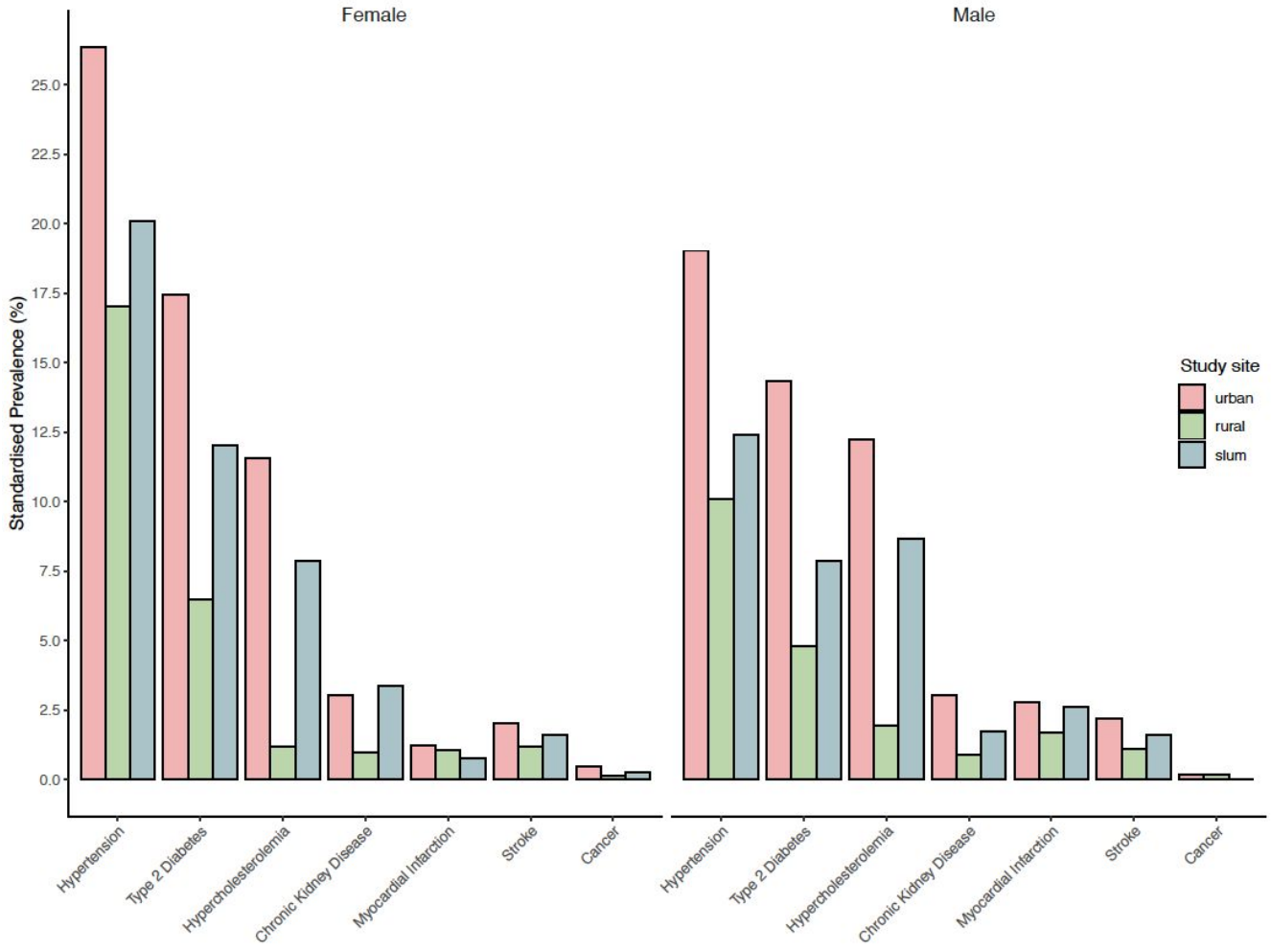
Prevalence was standardised using the sex and age distribution of the Bangladesh 2022 population aged 20-79.

Supplementary Figure 4. Standardised prevalence of selected chronic conditions in participants aged 20-79, by age and site



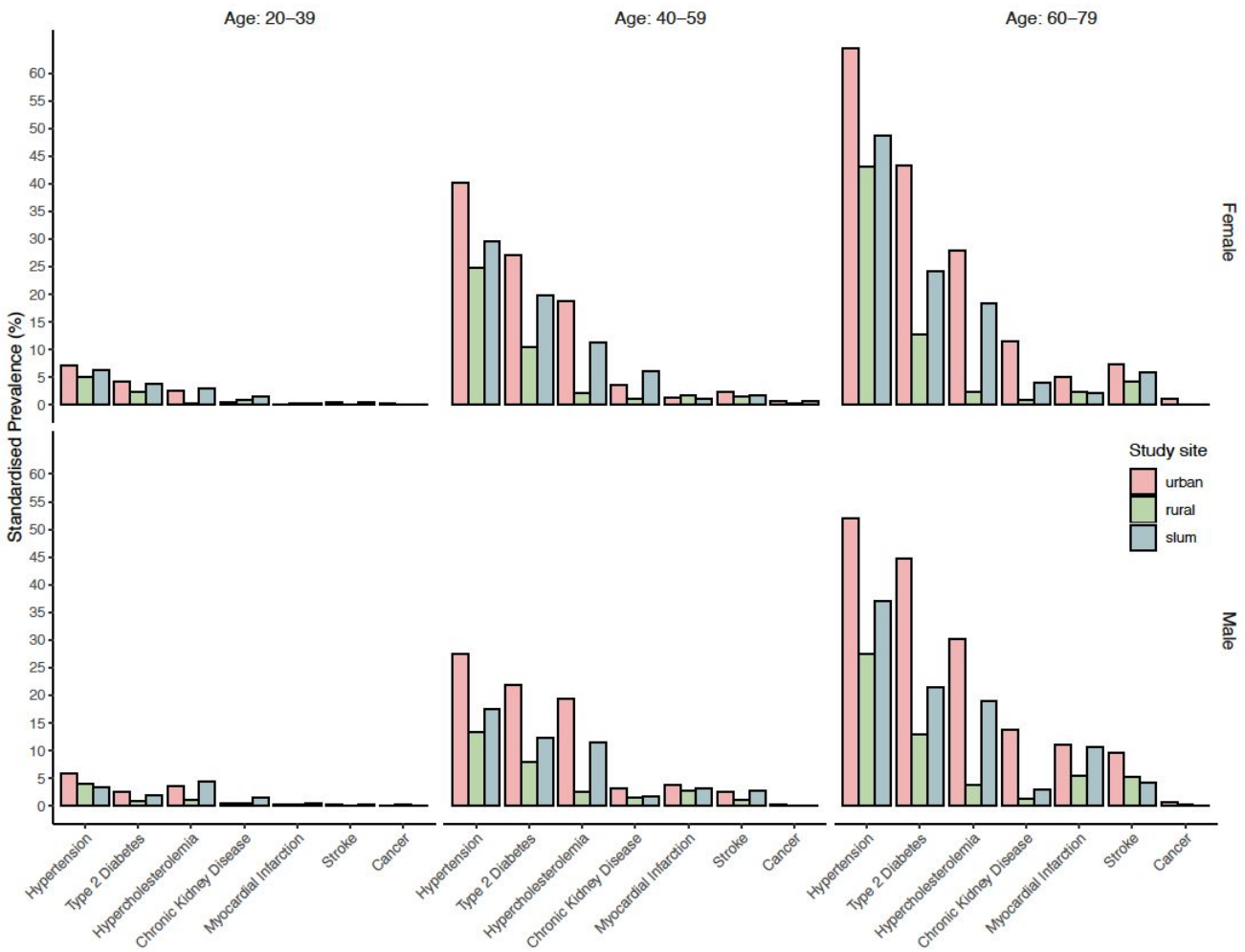
MI: myocardial infraction
Prevalence was standardised using the sex and age distribution of the Bangladesh 2022 population aged 20-79.

Supplementary Figure 5. Standardised prevalences of selected chronic conditions in participants aged 20-79, by sex and site



MI: myocardial infraction
Prevalence was standardised using the sex and age distribution of the Bangladesh 2022 population aged 20-79.

Supplementary Figure 6. Standardised prevalences of selected chronic conditions in participants aged 20-79, by sex, age and site



MI: myocardial infraction
Prevalence was standardised using the sex and age distribution of the Bangladesh 2022 population aged 20-79.