UNIVERSITY OF SOUTHAMPTON

FACULTY OF MEDICINE

Human Development & Health

Volume X of Y

Biomass Fuel and Coronary Heart Disease among Women in Pakistan

by

Syed Zafar Ahmed Fatmi

Thesis for the degree of Doctor of Philosophy

August 2017

UNIVERSITY OF SOUTHAMPTON

ABSTRACT

I investigated the risk of coronary heart disease (CHD) from indoor air pollution caused by use of biomass fuel for cooking. Following a systematic review of the relevant scientific literature, I conducted three linked studies among women in a rural region of Sindh, Pakistan.

The first was an investigation of levels of pollutants in kitchens and their determinants. 24-hour average concentrations of fine particulate matter ($PM_{2.5}$) and carbon monoxide (CO) were measured in samples of households that used biomass or natural gas for cooking, and information was collected about other factors that might influence pollution levels. Associations with pollution were explored by regression modelling.

Secondly, a cross-sectional survey of cardiovascular morbidity was conducted in a sample of women aged 40 years or older who had used biomass fuel for cooking for at least the past year (n = 436), and a similar number of women (n=414) who had used natural gas for cooking for at least the past year. CHD was indicated by history of angina (Rose questionnaire), previous history of heart attack, and changes of CHD on electrocardiogram (ECG). Hypertension was assessed as a further outcome. Potential risk factors were ascertained by questionnaire and anthropometry. Associations between CHD outcomes and risk factors were assessed by logistic regression, adjusting for potential confounders.

The third study used a case-control design to determine the association of acute coronary syndrome (ACS) with use of biomass fuel. Women from a defined geographical area who were admitted to two public tertiary care hospitals in southern Sindh with ACS (n = 364) were identified prospectively, and compared with controls (n=727), matched for sex and age, who were admitted to the same hospitals for reasons other than ACS. Information about exposure to potential risk factors, including use of biomass fuel for cooking was ascertained through a questionnaire. Associations with risk factors were assessed by conditional logistic regression.

The first study found high average concentrations of CO and particularly $PM_{2.5}$ in the kitchens of biomass-users. Ventilated kitchens tended to have lower levels of the pollutants, and houses with smokers somewhat higher concentrations. However, stove chimneys had no discernible impact on levels of $PM_{2.5}$. In my cross-sectional survey, I found no association of hypertension or the three measures of CHD – angina, previous history of heart attack and definite or probable CHD on ECG - with current use of biomass for cooking. This may have been because of inaccuracies in the outcome measures, or because most users of natural gas had previously used biomass. In

contrast, the case-control study found a clearly elevated risk of ACS among women who had ever used biomass for cooking, although not particularly with more recent use.

Overall, my findings add to the weight of evidence for an importantly increased risk of CHD from use of biomass for cooking, and are a further encouragement to initiatives aimed at reducing exposures to the indoor air pollution that it produces. However, they suggest that the full benefits from better design of stoves or switching to other fuels may not accrue until many years after the changes are introduced. Further studies are needed to clarify the relationship of cardiovascular morbidity to use of biomass fuel. These could perhaps be embedded in established cohort studies of cardiovascular disease and national surveys.

FACULTY OF MEDICINE

Human Development & Health

Thesis for the degree of Doctor of Philosophy

BIOMASS FUEL AND CORONARY HEART DISEASE AMONG WOMEN IN PAKISTAN

Syed Zafar Ahmed Fatmi

Table of Contents

List of tables

List of figures

List of accompanying materials

Appendix 1: Questionnaire for cross-sectional study

Appendix 2: Questionnaire for case-control study (case form)

Appendix 3: Ethics Review Committee approval letter.

Academic Thesis: Declaration of Authorship

I, Syed Zafar Ahmed Fatmi, declare that this thesis and the work presented in it is my own and has been generated by me as the result of my own original research.

'Biomass Fuel and Coronary Heart Disease among Women in Pakistan'

I confirm that:

1. This work was done wholly or mainly while in candidature for a research degree at this University;
2. Where any part of this thesis has previously been submitted for a degree or any other qualification at this University or any other institution, this has been clearly stated;
3. Where I have consulted the published work of others, this is always clearly attributed;
4. Where I have quoted from the work of others, the source is always given. With the exception of such quotations, this thesis is entirely my own work;
5. I have acknowledged all main sources of help;
6. Where the thesis is based on work done by myself jointly with others, I have made clear exactly what was done by others and what I have contributed myself;
7. Parts of this work have been published as: **Fatmi Z**, Coggon D. Coronary heart disease and household air pollution from use of solid fuel: a systematic review. Br Med Bull. 2016 Jun;118(1):91-109.

Signed:.....

Date: .....

Acknowledgements

I, under the supervision mainly of Professor David Coggon, designed the research on which this dissertation is based, oversaw its implementation, analysed the data that were generated, and wrote this thesis. The data were collected under my direct supervision in my home country (province of Sindh, Pakistan). Professor Keith Palmer in the UK and Professor M Masood Kadir in Pakistan also supported me as supervisors.

Several others contributed to components of the work as set out below.

Data collection for the pollution monitoring and cross-sectional study was coordinated by Mr Syed Nayab Ali Shah. Mr Rashid Jamali and Mr Shoukat Jamali conducted the pollution monitoring with technical help from Dr Tanzil Jamali. Ms Shereen Jamali, Ms Fozia Jamali, Ms Iqra Memon and Ms Sana Memon administered the questionnaires at interview and recorded the ECGs. The data were double-entered by me and Mr Nayab Ali Shah. I and Professor David Coggon carried out independent assessment of electrocardiograms (ECGs) using Minnesota Codes.

Dr Ambreen Sahito coordinated the case-control study and assisted me importantly in designing the tools for data collection, enlisting hospitals to recruit patients, supervising the data collection team, and coding and cleaning of data. Nursing staff including Ms Shamshad, Ms Tasleem, Ms Iqra Memon, Ms Sana Memon, Mr Riaz Hussain and Mr Ghulam Abbas collected the data in the hospitals. Dr Sana Tanzil helped at the initial stage in enlisting the study hospitals, and Dr Asif Sahito interpreted the ECGs of cases. The data from the study were double-entered by Dr Ambreen Sahito, Ms Aiman, Mr Syed Nayab Ali Shah, Mr Ashraf and me.

Validation and cleaning of data for all of the studies was carried out by me and Mr Syed Nayab Ali Shah under the guidance of Dr Georgia Ntani.

I would like to acknowledge the support of The Colt Foundation, UK for awarding me a PhD fellowship which covered the fees, costs of travel and accommodation in UK, and also funding for the cross-sectional study and pollution monitoring equipment. I specially thank Ms Jackie Douglas (Director, Colt Foundation) for the care and support that she gave me throughout my studies in UK.

In addition, the department of Community Health Sciences, Aga Khan University provided backing throughout my studies at the University of Southampton, UK, and allowed me time to work in the UK.

I would like particularly to thank Dr Georgia Ntani for her guidance, for developing programs for data-cleaning, and for working with me in the statistical analysis.

Definitions and Abbreviations

ACCF - American College of Cardiology Foundation

ACS – Acute coronary syndrome

AHA - American Heart Association

AMI – Acute myocardial infarction

CHD – Coronary Heart Disease

CK-MB – Isoenzymes creatinine kinase-MB

CO – Carbon monoxide

cTnI – Cardiac troponin I

cTnT – Cardiac troponin T

CVD – Cardiovascular disease

DALYs – Disability adjusted life years

ECG - Electrocardiogram

ESC – European Society of Cardiology

ETS – Environmental tobacco smoke

IAP – Indoor air pollution

MI – Myocardial infarction

NSTEMI – Non-ST elevation myocardial infarction

PM – Particulate matter

SCD – Sudden cardiac death

STEMI – ST elevation myocardial infarction

WHF - World Heart Federation

WHO – World Health Organization

Chapter 1: Introduction

This thesis concerns the relationship between indoor air pollution (IAP) from use of biomass fuel and coronary heart disease (CHD) among women in Pakistan. Most households in developing countries use biomass fuel for cooking, which is mainly done by women. Thus, a hazard of CHD could be of great importance to public health.

Chapter 2 considers the definition, classification and clinical features of CHD, diagnostic criteria for epidemiological research, and the burden of CHD globally. It then summarises the main risk factors for CHD, and what is known about the occurrence of CHD and these risk factors in Pakistan.

Chapter 3 describes the definition and types of biomass fuel that are used globally and in Pakistan. It then reviews the pollutants emitted through use of biomass fuel, especially particulate matter (PM) and carbon monoxide (CO), the methods by which they can be measured, levels that have been reported, and their determinants. Finally, it outlines the established and suspected health effects of household air pollution other than cardiovascular disease.

Chapter 4 systematically reviews currently available evidence regarding the link between CHD and IAP from use of biomass fuel, and identifies several important unanswered questions.

Chapter 5 reports a study on the levels and determinants of PM and CO in the kitchens of a sample of households in rural Pakistan.

Chapter 6 describes a cross-sectional survey of CHD and use of biomass fuel among women in rural Pakistan. It reports on the association of IAP with four outcomes: hypertension, angina, previous history of heart attack, and definite or probable changes on ECG.

Chapter 7 then presents the findings from a case-control study of the acute coronary syndrome (ACS) and use of biomass fuel among women in rural Pakistan.

Finally, Chapter 8 gives an overview of the results and discusses directions for future research and interventions to reduce IAP from use of biomass fuels.

Chapter 2: Coronary heart disease

2.1 Classification, clinical features and diagnosis

Coronary heart disease (CHD), also known as ischaemic heart disease, is defined as 'myocardial impairment due to an imbalance between coronary blood flow and myocardial requirements (called ischaemia) caused by changes in the coronary circulation' (Warrell D, 2010). CHD arises mainly from atherosclerotic narrowing of one or more coronary arteries, sometimes with formation of a superimposed blood clot (thrombus). More rarely, blood flow in the coronary vessels is obstructed by arterial spasm or vasculitis (Warrell D, 2003). Atherosclerosis is a pathological condition that develops over many years, in which deposits of fatty material and cholesterol are formed in the walls of medium- and large-sized blood vessels. These deposits (called plaques) narrow the lumen and make the inner surface of the arteries irregular, which impairs the blood flow. They also make the blood vessels less pliable. Eventually, a plaque may rupture, triggering the formation of thrombus.

2.1.1 Classification and clinical features of CHD

Depending on the nature of the blockage of the coronary arteries and level of ischaemia of cardiac muscle, the clinical features of CHD vary. Broadly they fall into following categories (Crawford MH: Cardiology, 3rd Ed., 2009):

1. Various forms of angina, including
    a. Chronic stable angina pectoris
    b. Variant angina pectoris (Prinzmetal's angina)
    c. Unstable angina pectoris
2. Acute myocardial infarction, often sub-divided as
    a. Non ST elevation myocardial infarction
    b. ST elevation myocardial infarction
3. Sudden cardiac death
4. Heart failure
5. Asymptomatic myocardial ischaemia

1. *Angina* is pain or discomfort, usually in the chest but sometimes in the upper extremity, epigastrium or jaw (cardiac compatible pain), that occurs on exertion or at rest, as a consequence of myocardial ischaemia which is insufficient to cause infarction (necrosis i.e. death) of cardiac muscle. There are various forms of angina:

    a. *Chronic stable angina pectoris* is characterised by a compatible pattern of chest or referred pain, in response to triggers such as physical exertion, emotional stress and cold, which may be relieved by rest or treatment with nitro-glycerine. It normally results from stable atherosclerotic narrowing of one or more coronary arteries. The most important diagnostic feature is the typical clinical history with identifiable precipitating factors and rapid relief when a

precipitating factor is removed. Exercise electrocardiograms (ECGs) are useful for diagnosis. Chronic stable angina may at any time be complicated by one of the acute coronary syndromes (described below).

b. *Prinzmetal's angina* is a rare and unusual form of angina that is caused by intermittent coronary artery spasm. The resultant ischaemia may produce chest pain or discomfort at rest and ST-segment elevation on the ECG. Diagnosis is often based on a typical clinical history in the absence of atherosclerotic plaques on coronary angiography.

c. *Unstable angina pectoris* is characterised by anginal pain, which occurs at rest or following minimal exertion, sometimes in a crescendo pattern with increasing frequency, severity and duration. The symptoms may be accompanied by ST segment elevation on ECG, and sometimes pathological Q waves, but with no elevation of cardiac biomarkers such as isoenzyme creatinine kinase (CK-MB), troponin – I or troponin – T. Crescendo angina may culminate in myocardial infarction (described below). Pathologically, atherosclerotic plaques may become unstable due to rupture or initiation of inflammation of the vascular walls, leading to accumulation of platelets and more severe obstruction of blood flow. Diagnosis depends on the crescendo pattern of worsening symptoms.

2. *Acute myocardial infarction (AMI)* is necrosis of heart muscle as a consequence of significant and sustained ischaemia. It leads to symptoms of severe chest pain, sometimes with radiation, and this may be accompanied by shortness of breath, sweating, nausea, vomiting, palpitations and anxiety. The ischaemia leads to ECG changes, normally ST-T segment elevation and prolonged Q waves. In addition, because of the damage to cardiac muscle, levels of one or more cardiac biomarkers are increased. Clinically, a distinction is often drawn between two sub-categories:

a. Non ST elevation myocardial infarction (NSTEMI)

In this form, besides the typical pain of myocardial infarction (MI) and other associated symptoms, the serum levels of cardiac biomarkers (CK-MB or Troponin – I or Troponin – T) are higher than their upper reference limits. However, no ST segment elevation or pathological Q-waves are seen on the ECG. Pathologically, this implies blockage of blood flow to a part of cardiac muscle leading to necrosis. Diagnosis is made on the basis of clinical symptoms and a raised cardiac biomarker.

b. ST elevation myocardial infarction (STEMI)

In this form of AMI, besides pain and increased levels of cardiac biomarkers, typical ECG changes are observed – i.e. elevation of the ST-T segment and/or pathological Q waves. If a Q-wave occurs, it may also be called Q-wave myocardial infarction. Pathologically, Q wave MI is often explained by persisting total occlusion of a coronary artery that is not compensated by collateral blood flow, and leads to a transmural necrosis of the myocardium. Diagnosis requires ECG changes of MI plus at least one value above the upper reference limit for a cardiac biomarker.

3. *Sudden cardiac death (SCD)* is an unexpected total circulatory arrest that occurs with little or no warning (generally within 1 hour of the onset of symptoms) in a person who may or may not be previously known to have cardiac disease. The death should not be directly attributable to non-cardiac factors which lead to haemodynamic failure such as stroke or acute injury. The reason for the circulatory collapse is most often an acute dysrhythmia (e.g. ventricular fibrillation or asystole), but there may be pulseless electrical activity following severe AMI, or more rarely, other pathology such as cardiac tamponade. CHD is the most common cause of SCD, accounting for 70-80% of cases (Crawford MH, Cardiology, 3rd edi., 2009).

4. *Heart failure* arises from abnormal structure or function of the heart, and causes symptoms and signs such as dyspnoea, fatigue, and fluid retention. CHD is one of the major causes of heart failure (Castelli WP, 1983). Other causes include hypertension, idiopathic cardiomyopathy, valvular disease and diabetes mellitus. The impaired performance of the heart as a pump may be a consequence of the necrosis of muscle that occurs in AMI, but it can also result from pressure overload (hypertension), volume overload (e.g. mitral regurgitation) and inherited and acquired cardiomyopathies (i.e. weak cardiac muscles).

5. *Asymptomatic myocardial ischaemia* entails latent ischaemia of cardiac muscle without any symptoms. It may be apparent from ST segment depression on the ECG in an exercise tolerance test. Several studies have shown that silent myocardial ischaemia is quite common. Of an estimated 9 million Americans who had CHD, 4-5 million had asymptomatic ischemia (Crawford MH, 3rd Edi., 2009). It has been estimated that in 18% of all CHD, sudden death occurs as the first event. Moreover, more than 50% of sudden cardiac deaths occur without a previous history of CHD. Silent myocardial ischaemia is relatively more common among the elderly, and patients with hypertension or diabetes (Crawford MH, 3rd Edi., 2009).

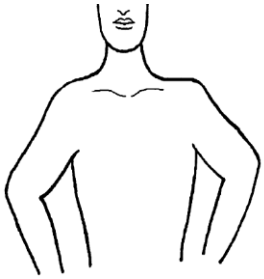
Acute coronary syndromes: Unstable angina, myocardial infarction and SCD are also known collectively as 'acute coronary syndromes (ACS)'. This may be a useful diagnostic category in epidemiological research because the distinction between AMI and unstable angina pectoris can be somewhat arbitrary and depends on the sensitivity and specificity of the methods that are used to identify heart muscle necrosis.

2.1.2 Diagnostic criteria for CHD in epidemiological research

Epidemiological research requires explicit diagnostic criteria and case definitions, which may differ from those that are used for clinical purposes. There have been repeated attempts to standardize case definitions for CHD in epidemiological studies. The main elements of these definitions have been symptoms, ECG, biomarkers, imaging, and/or autopsy findings.

The typical symptoms of CHD include pain or discomfort in the chest, jaw, upper extremity and epigastric area, which sometimes is accompanied by signs of heart failure or cardiogenic shock. The Rose angina questionnaire was developed in 1962 to ask about such symptoms in a standardized way. It comprises seven questions relating to pain, its duration, site, severity and relieving factors (Table 2-1). A diagnosis of angina requires answers of 'Yes' to questions (1) and (2), 'Stop or Slow down' to (4), 'Relieved' to (5), and '10 minutes or less' to (6), and the site of symptoms must include either the sternum (any level) or both the left anterior chest and left arm. The angina is classed as less severe (Grade 1) if the answer to (3) is 'No', and more severe (Grade 2) if it is 'Yes'.

Table 2-1. Rose Angina Questionnaire

Part A	
(1) Have you ever had any pain, pressure, or discomfort in your chest?	1. Yes 2. No
(2) Do you get it when you walk uphill or hurry?	1. Yes 2. No
(3) Do you get it when you walk at an ordinary pace on the level?	1. Yes 2. No
(4) What do you do when you get it while you are walking?	1. Stop or slow down 2. Carry on
(5) If you stand still, what happens to it?	1. Relieved 2. Not relieved
(6) How soon?	1. 10 minutes or less 2. More than 10 minutes
(7) Will you show me where it was?	1. Sternum (upper or middle) 2. Sternum (lower) 3. Left anterior chest 4. Left arm 5. Other
If other, mark on the diagram	

There is no agreed 'gold standard' for the diagnosis of angina, but to validate the Rose questionnaire, studies have tested it against clinicians' diagnoses (Friedman LM, 1985), ECG (Wilcosky T, 1987), thallium scans (Bass EB, 1989), and angiographic findings. Depending on the gold standard and population studied, sensitivity has been reported to range from 19% to 83%, and specificity from 80% to 95% (Fischbacher CM, 2001).

ECG changes of CHD include ST abnormalities, T wave inversion, and Q waves. These changes, and their evolution over time, can be measured in terms of magnitude (voltage) and duration. A standardised and extensively used scheme, the Minnesota classification, helps to make the assessment of ECG changes more objective and repeatable. It was first developed in 1960, and later updated in 1983 and 2010 (Prineas RJ, 2nd edition, 2010). The classification has codes for all abnormal findings on ECG, and consists of a series of items which are organised in nine principal classes. Codes 1 (1.1.1-1.1.7, 1.2.1-1.2.7 – pathological Q wave), 4 (4.1.1, 4.1.2 – ST

depression), 5 (5.1, 5.2 – T wave inversion) and 9 (9.2 – ST elevation) are relevant to CHD. These have been further grouped as major and minor abnormalities. Minor ST-T depression/inversion alone or minor Q wave evolution alone are classed as 'non-specific' ECG changes. Besides being used in assessment of the prevalence of ECG abnormalities, Minnesota codes have prognostic value. In the Multiple Risk Factor Intervention Trial (MRFIT), major serial Q-wave changes showed an independent prognostic association with total and CHD mortality (Crow RS, 1989). In a follow up study of MRFIT, the adjusted relative risk for CHD mortality over 16 years in men with evolving minor Q waves plus evolving ST-T waves was 4, the same as for evolving major Q waves. Silent evolving ST-T waves without Q-wave changes had an adjusted relative risk for CHD mortality of 1.6 (Crow RS, 1997).

Biochemical markers of myocardial necrosis that can be measured in blood include creatine kinase-MB (CK-MB), creatine kinase mass (CK-MBm) and troponins (I (cTnI) and T (cTnT)). Myocardial necrosis results in the release of these proteins into the blood, where they can be detected by various methods (Heidenreich PA, 2001). In rank order, their diagnostic value is considered to be cTn>CK-MBm>CK-MB. To detect a rise and /or fall in serum level which has diagnostic value, blood samples need to be drawn serially: on initial assessment and 3–6 hours later. Where only one measurement is available, it is considered positive if the value is higher than the 99th percentile of the distribution in the healthy population.

Coronary angiography is an invasive imaging technique that can be used to identify the atherosclerotic lesions of CHD, while scanning by echocardiography can demonstrate impaired motion of the heart wall indicative of a loss of viable cardiac muscle. In addition, atherosclerotic lesions and infarction of heart muscle may be visualised at autopsy in fatal cases of CHD.

The incidence of MI can be used as an indicator when estimating the burden of CHD in a population epidemiologically. Therefore, attempts have been made to standardize its definition (Mendis S, 2011). The most recent, 'Third Universal Definition of Myocardial Infarction' was released in October 2012, jointly by the European Society of Cardiology (ESC), the American College of Cardiology Foundation (ACCF), the American Heart Association (AHA), and the World Heart Federation (WHF). This revised definition makes the detection of a rise and/or fall in a cardiac biomarker (preferably troponin) central to the diagnosis of MI. In addition to changes in the biomarker, one of the following criteria needs to be met: (1) symptoms of myocardial ischaemia; (2) new (or presumably new) significant ST-segment/T-wave changes or left bundle branch block; (3) development of pathological Q waves; (4) new loss of viable myocardium or

regional abnormality of heart wall motion demonstrated by imaging; (5) identification of intracoronary thrombus by angiography or autopsy (Thygesen K, 2012).

This case definition can, however, be difficult to apply in developing countries with limited resources. The new biomarkers (troponins) are costly and not widely available, and it is logistically challenging to get two samples of blood at appropriate times to detect a rise and/or fall in the levels. Many cardiac units in low resource settings still rely on the lower cost and more readily available marker, CK-MB.

The World Health Organization (WHO) published an earlier definition of MI, which has been used in large scale epidemiological studies since the 1970s. This was based on WHO European Acute Myocardial Infarction registry criteria (WHO, 1976), which were revised in 1979 in a joint report with the International Society and Federation of Cardiology (ISFC/WHO, 1979). The definition depends on combinations of unequivocal findings of Q waves and/or ST segment elevation or depression in serial recordings on ECG, cardiac enzyme measurements, or, in fatal cases, post-mortem findings. The multicentre MONICA (monitoring trends and determinants in cardiovascular disease) project, which was conducted in the 1970s and 80s, applied these criteria, but with standardization of ECG assessment using Minnesota coding (WHO-MONICA, 1983; Tunstall-Pedoe H, 1994; Tunstall-Pedoe H, 2003).

A group of scientists from the American Heart Association Council on Epidemiology and Prevention; the American Heart Association Statistics Committee; the World Heart Federation Council in Epidemiology and Prevention; the European Society of Cardiology Working Group for Epidemiology and Prevention; the Centre for Disease Control and Prevention; the National Heart, Lung and Blood Institutes; and the WHO subsequently met to consider new standards and make recommendations for the collection of data in developing countries, where comprehensive information may not be available (Luepker RV, 2003). Based on the extent and quality of data, definite, probable, and possible MI, and stable and unstable angina pectoris were defined. The classification of MI was as set out in Table 2-2.

Table 2-2. Classification of Myocardial Infarction (MI)

ECG findings	Biomarker findings			
	Diagnostic	Equivocal	Missing	Normal
Cardiac symptoms present				
Evolving diagnostic	Definite	Definite	Definite	Definite
Positive	Definite	Probable	Probable	No
Nonspecific	Definite	Possible	No	No
Normal or other findings	Definite	Possible	No	No
Cardiac symptoms absent				
Evolving diagnostic	Definite	Definite	Definite	Definite
Positive	Definite	Probable	Possible	No
Nonspecific	Definite	Possible	No	No
Normal or other findings	Definite	No	No	No

Biomarkers were classed as 'diagnostic' if two measurements of the same marker taken 6 hours apart included at least one positive value (i.e. exceeding the 99th percentile of the distribution in the healthy population), and showed a rising or falling pattern. They were deemed 'equivocal' if there was only one available measurement and it was positive; 'missing' if the biomarker was not measured; and 'normal' if it was measured but did not meet the criteria for positivity. ECG findings were classed as 'evolving diagnostic' when an evolution of ECG findings could be traced either between ECG(s) associated with the event or between a previously recorded ECG and the event ECG(s). If there was no previous ECG and only one event-related ECG which indicated a CHD event, it was termed a 'positive' ECG. The presence of minor ST-T depression/inversion alone or minor Q wave alone was considered 'non-specific'. As is apparent from Table 2-2, either diagnostic biomarker changes or evolving diagnostic ECG abnormalities were taken to be sufficient for a definite diagnosis of MI.

Unstable angina pectoris: Unstable angina is diagnosed when there are new cardiac symptoms (or a changing symptom pattern) and positive ECG changes (described above) with normal biomarkers. The distinction between new angina, worsening angina and unstable angina is notoriously difficult to make, and is based on clinical assessment with a careful and full clinical history.

Stable angina pectoris: The diagnosis of stable angina pectoris is based on chest pain or discomfort alone. The occurrence of cardiac symptoms remains constant in presentation, frequency, character, and duration over time. The Rose angina questionnaire can be used to detect stable angina pectoris in population studies.

Acute coronary syndrome (ACS) is a term that covers both myocardial infarction and unstable angina. Their features are summarised in the Figure 1 below, where NQMI is non-Q wave myocardial infarction; NSTEMI is non-ST elevation myocardial infarction; and QwMI is Q wave myocardial infarction (Alpert JS, 2000).

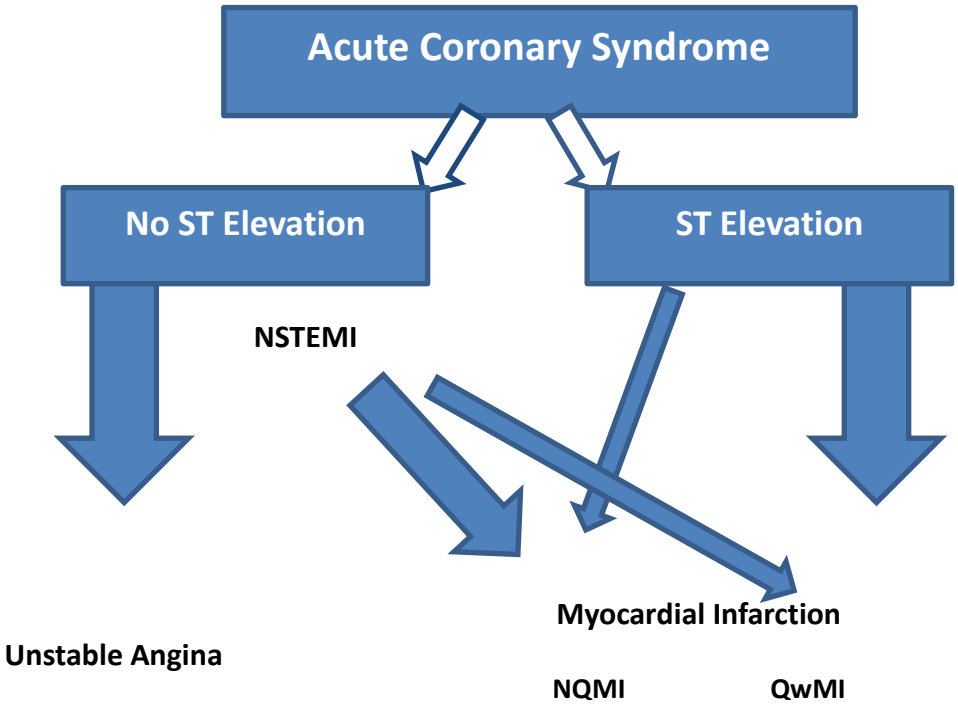


Figure 1. Acute Coronary Syndrome Classification

The application of this definition in the low resource settings of developing countries, especially in rural areas, may lead to under-ascertainment of definite and probable cases because of incomplete information. Inclusion also of possible cases may give a more consistent and reliable definition for tracking of trends. Older biomarkers CK-MB and CK-MBmass may also be used where more recent markers are unavailable. This has implications in particular for the classification of unstable angina.

Based on the above, a simplified definition for acute coronary syndrome would be as follows:

1. ECG changes of MI [ST segment elevation or pathological Q waves] plus at least one value above the upper reference limit for a cardiac biomarker [CK-MB or Troponin – I or Troponin – T] – (STEMI).

2. Pain or discomfort in the chest, jaw, upper extremity or epigastric area in combination with at least one value above the upper reference limit for a

cardiac biomarker [CK-MB or Troponin – I or Troponin – T], but with no ECG changes of MI [ST segment elevation or pathological Q waves] – (NSTEMI).

3. Pain or discomfort in the chest, jaw, upper extremity or epigastric area in combination with ECG changes [ST segment elevation or pathological Q waves], but with no value above the upper reference limit for any cardiac biomarker [CK-MB or Troponin – I or Troponin – T] – (unstable angina).

2.2 Global burden of CHD

CHD was the leading cause of death and life-years lost worldwide in 2010. It led to an estimated 7 million deaths and was responsible for loss of an estimated 130 million disability adjusted life years (DALYs) (Murray CJ, 2012). In developing countries CHD caused over 4 million deaths and loss of 85 million DALYs – i.e. more than 60% of the burden worldwide (Murray CJ, 2012).

In terms of DALYs between 1990 and 2010, CHD increased by only 2% in developed countries, while during the same period it increased by 79% in developing countries. It became the leading cause of death in developing countries, up from 5th rank at the start of the period (Murray CJ, 2012).

2.3 Risk factors for CHD

Risk factors for atherosclerosis and CHD can be grouped as follows:

2.3.1 Constitutional factors

a. Hereditary
b. Age
c. Gender

2.3.2 Early life programming of metabolism

2.3.3 Behavioural factors

a. Tobacco use
b. Lack of physical activity and exercise
c. Unhealthy diet (rich in salt, fat and calories)
d. Alcohol

2.3.4 Environmental factors

a. Poverty
b. Psychological stress
c. Ambient air pollution and environmental tobacco smoke

2.3.5 Other diseases

a. Hypertension
b. Diabetes
c. Elevated blood lipids (dyslipidaemia)
d. Hyperhomocysteinaemia
e. Obesity

2.3.1 Constitutional risk factors

Pointers to a possible genetic component of disease come from the demonstration of its aggregation within families. The Framingham Offspring Study revealed that positive parental history predicted premature CHD with a relative risk of 1.45, while occurrence of the disease in a sibling carried a 1.99-fold relative risk (Murabito JM, 2005). Relative risk estimates for CHD in subjects with a parental history of premature CHD (<60 years) ranged from 1.15 to 2 in a large cohort study (Sesso HD, 2001), and in another, the risk of fatal CHD in those with parental premature CHD was again elevated (Colditz GA, 1986). INTERHEART, a large case-control study of acute MI conducted in 53 countries, indicated a relative risk of 1.55 for family history of CHD, but information about how family history was ascertained was not reported (Yusuf S, 2004).

An increased risk with positive family history is compatible with genetic causation, but could also reflect similarities in lifestyle habits and environmental exposures, such as smoking or poor diet. Stronger pointers to genetic predisposition come from twin studies. In a large cohort of Swedish twins, the relative hazard of death from CHD among men whose twin died of CHD before the age of 55 years, as compared with those whose twin did not, was 8.1 for monozygotic twins as compared with 3.8 for dizygotic twins. Among women whose twin died of CHD before the age of 65 years, the relative hazard was 15.0 for monozygotic twins and 2.6 for dizygotic twins. The magnitude of this difference between monozygotic and dizygotic twins decreased for both men and women as the age at which the first twin died increased, suggesting a stronger influence of genetics on CHD at younger than at older ages (Marenberg ME, 1994).

The other major evidence for genetic causation of CHD comes from the identification of specific genetic abnormalities that are associated with the disease. These may act through established risk factors for atherosclerosis such as dyslipidaemia, hypertension and diabetes mellitus (see below), or through other unidentified pathways. A recent genome wide association study (GWAS) comparing people with CHD and a normal population, found associations with 46 gene loci. Of these, 12 showed a significant association with a lipid trait, and five with blood pressure. However, the remainder were not associated with established risk factors for CHD (The CARDIoGRAMplusC4D Consortium, 2013). Similar findings were also reported in a meta-analysis of GWAS based on 14 studies (Schunkert H, 2011).

Older age and male gender are both strong risk factors for CHD. The Framingham cohort study found that the incidence of coronary events increased rapidly with age, and that women had rates similar to those of men 10 years younger (a mean ‘‘delay’’

of 10 years) (Castelli WP, 1984). For MI and SCD, the "delay" in the incidence rates in women was about 20 years, although the difference decreased at older ages (Lloyd-Jones D, 2010). In premenopausal women, MI and sudden death are relatively rare, but after the menopause, the incidence and severity of CHD increase rapidly, and reach up to three times that in premenopausal women of the same age (Gordon T, 1978). One of the important driving factors for the rapidly increasing burden of CHD in low and middle income countries is the ageing of their populations. According to United Nations (UN) projections, in 2025 there will be 1.2 billion elderly people worldwide, with 71% of them likely to be in developing countries, adding hugely to the burden of CHD (UNDESA, 2008).

2.3.2 Early life programming of metabolism

Low birth weight is associated with an increased risk of CHD in adults (Barker DJP, 1989). Ample epidemiological evidence is available that under-nutrition in early life increases susceptibility to the effects of a later affluent diet, leading to CHD in adulthood (Barker DJP, 1986; Barker DJP ,1993; EARLYREAD, 2008). Although, there is an established link and abundant evidence for this relationship, the underlying mechanisms are less well understood. It is hypothesized that it occurs through a phenomenon of 'programming', whereby events in foetal life lead both to altered size at birth, and also to permanent changes in structure and function which predispose to disease in adult life. Nutrition has been implicated as an important stimulus of programming in several experimental studies (Harding JE, 2001), and in rural India, there is evidence of improved risk factors for CHD following a nutritional intervention given from before birth (during pregnancy) and into early childhood (<6 years of age) (Kinra S, 2008).

2.3.3 Behavioural risk factors

Smoking is one of the important avoidable risk factors for CHD. On average, smokers are almost three times more likely to develop the disease than non-smokers, the increase in risk of MI being dose-related and linear (Teo KK, 2006). The INTERHEART case-control study found a nine-fold elevation in the odds of MI in smokers consuming more than 40 cigarettes a day (Yusuf S, 2004). Also, there is ample evidence from cohort studies regarding the beneficial effects of smoking cessation on CHD mortality (WHO, 2007& 2010). Worldwide, fewer women smoke than men. Furthermore, the female-to-male gender ratio for smoking is even lower in developing countries such as Pakistan (Hitchman SC, 2011). Manufactured cigarettes are the commonest tobacco product, but other forms of tobacco are also used, including "bidis" (a type of non-

filtered cigarette that is hand-rolled, often in a leaf), cigars, hookahs and chewing tobacco (WHO, 2008 & 2010).

Physical activity reduces the risk of CHD in a dose-dependent manner (WHO, recommendation 2010; Oguma Y, 2004; Wendel-Vos GC, 2004; Berlin JA, 1990). The INTERHEART study showed that moderate to strenuous physical activity for four hours or more per week led to a 0.86 relative reduction in CHD (Yusuf S, 2004). Physical activity tends to decrease weight and improve blood pressure, lipid profile and insulin sensitivity, and its benefits are mediated at least partly through these intermediate risk factors. Worldwide, men are more active than women, with the biggest difference in the Eastern Mediterranean region, extending to Pakistan. Men and women in high income countries are less active than their counterparts in low-income countries (WHO, global status 2010).

High dietary intakes of saturated fat, trans-fat cholesterol and salt, and low intakes of fruit, vegetables and fish have all been linked to CHD risk (WHR, 2002). However, a recent large review has indicated that the evidence is inconsistent, and there is controversy regarding guidelines to encourage higher consumption of polyunsaturated fatty acids and lower consumption of total saturated fats to prevent CHD (Chowdhry R, 2014). There is clear evidence that lower intake of salt leads to reductions in blood pressure, which in turn decreases the risk of CHD (He FJ, 2007&2009). Evidence regarding protective effects of fruit and vegetables is still scarce. Most studies have been observational, and do not provide clear evidence of protection against CHD (Dauchet L, 2009). However, the INTERHEART study found that daily consumption of fruit and vegetables was associated with a 30% lower risk of CHD (odds ratio (OR) = 0.7) (Yusuf S, 2004). Long term cohort studies have not shown a protective effect of fish consumption in low risk populations, although it may provide some protection from CHD in people at high risk (Marckmann P, 1999).

A review of studies reported that the risk of CHD in relation to level of alcohol intake is J-shaped – i.e. risk is lower in low to moderate alcohol drinkers and higher in heavy drinkers, as compared with non-drinkers (Rehm J, 2003). The INTERHEART study found that regular alcohol consumption (three or more times a week) was associated with a relative risk of 0.91 for CHD (Yusuf S, 2004), and in a recent systematic review, the pooled adjusted relative risks for alcohol drinkers relative to non-drinkers were 0.71 (0.66 to 0.77) for incident CHD (based on 29 studies), and 0.75 (0.68 to 0.81) for CHD mortality (based on 31 studies) (Ronksley PE, 2011). A systematic review and meta-analysis of intervention studies indicated that moderate alcohol use increased high density lipoprotein (HDL) cholesterol (see below) and adiponectin in the blood (Brien

SE, 2011). However, in another recent systematic review, adiponectin was associated with slightly increased risk of recurrence of CHD (Sook LE, 2013).

2.3.4 Environmental risk factors

Various aspects of the social environment are associated with risk of CHD. In a long term follow-up study, 20 years of exposure to neighbourhood poverty was associated with a greater CHD risk in women (Murray ET, 2010), and the Glasgow MONICA coronary event register cohort study determined that CHD events were twice as frequent in those living in the most deprived compared to the least deprived areas (Morrison C, 1997). Low income level has also been linked with worse outcome among patients with acute coronary syndromes, in a way that could not be explained by differences in the management of cases in hospital (Rao SV, 2003). Factors that might have led to this difference include disparities of follow-up care at home (which may influence compliance with medication) and in social support, which are worse in the poor. However, it needs further investigation.

An Expert Working Group of the National Heart Foundation of Australia undertook a review of systematic reviews and concluded that there was strong and consistent evidence for independent associations of depression, social isolation and inadequate social support with the development and prognosis of CHD (Bunker SJ, 2003). However, they also reported that there was no strong or consistent evidence for an association between chronic life events, work-related stressors (job control, demands and strain), type A behaviour patterns, hostility, anxiety disorders or panic disorders and CHD. On the other hand, another more recent meta-analysis of cohort studies on work stress estimated a 50% increase in risk of CHD (Kivimäki M, 2006), and a meta-analysis of cohort studies found an aggregate risk ratio of 1.27 (95% CI 1.12 – 1.45) for incident CHD in relation to high perceived stress (Richardson S, 2012). In another meta-analysis, the pooled hazard ratio for CHD in people with post-traumatic stress disorder, adjusted for depression, was 1.27 (95% CI 1.08-1.49) (Edmondson D, 2013).

Physical aspects of the environment are also important. Particulate matter (PM) in outdoor air is known to increase morbidity and mortality from cardiovascular disease (CVD), an effect which has been established by time-series and cohort studies around the world (Dockery DW, 1993; Pope CA, 1995). In 2004, based on available evidence, the American Heart Association scientific statement on “Air Pollution and Cardiovascular Disease” concluded that PM air pollution contributes to cardiovascular morbidity and mortality. Moreover, $PM_{2.5}$ exposures was considered a modifiable risk factor of cardiovascular morbidity and mortality. Reviewed evidence suggested that exposure to $PM_{2.5}$ over a few hours to weeks may trigger cardiovascular disease-related mortality and nonfatal events, and that longer-term exposure (e.g., a few years)

increases the risk of cardiovascular mortality to an even greater extent than exposures over a few days. Also, reductions in PM levels are associated with decreases in cardiovascular mortality. Many credible pathological mechanisms have been elucidated to explain the relationship (Brook RD, 2004).

Besides the link with ambient air pollution, it has been shown in several systematic reviews and meta-analyses that environmental tobacco smoke (ETS) is associated with CHD among both men and women (Howard G, 1999). ETS increases risk of CHD by 25-35% among exposed compared to non-exposed persons (Wells AJ, 1998; Jousilahti P, 2002). Another meta-analysis estimated that among women, exposure to ETS was associated with a 15% increase in the risk of dying from heart disease (RR = 1.15, 95% CI 1.03-1.28) (Kaur S, 2004). Earlier studies have also shown a dose-response relationship with the increasing amount of ETS (Law MR, 1997). Another analysis further suggests that spousal smoking led to 5% increased risk of death from CHD (Enstrom JE, 2006).

2.3.5 Other diseases

Raised blood pressure, both systolic and diastolic, is a major independent risk factor for CHD. The Prospective Studies Collaboration meta-analysis of 61 studies involving a million individuals without initial cardiovascular disease showed a twofold increase in mortality from myocardial infarction for every 20-mmHg increase in systolic or 10-mmHg increase in diastolic blood pressure (Prospective Studies Collaboration, 2002). Among patients who have CHD, there seems to be J-shaped relationship between blood pressure and mortality from CHD, particularly for diastolic blood pressure – i.e. after a decline across most of the range, mortality starts to increase again at systolic blood pressure levels below 120-125 mmHg, and particularly below diastolic pressures of 70-75 mmHg (Nogueira JB, 2013). There are at least three possible pathophysiological mechanisms for this J-shaped relationship: (1) a reduction in coronary perfusion (which occurs in diastole) with critically low diastolic BP levels; (2) increased differential (pulse) pressure due to low diastolic BP, secondary to increased arterial stiffness; and (3) reverse causality (i.e. that low BP is in some cases a consequence of CHD) (Nogueira JB, 2013).

Diabetes mellitus is also an important risk factor for CHD. An analysis which collated data from 64 cohort studies, estimated a relative risk of 2.82 in women and 2.16 for men for incident CHD in association with diabetes. (Peters SA, 2014). The frequency of asymptomatic CHD is also higher among patients with diabetes mellitus (Baweja PS, 2014).

Dyslipidaemia is another important modifiable risk factor for CHD (Assmann G, 1996; Goldbourt U, 1997), and has been reported to be associated with more than half of all ischemic heart disease (WHR, 2002). Different types of dyslipidemia have been investigated (Pekkanen J, 1990; Conroy RM, 2003). High levels of low density lipoprotein (LDL) cholesterol and triglycerides are associated with increased risk of CHD (Austin MA, 1994), whereas population studies have consistently demonstrated that high density lipoprotein (HDL) cholesterol is inversely associated with risk of CHD (Kosmas CE, 2014). Dyslipidaemia has been implicated as one of the reasons for a higher risk of CHD among South Asian populations (Dodani S, 2008).

A meta-analysis of studies published between 1966 and 2006 found that after adjustment for other risk factors, each increase of 5 µmol/L in the level of homocysteine in blood was associated with an approximately 20% increase in the risk of CHD events (Humphrey LL, 2008). However, attempts to reduce this risk through folate fortification and vitamin B (possibly by inducing coronary plaque regression) have given mixed results (Antoniades C, 2009).

Obesity increases the risk of hypertension, diabetes mellitus and dyslipidaemia (Hubert HB, 1983; Todd Miller M, 2008), and partly through these diseases, increases the risk of developing, and progression of, CHD. However, in numerous studies it has been shown that obesity, particularly when assessed by body mass index (BMI), is associated with better outcomes among patients who have CHD and receive hospital care, a phenomenon commonly known as the 'obesity paradox' (De Schutter A, 2014; Romero-Corral A, 2006; Lavie CJ, 2003; Angerås O, 2013). The INTERHEART study has suggested that waist-to-hip ratio (abdominal obesity) is a better marker of risk for CHD than BMI (Yusuf S, 2005).

2.4 The burden of CHD and risk factors in Pakistan

No national level estimates of the prevalence of CHD and its risk factors in Pakistan are available from the past 20 years. However, limited information is furnished by population-based studies conducted only in urban areas. In addition, a small number of studies have attempted to determine the prevalence and determinants of CHD among South Asian people including from Pakistan, who have migrated to various developed countries.

A population-based study, conducted in an urban area in Pakistan, and using objective measures of CHD (definite or probable CHD based on Minnesota classification of ECG or a history of 'heart attack'), indicated that one in four subjects aged >40 years might have CHD. Current smoking, proteinuria (Jafar TH, 2005), and metabolic syndrome

(diabetes, hypertension, obesity, dyslipidaemia) were associated with CHD, and women were at greater risk than men (Jafar TH, 2008), a reversal of the pattern in Western countries. An earlier population-based study among adults, which measured CHD by history of 'angina or heart attack', estimated a prevalence of 1.9% among affluent participants and 0.6% among those who were poor (Hameed K, 1995).

The National Health Survey of Pakistan (NHSP), conducted during 1990-94, provides the only national level estimates for risk factors for CHD among adults >18 years of age. The prevalence of obesity (BMI>25 kg/m^2) was 12% in men and 20% in women. Hypertension (systolic or diastolic or both ≥140/90 mmHg) was found in 18% of men and 15% of women. Serum cholesterol exceeding 200 mg/dL was observed in 17% of men and 14% of women. The overall prevalence of smoking was 35% among men and 4% among women (NHSP, 1990-94). A more recent hospital-based case-control study concluded that high waist-to-hip ratio and low high-density lipids (HDL) are predictors of CHD in Pakistan (Nishtar S, 2004).

Overall, studies conducted among South Asian immigrants have indicated a higher prevalence of CHD than in western populations (McKeigue PM, 1989; Singh RB, 1999 & 1993; Bhopal R, 1999). However, many of these studies have been conducted in only small samples and selected populations, making any inference uncertain (Bhopal R, 2000). Surveys of CHD risk factors have also been conducted among South Asian immigrants. For example, a review which assessed 12 studies among adults and five in children, found lower levels of physical activity among South Asian (Bangladeshi, Indian, Pakistani) immigrants than in the general population of England (Fischbacher CM, 2004).

In conclusion, limited evidence suggests that risks of CHD may be higher in women than men in Pakistan, in contrast to most other countries. Given that Pakistani women tend to smoke less often and have been found to have a better profile than Pakistani men for most other cardiovascular risk factors, this pattern requires an explanation. The next chapter will focus on a potential risk factor that might explain the paradox and which has not been covered so far in this account.

Chapter 3: Biomass fuel and Indoor Air Pollution (IAP)

3.1 Definition and uses

Biomass fuel is a major source of IAP in non-westernized developing countries. The term refers to any plant-or animal-based material that is deliberately burned by humans to generate energy. Biomass fuels include wood, crop or other agricultural waste, animal dung, shrubs and charcoal. In addition, some countries use coal and/or coke as a source of energy. Together, biomass, coal and coke are called 'solid' fuels. Biomass fuel is used mainly for cooking, but also (in colder environments) for heating homes, and occasionally for lighting.

Biomass comprises organic material, the carbon which is originally taken up by plants from carbon dioxide (CO_2) in the atmosphere, and incorporated into more complex compounds using energy from the sun. Plants may subsequently be eaten by animals and converted into animal biomass such as cow-dung. Carbon is released back into the atmosphere when biomass is burned. Fossil fuels such as coal, oil and gas are also derived from biological materials, but were formed many millions of years ago. In addition to this difference in time of formation, an important difference between biomass and fossil fuels is the efficiency of their combustion. Fossil fuels burn more completely than biomass fuels, which in turn cause more air pollution, especially in the enclosed environment of the kitchen and home.

3.2 Global pattern of use

Globally, the proportion of households relying mainly on solid fuels for cooking was 41% (95% CI: 37% to 44%) in 2010 (Banjour S, 2013). The number of persons exposed to household air pollution from solid fuel was estimated to be around 2.8 billion, a figure which has remained stable over the last three decades in the presence of population growth. More than 60% of households in Africa and Southeast Asia cook with solid fuels, while its use elsewhere ranges from <20% in the Americas and Europe, to 35% in the Eastern Mediterranean and 46% in the Western Pacific (Banjour S, 2013).

In Africa, use of solid fuel is increasing, with an estimated 77% of the population (646 million people) exposed in 2010. In Southeast Asia, the percentage of solid fuel users declined from 95% in 1980 to 61% in 2010, but the number of people exposed was still around one billion (Banjour S, 2013).

As a proportion of all sources of energy, the use of biomass fuel has declined with economic development, but it still accounts for 10% of the total energy production

worldwide. Of this, 90% is for household cooking and heating in developing countries, and it remains the main source of energy for most of the population worldwide. The other use of biomass as a fuel is in modern power plants, mainly in developed countries (UNDP, 2004), where there has been a move to greater use of biomass in response to the rising cost of fossil fuels, and a push for wider utilization of renewable energy sources. Although, consequent exposures differ substantially between the populations of Organization for Economic Cooperation and Development (OECD) countries and Asian ones, the average per capita use of biomass is similar (UNDP, 2004).

In developing countries, the type of fuel used in the home often relates to socioeconomic status. The poorest households frequently rely on animal dung, crop waste, charcoal and wood, while in those that are more advantaged, there is wider use of more efficient and convenient, but costly fuels such as coal, kerosene, liquid petroleum gas (LPG), natural gas, and (in the most affluent) electricity. This progression, which is seen from rural to peri-urban and urban areas, has been termed the 'energy ladder' (Smith KR, 1994) (Figure 2).

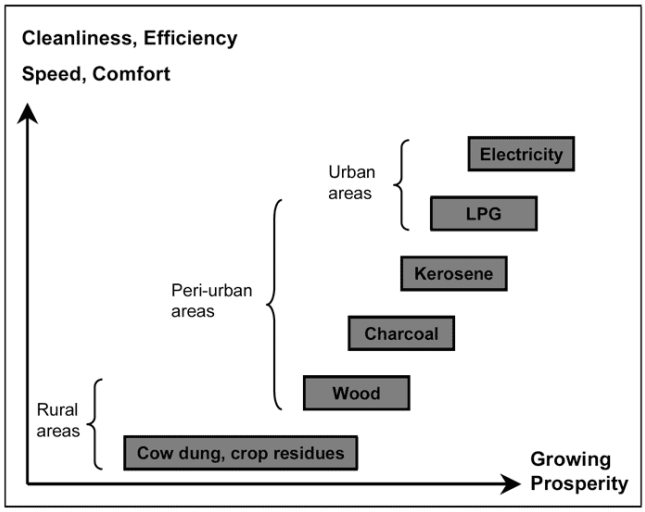


Figure 2. Energy ladder in developing countries

(Adapted from Smith KR, 1994)

3.3 Use of biomass fuel in Pakistan

In Pakistan, more than 62% of all households and 87% of rural households were using solid fuel in 2012 (PDHS, 2012-13). Most of the remainder used natural gas, LPG or biogas as their main cooking fuel. Many households burned a variety of biomass fuels depending on their availability and the season, but overall 47.4% reported using wood as their main cooking fuel, 8% animal dung, 4.5% straw/shrubs/grass, 2.1% charcoal and a negligible number coal. Corresponding figures for rural households specifically were 66% wood, 11.5% animal dung and 6.5% straw/shrubs/grass (PDHS, 2012-13).

An average household using biomass was estimated to consume 2325 kg of wood, 1480 kg of dung or 1160 kg of crop residues per annum (Mirza UK, 2008) (Figure 3).

Figure 3. Biomass and other fuels, types of stoves and kitchens in rural, Pakistan.

3.4 Household air pollution from use of biomass fuel

3.4.1 Air pollutants produced by biomass fuel

Biomass is commonly burned in traditional stoves or open fires, releasing multiple pollutant gases and fumes, due to incomplete combustion. Significant amounts of particulate matter (PM), carbon monoxide (CO), volatile organic compounds (VOCs) and several inorganic compounds and ionised elements are released. Many of the pollutants in biomass smoke can damage health, including PM, CO, benzo[a]pyrene (BaP), formaldehyde, nitrogen oxides, oxides of sulphur (although these are formed more from burning coal), and polycyclic aromatic hydrocarbons. The potential adverse health effects of some of these pollutants are summarised in Table 3-1 (Bruce N, 2000; Naeher LP, 2007).

Table 3-1. Pollutants in smoke from biomass sources

Pollutant	*Source*	*Mechanism/Toxicity*
Fine particles (respirable particles with aerodynamic diameter less than 10 microns, and particularly less than 2.5 microns)	Condensation of combustion gases; incomplete combustion;	Inflammation and oxidative stress
Carbon monoxide	Incomplete combustion	Asphyxiant (reduces oxygen delivery to tissues)
Hydrocarbons (many hundreds): *Unsaturated (40+, e.g. 1, 3 butadiene);Saturated (25+, e.g. n-hexane); Polycyclic aromatic (PAH), (20+, e.g. benzo[a]pyrene); Monoaromatics (28+, e.g. benzene, styrene)*	Incomplete combustion (also react to form organic aerosols. Species vary with biomass and combustion conditions)	Irritant, carcinogenic, mutagenic, neurotoxic
Oxygenated organics (hundreds): *Aldehydes (20+ e.g. formaldehyde); Organic alcohols and acids (25+ e.g. methanol); Phenols (33+ e.g. catechol, cresol); Quinones (e.g. hydroquinone)*	Incomplete combustion (also react to form organic aerosols. Species vary with biomass and combustion conditions)	Irritant, carcinogenic, mutagenic, teratogenic, allergenic, redox-active, can cause oxidative stress and inflammation
Chlorinated organics: *Methylene chloride, methyl chloride, dioxin*	Chlorinated ingredients in biomass	Central nervous system depressant (methylene chloride), possible carcinogenic
Free radicals: *Semiquinone type radicals*	Little is known about their formation	Redox-active, cause oxidative stress and inflammatory response, possibly carcinogenic

An experimental study in which dry wood was burned domestically using appliances and woods typically used in wood-burning communities in the US, estimated that 4-9 g of PM(<2.5μm), 102-178 g of CO and 5-22 g of total VOCs were emitted per kg of fuel (McDonald JD, 2000). By weight, organic carbon comprises 75-100% of the fine particulate that is produced (Wolff GT, 1982). Many VOCs are present only in trace amounts, so most studies on indoor air pollution have focused on PM and CO, which are the two main concerns (WHO database).

PM is a mixture of solid particles and liquid droplets suspended in the air, and may contain a broad range of chemical species. Primary PM is formed directly during combustion while secondary PM is produced in the atmosphere through chemical and

physical reactions involving oxides of sulphur, nitrogen oxides, volatile organic compounds, gaseous ammonia and sunlight. The size of the particles ranges from 0.005 to 100 microns in diameter. Particles with diameters less than 10 microns (PM_{10}), and especially those with diameters less than 2.5 microns ($PM_{2.5}$), can penetrate deeply into the lungs and have the greatest potential to damage health. $PM_{2.5}$ particles are called 'fine', while those with diameter greater than 2.5 to 10 microns are called 'coarse'. Generally, coarse particles are produced from mechanical processes such as weathering, volcanic activities, windblown soil, sea salt spray, pollen, and grinding operations (mining), and because of their mass they usually settle out of the air within a few hours to days. Fine particles are usually formed through condensation of vapours, and may then grow and agglomerate. For a given mass, they are greater in number and have greater surface area than coarse particles, and they can persist in the atmosphere for days to weeks. Particles in wood smoke are generally smaller than 1 micron, with the peak of the size distribution between 0.15 and 0.4 microns (Kleeman MJ, 1999). Fine particles can travel long distances in the air (Echalar F, 1995).

The second major biomass combustion pollutant is CO. Fuels such as natural gas, LPG, oil, and solid and biomass all have the potential to emit CO in variable quantity. CO is a colourless, odourless, tasteless gas that is highly toxic and can kill quickly without warning. It can be emitted directly when biomass fuel is burned in closed kitchens and stoves where there is not enough oxygen. However, CO is less dense than air and in the open atmosphere it is short lived. When carbon monoxide enters the body, it prevents oxygenation of cells, tissues, and organs by forming carboxyhaemoglobin.

3.4.2 Other sources of PM and CO in household air

PM in ambient air that is produced by combustion of fossil fuels in vehicle engines and industrial processes may enter into buildings. However, its contribution to indoor air pollution in rural areas of Pakistan would be negligible. More important, and the other major source of PM and CO in household air is tobacco-smoking. Burning of general and agricultural waste may also cause particulate pollution of air in rural households (Tenenbaum DJ, 2000).

3.4.3 Measurement of PM and CO in household air

Although, PM arguably is the main determinant of long-term risks to health from indoor air pollution, CO can be more readily measured, particularly when assessing personal exposures, due the availability of convenient passive diffusion tubes for sampling. Apparatus for measuring particulates, which requires the use of a sampling pump, is more expensive and less convenient. Airborne concentrations of CO in

households using biomass have been shown to correlate strongly with levels of PM in the same kitchens, suggesting that in these circumstances, CO may serve as a proxy for PM (Naeher LP, 2001). It is apparent from the WHO database, that most of the studies on indoor air pollution have monitored PM and CO as the main indicators of exposure (WHO Global HAP pollution measurement database). The measurement of PM and CO has been done using both personal sampling and area monitoring (kitchen or living room).

Both active and passive sampling methods have been used. In active sampling, a mechanical pump is used to suck air through a collection system (e.g. a filter or light scattering sensor). Passive sampling uses diffusion methods, generally for the detection of gases.

Area monitoring is convenient to conduct, but measurements may not correlate so strongly with personal exposures and health effects in individuals. Personal monitoring is difficult to apply, particularly if the instrument is heavy and inconvenient for the participant, but gives measurements that should relate more closely to health outcomes. Area and personal exposure measurements among a subgroup of a target population can be used to develop exposure models by which to estimate individual exposures in the absence of personal monitoring (Clark ML, 2013).

Particles of variable size fractions have been monitored, from the larger total suspended particles (TSP) (<50-100 micron in size) to smaller particle sizes such as PM_{10}, PM_{4}, $PM_{3.5}$ and $PM_{2.5}$. Most studies currently focus on fine particles (<2.5-micron diameter) as these are considered to relate most closely to health outcomes. They can penetrate deep into lungs, and can then be absorbed into the blood. Also, as described above, biomass burning mainly leads to emission of finer particles (Kleeman MJ, 1999).

Many types of measuring device have been employed to assess particulate pollution, but gravimetric methods have been considered a gold standard. In these, the PM is collected on a filter paper using an active pump. The filters are pre-weighed and post-weighed in an environment with controlled temperature and relative humidity to derive the weight of the particulate deposit, and the average airborne concentration is then calculated as weight per unit of volume of air, taking into account the volume of air filtered.

Several types of real-time monitor have also been used to measure PM. Real-time monitors can be used to assess peaks and troughs of concentrations as well as mean values, and are convenient for fixed site, area monitoring. A comparison of real-time

instruments used to monitor airborne PM was carried out by Chung et al., who reported that measurements made with a beta attenuation monitor (BAM), an integrating nephelometer, and a continuous aerosol mass monitor (CAMM) correlated well with reference measurements made by a filter-based gravimetric method (Chung A, 2001). The BAM consists of a filter tape, a beta radiation source and a beta radiation detector. Particles are collected at a single point on a length of filter tape. The difference in the transmission of beta radiation through the filter tape before and after exposure to particulate is used to determine the mass of collected particulate matter. The mass absorption coefficient for beta radiation is determined through the measurement of a series of known standards that bracket the mass range of interest. The CAMM measurement of PM is based on the relative difference in pressure drop between a reference airstream channel and an airstream channel where PM is collected on a filter tape. This pressure difference is then correlated to the PM concentration. The instrument provides continuous measurements with a time resolution between 30 and 60 min. Integrating nephelometers measure particle concentrations by intersecting an aerosol sample with light at several wavelengths in the visible range (0.55 μm effective centre wavelength). The amount of laser light scattered at certain angles by particles suspended in the sample flow is measured, to obtain a particle-scattering coefficient, which is assumed to be proportional to the mass of PM.

Similarly, CO monitors have been used for direct real-time measurement by chemical sensors. The sensitivity of the measurements varies. However, commonly available real-time monitors can measure concentrations of CO in the range of 1-1000 ppm. In addition, active and passive gas detection colour dosi-tubes are available. For active sampling the tube needs to be attached to a pump, whereas passive samplers do not. The tubes are calibrated, and can be read directly according to a change in colour that occurs when CO is present. Cumulative exposures can be calculated in parts per million–hours (ppm-hrs), and are converted to time-weighted average exposures according to the duration of sampling. Draeger CO passive diffusion tubes can measure cumulative exposures in the range of 1.04-2000 ppm-hrs. These tubes can be easily carried tucked within an individual's clothes adjacent to the breathing zone, allowing convenient personal monitoring of exposure.

3.4.4 Levels and determinants of PM and CO in indoor air

A comprehensive summary of area and personal exposure data measured in the kitchens and living rooms of households using biomass is available from WHO Global Household Air Pollution Measurement Databases (http:// www.who.int/indoorair/health_impacts/ databases_iap/en/). These collate data from studies which have been conducted around the world, mostly in developing countries

of Africa, Asia and Central America. Most of the studies have measured PM of various sizes including coarse and fine particles and CO. Some studies have also measured volatile organic compounds (VOCs), nitrogen oxides, sulphur oxides, polycyclic aromatic hydrocarbons (PAH), benzo(a)pyrene (BaP), or trace metals such as arsenic.

Within the database, the measured levels of indoor air pollutants exhibit marked heterogeneity. This may be attributable to several factors including differences in cookstove use and time–activity patterns, weather conditions, household room configuration, volume and ventilation, fuel type and moisture, and instrument error (Clark ML, 2013).

There is so much variability between studies that generalizations are difficult to make. Among the studies which have measured $PM_{2.5}$ most reported average concentrations have fallen in the range of 500-2000 $\mu g/m^3$. However, at the extremes, values as low as 7$\mu g/m^3$ and as high as 7203$\mu g/m^3$ have been recorded. There is even greater variability in measurements of PM_{10}. Levels of CO have varied from 2-3ppm to a maximum of 2300 ppm. However, most studies have reported concentrations in the range of 10-100ppm (http:// www.who.int/indoorair/health_impacts/ databases_iap/en/) (see Figure 4).

Several conclusions can be drawn from these data. Firstly, many studies may have been limited by financial, technical and logistical constraints, and had only small sample sizes; secondly, the measurements are characterized by large variability between different studies. Even so, by any measure the values of PM and CO are typically extremely high (100-200 fold greater than internationally accepted standards for ambient air).

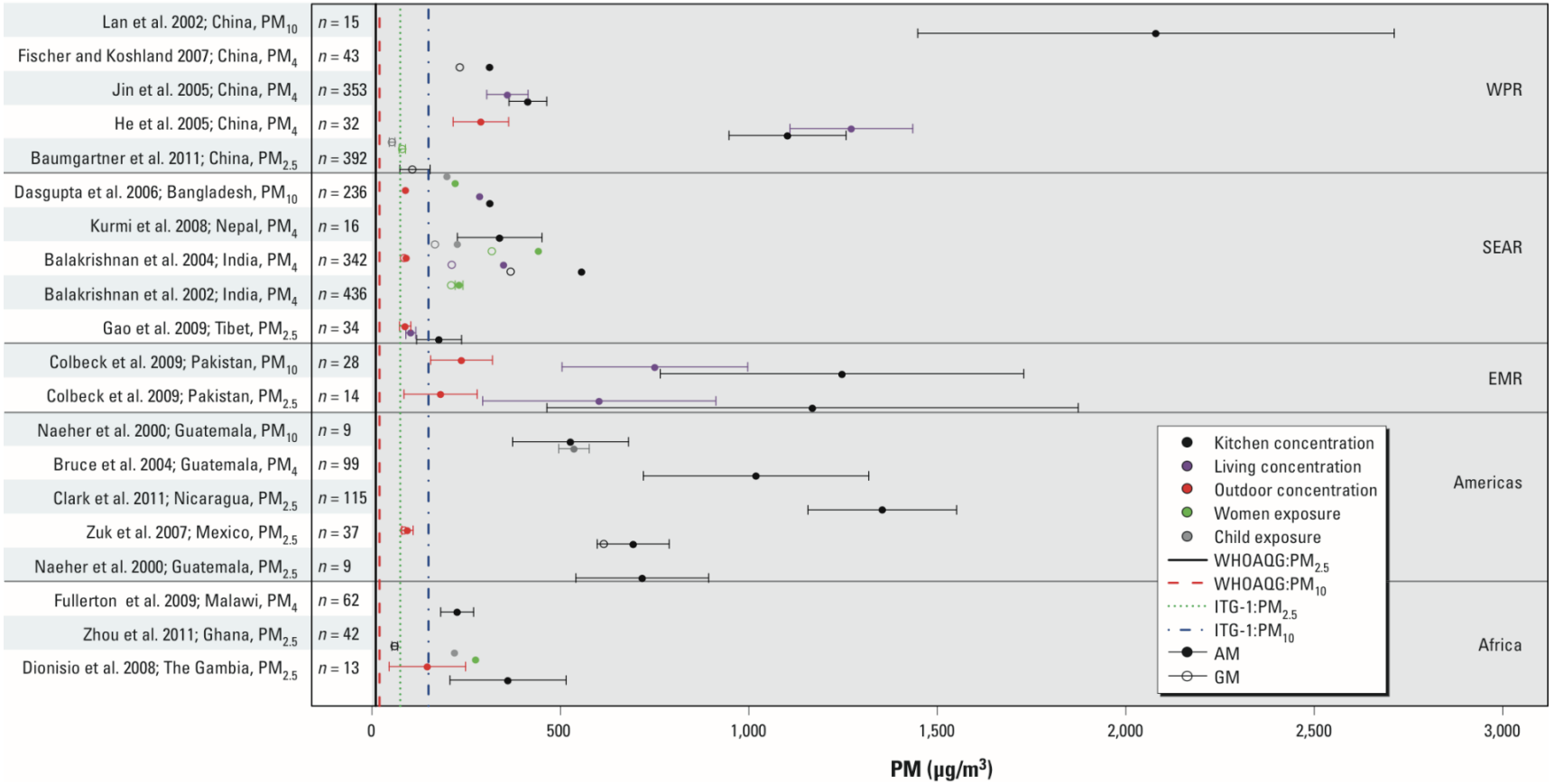


Figure 4. Concentrations of particulate matter in the WHO Global household air pollution measurement database

Reported means ± SDs of 24-hr PM (PM_{10}, PM_4, and $PM_{2.5}$) concentrations and/or exposures ($\mu g/m^3$) from selected studies included in the WHO Global household air pollution measurement database (http://www.who.int/indoorair/health_impacts/databases_iap/en/). Pollutant-specific WHO interim and guideline values, respectively, for air quality displayed refer to the annual guidelines of 70 $\mu g/m^3$ and 10 $\mu g/m^3$ for $PM_{10}$and 35 $\mu g/m^3$ and 10 $\mu g/m^3$ for $PM_{2.5}$ (WHO 2006). Studies are labeled according to the reference, country, and reported PM fraction. For some studies reporting mean levels across multiple categories, such as season or fuel/kitchen type, results are shown as the pooled means and pooled SDs. Abbreviations: AM, arithmetic mean; EMR, Eastern Mediterranean Region; GM, geometric mean; ITG-1, interim target guideline; PM_4, ≤ 4 µm in aerodynamic diameter; PM_{10}, ≤ 10 µm in aerodynamic diameter; SEAR, Southeast Asian Region; WHOAQG, World Health Organization Air Quality Guideline; WPR, Western Pacific Region (Reproduced with permission from Clark ML, 2013).

3.5 Health effects of household air pollution other than CHD

3.5.1 Respiratory tract infections among children

A review by the Forum of International Respiratory Societies (FIRS) examined risks to respiratory health from household air pollution. FIRS is a cooperation of international scientific societies active in the field of respiratory medicine, including Associacion Latino-Americana del Torax (ALAT), the American Thoracic Society (ATS), the American College of Chest Physicians (ACCP), the Asian Pacific Society of Respirology (APSR), the European Respiratory Society (ERS), and the International Union Against Tuberculosis and Lung Disease (IUATLD). The review by FIRS found strong evidence for an association of solid fuel use with acute lower respiratory infection (ALRI) among children <5 years of age (Torres-Duque C, 2008), based on a systematic review conducted by Smith and colleagues (Smith KR, 2000). Most of the evidence came from case-control studies, but a few cohort investigations were also available. Odds ratios ranged from 1.8 to 5.5 (Torres-Duque C, 2008). Another review based on eight well-conducted studies estimated an overall relative risk of 2.3 (95% CI 1.9-2.7), the highest OR (3.1) being for children who were carried on their mother's back while she was cooking (Smith KR, 2004). In children, the frequency of acute infections of both the upper and lower respiratory tract increases exponentially with PM_{10} concentrations above 2000 $\mu g/m^3$, a relationship that might reflect impairment of immune responses (Ezzati M, 2001). Another recent review further emphasized the need for exposure assessment, and for interventions to reduce exposures and the burden of respiratory diseases from household air pollution in low and middle income countries (Gordon SB, 2014).

3.5.2 Chronic obstructive pulmonary disease

A recent systematic review and meta-analysis estimated the risk of chronic obstructive pulmonary disease (COPD) from use of solid fuel, including studies which followed standardised criteria for the diagnosis of COPD and dealt with potential confounding factors. It found a positive association, with pooled ORs of 2.80 for COPD and 2.32 for chronic bronchitis (Kurmi OP, 2010). Moreover, limited evidence suggests that the pathology of biomass-induced and cigarette smoke-induced COPD is the same (Mortaz E, 2012). Another review concluded that non-smoking women can develop COPD from exposure to biomass fuel (Liu Y, 2008). The review by FIRS concluded that the overall relative risk of COPD in women exposed to indoor air pollution from solid fuel use was consistently higher (OR=3.2) than that in men (OR = 1.8), who were less likely to be exposed (Torres-Duque C, 2008).

Further research is needed to determine the effects of indoor air pollution on patients who already have COPD or bronchitis. In a study conducted among people with mild to moderate COPD, there was no association of lung function with outdoor or indoor concentrations of particulate matter (de Hartog JJ, 2010). However, another study showed a decline in respiratory health and increased symptom burden (measured by the St. George's Respiratory Health Questionnaire) with increasing $PM_{2.5}$ concentrations in the homes of COPD patients using biomass fuels (Osman LM, 2007). Additionally, there may be an interaction of indoor air pollution with atopy, as atopic individuals with COPD appear to be at higher risk of adverse respiratory health effects from PM exposure than non-atopic individuals (Kaji DA, 2014).

3.5.3 Asthma

Some studies have suggested a relation of asthma to indoor air pollution from use of biomass fuel. Exacerbation of asthma attacks has been documented with a relative risk of 1.6 (95% CI, 1.0-2.5) for children aged 5-14 years and 1.2 (95% CI, 1.0-1.5) at 15 years and older (Mohamed N, 1995; Xu X, 1996; Azizi BH, 1995). Another study suggested an effect of cooking smoke on the development of asthma in the elderly (>60 years), which was greater among women (OR = 1.83; 95% CI, 1.32–2.53) than among men (OR = 1.46; 95% CI, 1.14–1.88) (Mishra V, 2003).

3.5.4 Lung cancer

A strong body of evidence indicates an association between domestic burning of coal and lung cancer among women (Liu Q, 1993; Behera D, 2005; Kleinerman R, 2000). However, whether there is an association of lung cancer with use of biomass fuel is uncertain, because most studies have determined exposures to use of any solid fuel (including coal), and not specifically biomass. A recent systematic review (2012) identified 20 case-control studies of lung cancer and use of biomass fuel, and one pooled analysis that included data from seven studies. Twelve of the studies specifically examined use of biomass (wood, charcoal, grass or straw). Studies from Hong Kong (Koo LC, 1983) and China (Liu Q, 1993; Gao Y-T, 1987) did not find an elevated risk with burning of wood. However, a positive association was reported with use of wood or charcoal among women in Taiwan (Ko Y, 1997; Lee CH, 2001) and Japan (Sobue T, 1990). Also a large multicentre study from Europe, which used a standardized questionnaire and adjusted for covariates, found increased risks of lung cancer from cooking (OR = 1.23, 95% CI: 1.00-1.52) and heating (OR =1.31, 95% CI: 1.06-1.61) with wood (Lissowska J, 2005).

3.5.5 Other health impacts and risks

Knowledge of adverse health effects of indoor air pollution from burning of biomass is still evolving. Other health outcomes that have been studied include tuberculosis, stillbirth, low birth weight and intrauterine growth retardation, and ocular disorders.

There have been mixed results regarding the association of tuberculosis with biomass use. Studies from Nepal, Malawi and China found no association (Behera D, 2010; Crampin AC, 2004; Kan X, 2011; Pokhrel AK, 2010), whereas studies from India and Mexico (Garcia-Sancho MC, 2009; Perez-Padilla R, 2001) found higher odds of exposure to biomass among cases than controls. A recent systematic review and pooled meta-analysis found no association of tuberculosis with indoor air pollution (Lin HH, 2014). There is some hint that positive associations have been found in studies which focused specifically on pulmonary tuberculosis, while no association was apparent in those which included cases of both pulmonary and non-pulmonary tuberculosis. Thus, further studies are needed to clarify this association.

A systematic review with meta-analyses found that indoor air pollution was associated with reduced mean birth weight (by 95.6 (95% CI 68.5 to 124.7) g), and increased prevalence of low birth weight (LBW; <2,500 g) (OR = 1.38, 95% CI: 1.25-1.52), and stillbirth (OR=1.51, 95% CI: 1.23 - 1.85). However, there is a need for further investigation as few studies on these outcomes have been conducted (Martin WJ 2nd, 2013).

Similarly, only a few epidemiological studies have looked at eye disease in relation to indoor air pollution. Studies in Nepal (Pokhrel AK, 2005) and India (Saha A, 2005) indicated that use of biomass was associated with cataracts or blindness. Smoke induces oxidative stress and depletes plasma ascorbate, carotenoids and glutathione, which provide antioxidant protection against cataract formation. A large, 89 000-household, national survey in India, found an adjusted odds ratio of 1.3 for blindness in women from homes using biomass fuel, even after correction for a wide range of potentially confounding socioeconomic factors. However, further studies are needed to extend the evidence on risk of cataract in men, and in exposed populations other than from India and Nepal. These studies need to control for important potential confounders such as smoking, exposure to UV light and nutritional factors (Martin WJ 2nd, 2013).

The next chapter reviews current evidence on the relation of biomass fuels to CHD.

Chapter 4: Indoor Air Pollution and CHD

As already described, particulate pollution of outdoor air and environmental tobacco smoke indoors are both established risk factors for coronary heart disease. It might therefore be expected that indoor air pollution from use of biomass fuels would pose a similar hazard. This chapter describes a systematic review to address the following questions:

What is the strength of epidemiological evidence for an association of CHD with IAP from use of solid fuel? and
What is the likely magnitude of any increased risk of CHD from such IAP?

4.1 Methods

To address these questions, I carried out a systematic search looking for all reports in peer-reviewed journals, which had at least an abstract in English, and which described primary epidemiological research concerning the relationship of indoor air pollution from use of biomass fuel to heart disease (particularly CHD) or to pathogenic mechanisms relevant to CHD.

I first interrogated four electronic databases (Ovid Medline, Embase Classic, Embase and Web of Science) from inception through to 12 June, 2015, using the combination of search terms set out in Table 4-1.

Table 4-1. Search terms used to identify relevant studies

Exposure terms	1) 'indoor air pollution', 2) 'biomass', 3) 'wood' 4) 'smoke', 5) 'particulate*', 6) 'solid fuel' 7) 'dung', 8) 'cooking', 9) 'heating' 10) 'coal', 11) 'indoor' 12) '[#11(#10 OR #9 OR #8 OR #7 OR #6 OR #5 OR #4 OR #3 OR #2 OR #1)]'
Outcome terms	13) 'cardiovascular diseases' 14) 'coronary artery OR coronary vessels' 15) 'myocardial ischemia OR isch?emic heart' 16) 'coronary heart' 17) 'hypertension' 18) 'atherosclerosis' 19) 'angina' 20) 'myocardial infarction' 21) 'acute coronary' 22) 'acute myocardial' 23) '#22 OR #21 OR #20 OR #19 OR #18 OR #17 OR #16 OR #15 OR #14 OR #13'
Combination terms	'#23 AND #12'

Potentially relevant references (with their abstracts) were imported into a single Endnote file, and after removal of duplicates, each was reviewed. Those that were clearly irrelevant were discarded, and full text copies of the remainder were obtained and scrutinised. Those that met the inclusion criteria specified above were abstracted and summarised using a standardised form. In addition, their reference lists were searched for further papers that might have been missed. Each stage of the process after the initial electronic search was carried out independently by me and my supervisor (Professor Coggon), and we compared our decisions and abstracted summaries, with resolution of discrepancies by discussion.

In evaluating the publications that were eligible for review, I grouped findings by health outcome, and considered the conclusions that could be drawn given the strengths and limitations of each study.

4.2 Results

The initial search identified 202 potentially relevant reports through Ovid Medline and Embase, and 378 in the Web of Science database. After removal of 98 duplicates, the titles and abstracts of the remaining 482 papers were read, and 440 which did not meet the specified inclusion criteria were discarded. Full copies were retrieved of the other 42 references, and following detailed scrutiny, 23 were judged eligible for inclusion. In addition, three further publications were identified from the reference lists of those papers, giving a final total of 26 reports that were included in the review.

The 26 articles (Table 4-2) had all been published since 2005, including 22 since 2010. They described 25 studies (two papers (Baumgartner J, 2011; 2014) related to the same study) conducted in South Asia (10), China (4), Turkey (2), Iran (1) and Central and South America (8). Five studies were reported only as abstracts. Eight provided information about risk of CHD or heart disease more generally, three about heart rate or its variability, four about measures of vascular pathology, six about oxidative stress and/or biomarkers of inflammation, thirteen about blood pressure, and one about lipid profile. Most compared use of biomass with non-use or with use of cleaner fuels, but four assessed the impact of biomass stoves with improved design, three compared different levels of exposure to PM, CO or black carbon and one assessed associations with occupational exposure to indoor barbecues. Sixteen were cross-sectional in design, four assessed interventions, two were case-control investigations, and three were cohort studies. Potential for confounding was addressed by various combinations of restriction (e.g. to women or non-smokers), matching, and statistical adjustment. However, in two studies there was no documented control for possible confounding.

As indicated in the comments in Table 4-2, some of the studies had important limitations.

Table 4-2. Epidemiological studies bearing on the relationship of coronary heart disease to indoor air pollution from use of solid fuel

Country and reference	Design	Study sample	Exposures compared	Outcome	Association	Confounders addressed	Comments
India Ray et al. (2006)	Cross-sectional	165 non-smoking women who cooked regularly with biomass and 155 non-smoking controls who cooked with liquefied petroleum gas	Cooking with biomass v liquefied petroleum gas	Hypertension, CD11b and CD18 expression on circulating neutrophils and monocytes, P-selectin expression on platelets, count of activated platelet-neutrophil and platelet-monocyte aggregates	Hypertension in 6.0% biomass users v 3.2% liquefied petroleum gas users Activation of leucocytes and formation of leucocyte-platelet aggregates significantly more common in women using biomass, but differences reduced after adjustment for tobacco-chewing and exposure to environmental tobacco smoke	Age, smoking, tobacco-chewing, environmental tobacco smoke	Methods of statistical analysis not fully described
Guatemala McCracken et al (2007)	Controlled intervention with intervention subsequently offered to control group	120 women aged >38 who cooked daily and lived in households participating in a randomised controlled trial of an improved woodstove (49 intervention and 71 controls)	Use v non-use of improved stove – Intervention v control After v before intervention in controls who subsequently received it	Systolic and diastolic blood pressure (SBP and DBP)	Differences in blood pressure Intervention v control group SBP -3.7 (95%CI -8.1 to 0.6) mm Hg DBP -3.0 (95%CI -5.7 to -0.4) mm Hg Control group after v before SBP -3.1 (95%CI -5.3 to -0.8) mm Hg DBP -1.9 (95%CI -3.5 to -0.4) mm Hg	Age, body mass index, ambient temperature, rainy season, day of week, time of day, use of wood-heated sauna, having household electricity, an asset index, ever smoked, environmental tobacco smoke	Personal 24-h $PM_{2.5}$ exposures during trial period were 264 v 102 $\mu g/m^3$

Country and reference	Design	Study sample	Exposures compared	Outcome	Association	Confounders addressed	Comments
Turkey Davutoglu et al (2009)	Cross-sectional	40 non-smoking male indoor barbecue workers using charcoal and 48 non-smoking age-matched healthy controls	Barbecue work v control	Carotid intima media thickness (CIMT), high-sensitivity C-reactive protein (hs-CRP), blood pressure (BP), lipid profile	CIMT 1.19 v 0.91 mm (p<0.001) HsCRP 2.71 v 1.10 mg/L (p<0.001) Systolic BP 128.3 v 124.5 mm Hg (ns) Diastolic BP 81.2 v 77.3 mm Hg (ns) Total cholesterol 171.7 v 169.0 mg/dl (ns) Low density lipoprotein cholesterol 102.7 v 99.5 mg/dl (ns) High density lipoprotein cholesterol 40.6 v 40.0 mg/dl (ns) Triglyceride 150.6 v 164.9 mg/dl (ns)	Sex, age and BMI well matched	Mean carboxy-haemoglobin was higher in exposed group (6.4% v 2.0%)
Turkey Butarak et al (2010)	Cross-sectional	47 healthy, non-smoking subjects exposed to biomass smoke since birth and 32 healthy, non-smoking controls with no exposure to biomass	Lifelong exposure to biomass v no exposure	Carotid intima media thickness (CIMT), flow associated dilatation (FAD %) and endothelium independent vasodilatation (GTN %) assessed by ultrasound	CIMT 0.47 v 0.49 mm (p=0.138) FAD % 5.06 v 10.7 (p<0.001) GTN % 14.41 v 21.85 (p<0.001)	Smoking	No adjustment for age (on average, controls were 3.7 years younger than exposed) or other potential confounders such as body mass index
India	Cross-sectional	244 healthy, non-smoking women	Use of biomass v	Hypertension, expression of	Prevalence of hypertension 29.5% v 11.0% (p<0.05)	Smoking, age	Women using biomass were less

Country and reference	Design	Study sample	Exposures compared	Outcome	Association	Confounders addressed	Comments
Dutta et al (2011)		aged 22-41, using biomass for cooking and 236 healthy, non-smoking women aged 23-40, using liquefied petroleum gas for cooking	liquefied petroleum gas for cooking	platelet P-selectin, platelet aggregation to collagen, generation of reactive oxygen species (ROS) in leucocytes, serum oxidised low density lipoprotein (oxLDL), serum anticardiolipin antibody (aCL)	P-selectin 9.1% v 2.4% Platelet aggregation 36% increase ($p<0.001$) ROS significantly higher Mean oxLDL 166.6 v 46.5 U/l ($p<0.001$) Prevalence of elevated serum aCL 28.7% v 2.1% ($p<0.001$)		educated and had lower family income. 8-h mean $PM_{2.5}$ concentrations in cooking areas 156 v 52 $\mu g/m^3$ Statistical methods are poorly described
Nicaragua Clark et al (2011)	Cross-sectional	123 non-smoking women aged 11-80, who cooked using traditional biomass stoves	Increase by inter-quartile range in 48-hr indoor $PM_{2.5}$ (1212 $\mu g/m^3$), indoor CO (24 ppm) and personal CO (2 ppm)	Difference in systolic blood pressure, diastolic blood pressure and heart rate (assessed by pulse oximeter)	Systolic blood pressure Indoor measurements: $PM_{2.5}$ 0.45 (95%CI -2.61 to 3.52); CO 1.8 (95%CI -1.25 to 4.81); Personal CO 1.89 (95%CI -0.48 to 4.26) Diastolic blood pressure Indoor measurements: $PM_{2.5}$ -0.12 (95%CI -2.15 to 1.9); CO 0.06 (95%CI -1.95 to 2.07) Personal CO 0.5 (95%CI -1.12 to 2.13) Heart rate (beats/min) Indoor $PM_{2.5}$ 1.55 (95%CI -0.53 to 3.63) Indoor CO 0.57 (95%CI -1.50 to 2.65) Personal CO (1.97 (95%CI 0.22 to 3.72)	Smoking, age, body mass index, environmental tobacco smoke, and education	
China	Cross-sectional	280 non-smoking women aged ≥25	Levels of personal 24-	Systolic and diastolic blood	A 1-log-$\mu g/m^3$ increase in $PM_{2.5}$ exposures was associated with	Age, waist circumference,	

Country and reference	Design	Study sample	Exposures compared	Outcome	Association	Confounders addressed	Comments
Baumgartner et al (2011) Baumgartner et al (2014)		in rural households using biomass fuels (mainly wood or charcoal)	hr average exposure to $PM_{2.5}$, black carbon and water-soluble organic mass	pressure (SBP and DBP)	2.2 (95%CI 0.8 to 3.7) mm Hg higher SBP and 0.5 (95%CI -0.4 to 1.3) mm Hg higher DBP Among different measures of particulate air pollution, associations with SBP and DBP were strongest and most robust for black carbon.	physical activity, socio-economic status, salt intake, day of week, time of day and average ambient temperature	
India Firdaus et al (2011)	Cross-sectional	5949 households selected by partially random multi-stage sampling	Use of traditional fuels v non-use	Cardiovascular disease the most frequently occurring disease faced by at least one household member in last 3 months	Odds ratio 1.22 (95%CI 1.09-1.35)		Crude analysis with poorly specified health outcome and no control for potential confounders.
Guatemala, McCracken et al (2011)	Controlled intervention with intervention subsequently offered to control group	119 women aged >38 who cooked daily and lived in households participating in a randomised controlled trial of an improved woodstove (49 intervention and 70 controls)	Use v non-use of improved stove – Intervention v control After v before intervention in controls who subsequently receive it	Heart rate variability (HRV) and ST-segment depression (average below -1 mm)	Intervention v control group OR for ST segment depression 0.26 (95% CI 0.08-0.90) Control group after v before OR for ST segment depression 0.28 (95% CI 0.12-0.63) No significant differences in HRV in either comparison	Age (quadratic), BMI (quadratic), asset index, ever smoked, ETS, owning a wood-fired sauna, recent use of wood-fired sauna, time of day, season (wet/dry), weather condition and season interaction	Adjustment for potential confounders differed according to comparison Personal 24-h $PM_{2.5}$ exposures during trial period were 266 v 102 $\mu g/m^3$
India Dutta et al (2012)	Cross-sectional	635 healthy, non-smoking women aged 24-44, using biomass	Use of biomass v liquefied petroleum	Hypertension, tachycardia (>100 beats per minute), serum	Prevalence of hypertension 30.7% v 11.5% (p=0.0005) Prevalence of tachycardia 6.6% v 1.3% (p<0.001)	Smoking Groups well matched for age,	Women using biomass were less educated and had

Country and reference	Design	Study sample	Exposures compared	Outcome	Association	Confounders addressed	Comments
		for cooking and 452 healthy, non-smoking women aged 25-44, using liquefied petroleum gas for cooking	gas for cooking	C-reactive protein (CRP), TNF- α, IL-8, IL-6, generation of reactive oxygen species (ROS) in leucocytes, erythrocyte superoxide dismutase (SOD)	Prevalence of elevated serum CRP 91.2% v 12.4% TNF-α 29.4 v 18.1 pg/ml (p<0.0001) IL-8 29.6 v 12.2 pg/ml (p<0.0001) IL-6 5.6 v 1.6 pg/ml (p<0.0001) ROS generation significantly higher SOD significantly lower	body mass index, smokers in family	lower family income. 8-h mean $PM_{2.5}$ concentrations in cooking areas 158 v 51 μg/m^3 Statistical methods are poorly described Unclear whether there is overlap with Dutta at al. (2011)
Nicaragua Clark et al (2012)	Intervention with before and after comparison	98 women who cooked using biomass stoves	Provision of cleaner burning cookstove	Change in C-reactive protein measured in dried blood spot samples	Reduction of 25% (95%CI 2% to 49%) among obese women.		Reported only as abstract
Sri Lanka Sathiakumar (2012)	Case-control	50 women aged 40-70 years treated in hospital for acute coronary syndrome and 50 controls	Use of biomass fuel v liquefied petroleum gas	Acute coronary syndrome	OR 2.57 (95%CI 1.07-6.13)	Not specified	Reported only as an abstract. Biomass included kerosene
China	Cross-sectional	240 children aged 5-14 in	Levels of personal 24-	Systolic and diastolic blood	A 1-log-μg/m^3 increase in $PM_{2.5}$ exposures was associated with	Sex, age, height, body mass index,	

Country and reference	Design	Study sample	Exposures compared	Outcome	Association	Confounders addressed	Comments
Baumgartner et al (2012)		rural households cooking with biomass	hr average exposure to $PM_{2.5}$	pressure (SBP and DBP)	a -1.8 (95%CI -3.6 to 0.1) mm Hg difference in SBP and a -0.5 (95%CI -2.1 to 1.2) mm Hg difference in DBP	passive smoking, socioeconomic status, salt intake, monosodium glutamate use, physical activity, day of week and time of day of blood pressure measurement	
China Lee et al. (2012)	Cross-sectional	13,438 adults randomly selected from census data	Ever v never use of solid fuel (coal or biomass)	Self-report of doctor-diagnosed CHD, hypertension	CHD odds ratio = 2.58 (95% CI 1.53-4.32) Hypertension odds ratio 1.70 (95% CI 1.40-2.07)	Age, gender, educational level, smoking, environmental tobacco smoke, pack-years smoked, body mass index and waist circumference	Risk of hypertension increased with duration of solid fuel use, but CHD did not show a consistent exposure-response relationship
Iran Mitter et al (2012)	Cohort	50,045 men	Years used wood and other biomass for cooking and heating	Mortality from heart disease	Hazard ratio for death from heart disease for each additional year of use: Cooking: Wood 0.996 (95%CI 0.990-1.001); Other biomass 1.003 (95%CI 0.997-1.010) Heating: Wood 0.999 (95%CI 0.993-1.004); Other biomass 1.003 (95%CI 0.996-1.009)	Age, sex, rural living, socioeconomic status, body mass index, smoking, use of opiates, diabetes and hypertension.	Report available only as abstract.
Bangladesh	Cohort	22,337 adult residents of 11	Use of solid fuel for	Mortality from ischaemic heart	Incidence rate ratios for IHD 0.82 (95%CI 0.50-1.34) overall	Sex	It is unclear whether there was

Country and reference	Design	Study sample	Exposures compared	Outcome	Association	Confounders addressed	Comments
Alam et al (2012)		villages (20,757 using solid fuel and 1,580 using natural gas) followed for 10 years	cooking or heating v use of natural gas	disease (IHD) determined by verbal autopsy (i.e. through interview of next of kin)	0.90 (95%CI 0.50-1.63) in men 0.77 (95%CI 0.31-1.92) in women		any adjustment for age
India Banerjee et al (2012)	Cross-sectional	142 women aged 23-40 who had never smoked and had cooked exclusively with biomass for ≥5 years, and 126 age-matched, non-smoking controls who cooked with liquefied petroleum gas (LPG)	Use of biomass v LPG for cooking	Surface expression of CD35, CD16 and CD11b/CD18 on circulating neutrophils Plasma concentrations of tumour necrosis factor-alpha (TNF-α), interleulin-6 (IL-6), IL-8, IL-12, nitric oxide (NO) Myeloperoxidase activity in circulating neutrophils Erythrocyte level of superoxide dismutase (SOD)	Among users of biomass fuel: Expression of CD35, CD16, CD11b and CD18 was significantly higher ($p<0.0001$); Plasma TNF-α, IL-6, IL-8 and IL-12 were significantly higher; Serum NO was increased by twofold from 23.3±12.6 μM in controls to 47.3±16.2 μM in biomass users ($p<0.0001$) Myeloperoxidase activity in circulating neutrophils was higher; and erythrocyte SOD was lower.	age, body mass index, years of cooking, hours of cooking per day, environmental tobacco smoke, food habits and use of mosquito repellants	Education, family income and homes with separate kitchens were lower in biomass users. The published report is unclear in places, and the methods of statistical analysis are not adequately explained
Peru Painschab et al (2013)	Cross-sectional	266 adults aged ≥35 including 154 using	Chronic exposure to biomass	Carotid intima media thickness (CIMT) and	Increase in mean CIMT 0.03 (95%CI 0.01 to 0.06) mm	Age, sex, low density lipoprotein, high	

Country and reference	Design	Study sample	Exposures compared	Outcome	Association	Confounders addressed	Comments
		biomass fuel and 112 using clean fuel (based on rural or urban residence)	smoke v use of clean fuel	prevalence of carotid plaque (assessed by ultrasound), blood pressure (BP)	Increase in maximum CIMT 0.03 (95%CI 0.01 to 0.06) mm Increase in systolic BP 9.2 (95%CI 5.4 to 13.0) mm Hg Increase in diastolic BP 6.5 (95%CI 4.1 to 8.9) Odds ratio for carotid plaque 2.55 (95%CI 1.08-5.98)	density lipoprotein, body mass index, homeostasis model of assessment-insulin resistance, use of anti-hypertensive	
Pakistan Fatmi et al. (2014)	Case-control	73 non-smoking women admitted to hospital with acute coronary syndrome and 73 non-smoking controls admitted for other reasons	Current use of biomass v natural gas for cooking	Acute coronary syndrome	Odds ratio 4.8, (95% CI: 1.5-14.8)	Age, smoking, body mass index, educational status, type of kitchen, type of house, use of ghee and consumption of meat	Risk was lowest among women who had not used biomass fuel in past 15 years
Nepal Pratali and Cogo (2014)	Cross-sectional	82 men and women without established cardiovascular disease	Use v non-use of biomass fuels	Endothelial function in brachial artery evaluated by flow-mediated dilation (FMD)	FMD tended to be lower in people using biomass fuels		Reported only as abstract
China Kim et al. (2014)	Cohort study	73,363 women	Use of coal in home for >30 years v never use.	Mortality from cardiovascular disease (CVD) and myocardial infarction (MI)	Hazard ratios CVD: 1.32 (95% CI: 1.11-1.57) MI: 1.62 (95% CI: 1.01-2.63)	Smoking status, family income, environmental tobacco smoke, occupational history, shift work,	Reported only as abstract. Duration of follow-up not mentioned.

Country and reference	Design	Study sample	Exposures compared	Outcome	Association	Confounders addressed	Comments
						body mass index, hormone therapy, and parity.	
Peru Caravedo et al (2014)	Cross-sectional	519 adults aged ≥35	Long-term use of biomass (n= 275) v clean fuels (n=244) for cooking	Serum N-terminal pro-B-type natriuretic peptide (NT-pro-BNP) Pulmonary artery systolic pressure (PASP) in subset of 159	No significant difference in NT-pro-BNP or PASP	Sex, age, height, body mass index, systolic blood pressure, hypertension, cardiovascular disease, diabetes asthma and others	
Peru Burroughs Peña et al (2015)	Cross-sectional	1004 adults aged ≥35	Daily use of biomass for cooking or heating for >6 months at any time in life (n=509) v not so exposed (n=495)	Systolic and diastolic blood pressure (SBP and DBP)	SBP overall higher by 7.0 (95%CI 4.4 to 9.6) mm Hg Men: 8.7 (5.4-12.1) mmHg Women: 5.4 (1.4-9.4) mmHg DBP overall higher by 5.9 (95%CI 4.2 to 7.6) mm Hg Men: 6.0 (3.6 – 8.3) Women: 5.6 (3.1 – 8.1)	Sex, age, body mass index, height, wealth, education years, depressive symptoms, smoking (pack-years), alcohol abuse, low physical activity	
Bolivia Alexander et al (2015)	Intervention with before and after comparison	28 non-smoking women from a rural community	Use v non-use of improved cookstove	Systolic and diastolic blood pressure (SDP and DBP)	Following intervention SBP fell by 5.5 mm Hg (p=0.01) and DBP by 1.1 mm Hg (p=0.5) (stratified data showed significant decrease only for >50 years' age women).		

Country and reference	Design	Study sample	Exposures compared	Outcome	Association	Confounders addressed	Comments
					In random subset of 13 women, reductions in SBP and DBP correlated with reductions in concentrations of particulate matter during cooking (p=0.01 for both)		
Nepal Neupane et al (2015)	Cross-sectional	519 women aged 30-83 in rural location	Cooked for ≥10 years primarily with biomass (n=300) v biogas (n=219)	Systolic and diastolic blood pressure (SBP and DBP)	Differences in blood pressure (mm Hg) at age 30-50: SBP -4.38 (95%CI -7.90 to -0.86) DBP -1.49 (95%CI -3.93 to 0.95) Differences in blood pressure (mm Hg) at age >50: SBP 9.84 (95%CI -0.76 to 20.43) DBP 6.49 (95%CI 0.82 to 12.15)	Sex, age, body mass index, socio-economic status, smoking, kitchen characteristics, ventilation, additional fuel use	

Heart disease

Two case-control studies assessed the association of hospital treatment for acute coronary syndrome with use of biomass fuel as compared with natural or liquefied petroleum gas (Sathiakumar N, 2012; Fatmi Z, 2014). Although they were relatively small, both found significantly elevated odds ratios (2.57 and 4.8). However, one was reported only as an abstract, and apart from age, it is unclear exactly which potential confounders were taken into account (Sathiakumar N, 2012). Furthermore, it grouped kerosene with biomass fuels, which may have biased risk estimates towards the null.

In Iran, Mitter et al. (Mitter SS, 2012) examined hazard ratios (HRs) for death from heart disease in a cohort of more than 50,000 men and women, according to years of using wood or other biomass fuel for cooking and heating. Positive associations were found with use of biomass other than wood, but they were weak and not statistically significant (HRs of 1.003 for each additional year of use). Again, the study was reported only as an abstract, making it difficult to be confident about the validity of the methods. Adjustment for hypertension could have caused the effects of biomass to be underestimated if effects on blood pressure lay on a causal pathway to heart disease.

In a cohort study of 73,363 women in China, use of coal in the home for >30 years carried a hazard ratio of 1.62 (95% CI: 1.01-2.63) for death from myocardial infarction in comparison with never use (Kim C, 2014). However, the investigation was reported only as an abstract, and the duration of follow-up was not described.

Alam et al. (Alam DS, 2012) ascertained deaths from ischaemic heart disease (IHD) by verbal autopsy during follow-up over 10 years of a cohort comprising 20,757 rural residents from Bangladesh who used solid fuel for cooking or heating and 1,589 who used natural gas. Incidence rate ratios for use of solid fuel were below one, but the reduction in risk was not statistically significant. It is unclear whether and how potential confounders were taken into account.

Lee and colleagues (Lee M-S, 2012) asked about use of solid fuel and history of doctor-diagnosed CHD, as part of a cross-sectional survey of 13,438 adults in China. They found a positive association (OR 2.58, 95%CI 1.53-4.32), but there was no consistent trend in risk with longer duration of using solid fuel. Moreover, the use of self-report to collect information about both exposure and disease may have led to bias (either inflationary because of differential reporting, or towards the null if there were non-differential errors in recall).

Another cross-sectional study, collected information from 5,949 households in India (Firdaus G, 2011). It found a significant association between use of traditional fuels and cardiovascular disease being "the most frequently occurring disease that was reported by at least one household member in the last three months" (OR 1.39, 95%CI 1.24-1.55). However, the health outcome and exact method of statistical analysis were poorly specified. It is unclear whether the adjustment for age took into account the ages of all household members, or just that of the individual who responded on behalf of the household, and whether and how allowance was made for differing sizes of households.

Complementing these findings from observational studies, McCracken et al (McCracken J, 2011). reported a significantly lower prevalence of ST segment depression in electrocardiograms with use of an improved stove in an intervention study.

Heart rate

Three studies considered heart rate or its variability as an outcome. In a cross-sectional survey of 123 non-smoking women in Nicaragua, who were using traditional biomass stoves, heart rate was significantly higher among those with higher personal exposures to CO, and non-significantly elevated with higher indoor concentrations of $PM_{2.5}$ (Clark ML, 2011). In India, Dutta et al. (Dutta A, 2012) found a significantly higher prevalence of tachycardia (>100 beats per minute) in non-smoking women using biomass as compared with liquefied petroleum gas for cooking (6.6% vs. 1.3%). On the other hand, McCracken and colleagues (McCracken J, 2011) found no significant differences in heart rate variability with use of an improved stove in an intervention study in Guatemala.

Vascular pathology

Four cross-sectional studies have related indoor air pollution from biomass fuels to abnormalities of vascular structure or function. Two showed significant associations with higher carotid intima media thickness (CIMT), (Davutoglu V, 2009; Painschab MS, 2013) and one also with the prevalence of carotid plaque ascertained by ultrasound (OR 2.55, 95%CI 1.08-5.98) (Painschab MS, 2013). Against this, a third study found no association with CIMT, although exposure was significantly related to reduced flow-associated dilatation and lower endothelium-independent vasodilatation of the brachial artery (Buturak, 2011). In the fourth study, reported only as an abstract, flow-mediated dilatation of the brachial artery again tended to be lower in people using biomass fuels, especially if there was no chimney in the kitchen (Pratali, 2014). However, only nine of the total of 81 subjects were in the control group used for comparison.

Oxidative stress and inflammatory markers

Increased oxidative stress and inflammatory responses play an important role in the initiation and progression of CHD (Toshima S, 2000; Libby P, 2002). Cross-sectional studies have also indicated that use of biomass fuel is associated with: increased generation of reactive oxygen species by leucocytes (Dutta A, 2011; 2012); reduction in erythrocyte superoxide dismutase (Dutta A, 2012; Banerjee, 2012); elevations in serum levels of interleukin-6 (Dutta A, 2012; Banerjee, 2012), interleukin-8 (Dutta A, 2012; Banerjee, 2012) and tumour necrosis factor-alpha (Dutta A, 2012; Banerjee, 2012); increases in platelet aggregation and expression of P-selectin by platelets (Dutta A, 2011); and higher serum concentrations of C-reactive protein (CRP) (Davutoglu V, 2009; Dutta A, 2012). The last finding is supported by an intervention study in Nicaragua, in which change to a cleaner burning stove for cooking was associated with a significant reduction in CRP among obese women (Clark ML, 2012).

Blood pressure

Blood pressure has been the most frequently studied cardiovascular outcome in research on IAP from solid fuels. Eight cross-sectional studies have found significant positive associations with higher blood pressure (Baumgartner J, 2011; Painschab MS, 2013; Burroughs Peña M, 2015; Neupane M, 2015) or prevalence of hypertension (Ray MR, 2006; Dutta A, 2011; Dutta A, 2012; Lee M-S, 2012) (it is unclear whether there was overlap between the study samples for two of the reports (Dutta A, 2011; Dutta A, 2012). Another found higher systolic and diastolic blood pressures in non-smoking indoor barbecue workers as compared with controls, although the differences (about 4mm Hg) were not significant (Davutoglu V, 2009). Furthermore, there was a significant reduction in blood pressure with use of improved stoves in two intervention studies, one in Guatemala (McCracken J, 2007) and the other in Bolivia (Alexander D, 2015). Against this, two cross-sectional surveys (Clark ML, 2011; Baumgartner J, 2012) (one in children (Baumgartner J, 2012)) have failed to demonstrate significant associations with blood pressure.

Lipid profile

The only study that examined lipid profiles found no significant associations with use of biomass fuel (Davutoglu V, 2009).

4.3 Discussion

This review indicates that the epidemiological literature on the relationship between IAP from solid fuel and CHD is limited but growing. Moreover, the research that has been conducted, although not yet conclusive, points to an effect that could be of major

public health importance, given the continuing widespread use of biomass fuel in developing countries for cooking and heating, and their increasing incidence of CHD.

Most studies classified exposure according to whether solid (or biomass) fuel was used, or the time for which it had been used. However, others assessed risks in relation to measured exposures to specific pollutants, or following the introduction of stoves designed to reduce IAP. The merits of these alternative approaches will depend on the mechanisms (if any) by which IAP causes the outcomes under investigation. Among users of biomass fuels, there may be wide variations in personal exposures to pollutants, depending on, for example, the time for which a fire or stove is burning, the time spent cooking and in the room where a fire is burning, and the design of the stove and house. Such distinctions will be lost when exposure is classified simply according to use of biomass fuel, such that risk estimates represent only a crude average. On the other hand, direct measurements of personal exposures to, or environmental concentrations of, pollutants may be misleading if levels vary over time and risk depends on longer term cumulative exposures. For the same reason, studies investigating short-term changes following the introduction of improved stoves will only detect impacts on outcome measures that are driven importantly by recent exposures.

I found only five studies that examined associations with CHD specifically. Two were relatively small case-control studies (Sathiakumar N, 2012; Fatmi Z, 2014), one of which was reported only as an abstract (Sathiakumar N, 2012). However, both found significant associations between use of biomass fuels and acute coronary syndrome in women, with adjusted odds ratios of 2.57 and 4.8. Another was a large cross-sectional survey in China, which relied on self-report of a doctor's diagnosis of CHD as its measure of outcome, and as a consequence may have been subject to inflationary bias (Lee M-S, 2012). Nevertheless, it too indicated a positive association, with an odds ratio of 2.58. This was supported by the findings from a cohort study of mortality from myocardial infarction in China, which found a hazard ratio of 1.62 for prolonged use of coal as a fuel, but was reported only as an abstract (Kim C, 2014). Against this, a cohort study in Bangladesh found no significant association between use of solid fuel for cooking or heating and mortality from ischaemic heart disease. However, cause of death was assessed by verbal autopsy, which although validated, is unlikely to have been completely accurate (Alam DS, 2012).

A large cohort study in Iran found no significant associations between years of using biomass fuels for cooking or heating and death from heart disease more generally (Mitter SS, 2012). As CHD accounts for a large proportion of deaths from heart

disease, the broader case definition would not be expected to dilute risks substantially. However, from the limited abstract that was published, it is unclear how durations of exposure to different categories of fuel were related, and what proportion of the exposed subjects were still using biomass fuels at the time of recruitment to the study. It may be that recent exposures are a more important determinant of risk than those that occurred many years in the past.

Evidence for short-term effects on risk comes from the intervention study by McCracken and colleagues (McCracken J, 2011), which found differences in the prevalence of ST depression on the electrocardiogram at a relatively short interval after improved stoves were introduced.

A further investigation was also reported as indicating an association between use of traditional fuels and cardiovascular disease (Firdaus G, 2011), but the outcome measure was poorly specified, and the method of analysis inadequately described, making it difficult to draw any useful conclusions.

If IAP from combustion of solid fuel does cause CHD, then one mechanism could be through the stimulation of inflammatory processes that promote atherogenesis or susceptibility to thrombosis. In addition to the studies that have assessed risk of CHD or heart disease more generally, others have explored associations with inflammatory biomarkers, indicators of atherosclerosis or its early development (e.g. CIMT, flow-mediated dilatation), and measures of platelet aggregation. For the most part, these too have given positive results, and while there is a possibility of publication bias, such that positive results are preferentially reported, the balance of published evidence supports the generation of inflammation as a plausible mechanism for a hazard of CHD.

There is also a notable consistency of evidence for an association of IAP from biomass fuels with higher blood pressure, which is a well-established risk factor for CHD. Ten studies have found significant positive associations (Ray MR, 2006; McCracken J, 2007; Dutta A, 2011; Baumgartner J, 2011; Dutta A, 2012; Lee M-S, 2012; Painschab MS, 2013; Burroughs Peña M, 2015; Alexander D, 2015; Neupane M, 2015), and another indicated a relationship, which although not significant, was of comparable magnitude (Davutoglu V, 2009). Only two studies have failed to find associations with blood pressure (Clark ML, 2011; Baumgartner J, 2011), and one of them was in children (Baumgartner J, 2012).

4.4 Unanswered questions

The current balance of epidemiological evidence points to an increased risk of CHD from IAP as a consequence of using solid, and especially biomass, fuels for cooking and heating. Relative risks from long-term exposure could be two- to fourfold. However, the evidence base is still limited, and although such an association is consistent with the known hazards from smoking, environmental tobacco smoke and ambient air pollution, and supported by evidence of effects on inflammatory processes, atherosclerosis and blood pressure, it requires confirmation by larger and more robust studies. The need for such research is particularly pressing because the incidence of CHD in developing countries is rising, and IAP may interact synergistically with the risk factors that are driving that increase. Furthermore, relatively cheap methods are available to reduce IAP from use of solid fuels, and there are indications from intervention studies that these may impact beneficially on CHD as well as other diseases caused by such pollution.

To generate further information on the relationship of IAP to CHD, I therefore undertook three new studies, focusing on the use of biomass fuel among women in Pakistan:

1. A study comparing the concentrations of $PM_{2.5}$ and CO in kitchens using biomass and natural gas for cooking, and exploring other possible determinants of the levels of these pollutants (Chapter 5).
2. A cross-sectional survey of cardiovascular morbidity and its relation to use of biomass fuels and other risk factors among middle aged and older women (Chapter 6).
3. A case-control study of acute coronary syndrome (ACS) in relation to use of biomass fuels and other risk factors (Chapter 7).

The objectives, methods and results of these studies are described in the chapters that follow.

Chapter 5: Levels and determinants of pollution by fine particulate matter ($PM_{2.5}$) and carbon monoxide (CO) in kitchens

The study of pollution levels was conducted in a sub-sample of the households that took part in the cross-sectional survey of cardiovascular morbidity (see Chapter 6). The purpose of the study was to determine to what extent potential exposures to $PM_{2.5}$ and CO differed between women using different types of fuel for cooking, and whether other factors importantly influenced levels of these pollutants.

5.1 Methods

The method of recruiting households to the survey of cardiovascular morbidity is described in Chapter 6. I intended to make measurements of $PM_{2.5}$ and CO in random subsets of 40 kitchens where women used biomass fuel for cooking and 40 where natural gas was used. However, due to technical problems with equipment and time constraints, I was only able to study 37 households (18 biomass and 19 natural gas) for $PM_{2.5}$ and 39 households for CO (20 biomass and 19 natural gas).

5.1.1 Methods of measurement

With agreement from the head of the household, fixed site monitors for CO and $PM_{2.5}$ were co-located and placed at a height of approximately one metre (equivalent to the breathing zone of a seated person), a metre from the stove (main fire) used for cooking. The monitors were attached to a wall or suspended from the ceiling, or where that was not possible, placed on a chair or stool. Care was taken not to place them downwind or upwind from the fire/stove.

$PM_{2.5}$ was measured using a MicroPEM version 3.2, an exposure-monitoring device developed by RTI (Research Triangle Institute) International. It is lightweight (240 grams), portable, and powered by AC mains electricity, but can also operate for 24 hours on three AA batteries. It measured using a light-scattering laser photometer that gave real-time aerosol mass readings. 48-hr continuous monitoring was carried out with logging of data at ten second intervals. Batteries were replaced every 24 hours, where needed (see Figure 5-1).

Static monitoring of CO was carried out using a Q-RAE (version II) monitor over the same 48 hours. The Q-RAE was a small battery-operated device, which weighed about 500 gm and used an active pump. The CO was monitored continuously with an electrochemical sensor, and data were logged at thirty-second intervals (see Figure 5).

Figure 5. Pollution monitoring devices (MicroPEM and QRAE).

Field workers were trained in the use of the sampling equipment, and a detailed manual with pictorial aids was developed to assist them. The Micropem and Q-RAE monitors were placed in the kitchens in the morning around 10 am. Data were downloaded directly from the two monitors into csv format Excel sheets and text files on a computer.

Determinants of exposure

Information was noted by the fieldworkers regarding potential determinants of the two pollutants ($PM_{2.5}$ and CO), including fuel type (biomass, natural gas), stove type (three-stone open traditional stove, improved stove, gas stove), and type of kitchen (open, semi-open or closed according to level of ventilation). In addition, information about smoking in the household was obtained through a questionnaire completed by the woman who cooked in the house (with help from the field worker).

Analysis

All measurements were collated in two datasets, one for $PM_{2.5}$ and one for CO. After exclusion of those with missing or clearly erroneous values, and correction to zero of those with small negative values (thought to result from minor errors in calibration), arithmetic mean values were derived for each unique combination of fuel, household, day, hour and minute across each of the two datasets. From the minute by minute values, hourly arithmetic mean concentrations were then calculated, together with a count of the number of minutes on which each hourly mean was based. In order to

ensure that the hourly means were robust, only those based on 45 minutes or more were retained.

Next, for each household, average concentrations were calculated for each of the 24 hours of the day (taking an average from the two days for which measurements had been made if the data were available). Average daily concentrations were then calculated as the means of these 24 hourly concentrations for households with data on a sufficient number of hours. For two households in which data on $PM_{2.5}$ were missing for only one and two hours respectively, the missing values were interpolated using the average value for the relevant time of day in other households with the same type of fuel, and the ratio of average measured concentrations across the other hours of the day to that for all other households using the same fuel. Similar imputation was applied for three households with missing data on CO for one or two hours.

Descriptive statistics were derived for the distributions of hourly mean concentrations in households using biomass and natural gas, and for each type of fuel the average hourly concentration across households was plotted against time of day.

The relationship between daily average concentrations of $PM_{2.5}$ and CO by household was examined in a scatter plot, and summarized by Spearman rank correlation coefficients.

Finally, determinants of daily average fixed site concentrations of $PM_{2.5}$ and CO were explored by linear regression analysis.

Ethical considerations

Written informed consent for the installation of fixed site monitoring devices was obtained from the head of each household. The results were shared with the participants, and if they wished, they were advised about possible modifications that might reduce exposures to pollutants at no or minimal cost.

5.2 Results

The total number of measurements for $PM_{2.5}$ across all households was 744,192 and that for CO 196,618. However, 78,055 measurements of $PM_{2.5}$ were excluded because of errors in recording by the machine (values either missing or <-10μg/m^3). For the remaining records (n=666,137), those values which were considered to be running measurement errors (i.e. values from -10 to -1μg/m^3) were converted to zero (n=127,275). No measurements were discarded for CO.

Averages were derived for 1,826 distinct combinations of day, hour and minute for $PM_{2.5}$, and 1,686 for CO. From these, hourly average values were obtained for 859

hours for $PM_{2.5}$ and 866 hours for CO. However, 19 hourly means for $PM_{2.5}$ and 55 for CO were discarded because measurements were available for <45 minutes in the hour.

Daily average $PM_{2.5}$ concentrations could not be calculated for two households (one with mean concentrations for only 10 hours and the other for 12 hours). Daily averages for CO were missing for five households which had hourly means for 17 hours or fewer.

Final analysis was therefore based on 35 households for $PM_{2.5}$ (16 using biomass and 19 using natural gas) and 34 households for CO (17 each using biomass and natural gas). 31 households had data on both pollutants.

Hourly mean concentrations of $PM_{2.5}$ and CO in houses using biomass were substantially higher than in those using natural gas (Table 5-1).

Table 5-1.Distribution of hourly mean concentrations of $PM_{2.5}$ and CO in kitchens of households using biomass and natural gas for cooking.

	$PM_{2.5}$(μg/m³)		CO (ppm)	
	Biomass user	**Natural gas user**	**Biomass user**	**Natural gas user**
Mean	531	69.9	6.1	3.4
Minimum	4.2	4.2	0	0
Maximum	4930	2580	92.0	35.5
Median	136	24.2	0.8	0.6
25th percentile	34	13.5	0	0
75 percentile	615	53.3	6.4	4.9
90th percentile	1650	147	16.0	11.2

In kitchens where biomass was used, the average hourly mean $PM_{2.5}$ concentrations was 531 μg/m³ with a median of 136μg/m³. The corresponding values for kitchens where natural gas was used were much lower at 69.9 and 24.2 μg/m³. For CO, the average hourly mean concentration in kitchens using biomass was almost twice that in those using natural gas (6.1 vs. 3.4 ppm). However, differences in median concentration were smaller (0.8 vs. 0.6 ppm).

Hourly mean concentrations by time of the day, averaged separately across households using biomass and natural gas, are presented in Figure 6 for $PM_{2.5}$ and Figure 7 for CO. Generally, most households using biomass seemed to cook twice during the day. Most of the cooking was done late in the evening when the concentrations of pollutants were highest and remained high for the longest duration. The mean $PM_{2.5}$ concentrations in kitchens using natural gas were less than 172 µg/m^3 throughout the day. However, they did have periods when mean CO concentrations were increased. These peaks occurred at similar times to those in households using biomass, but tended to be lower.

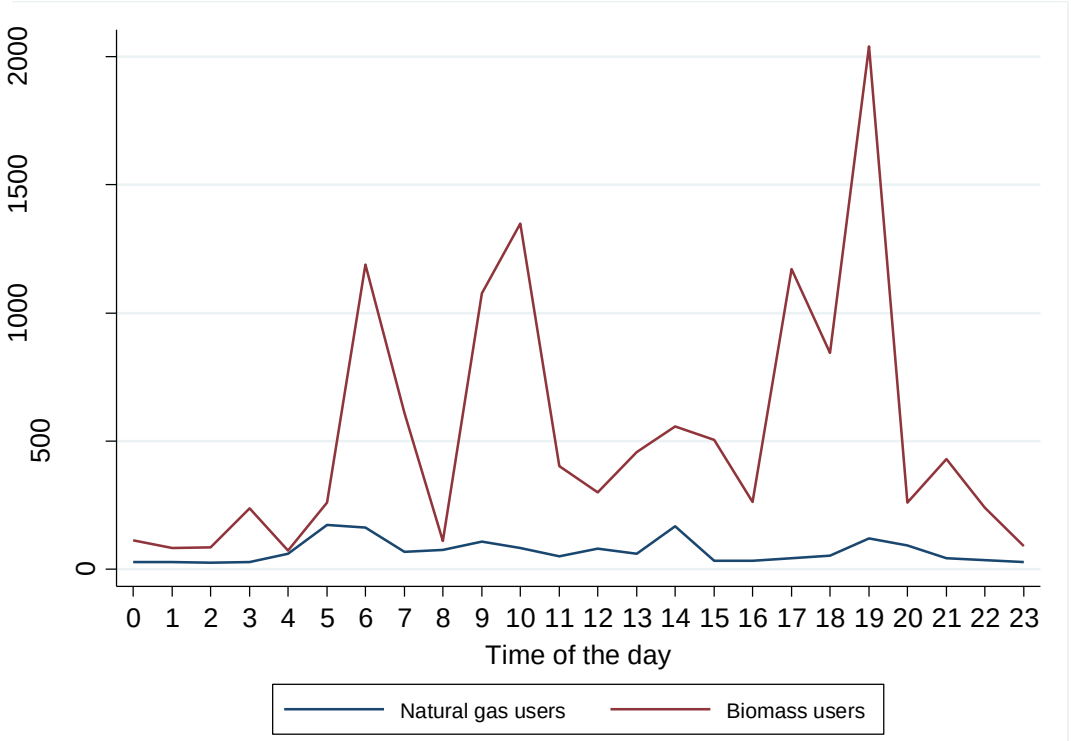


Figure 6. Hourly mean $PM_{2.5}$ (µg/m3) concentrations across all households by type of fuel used.

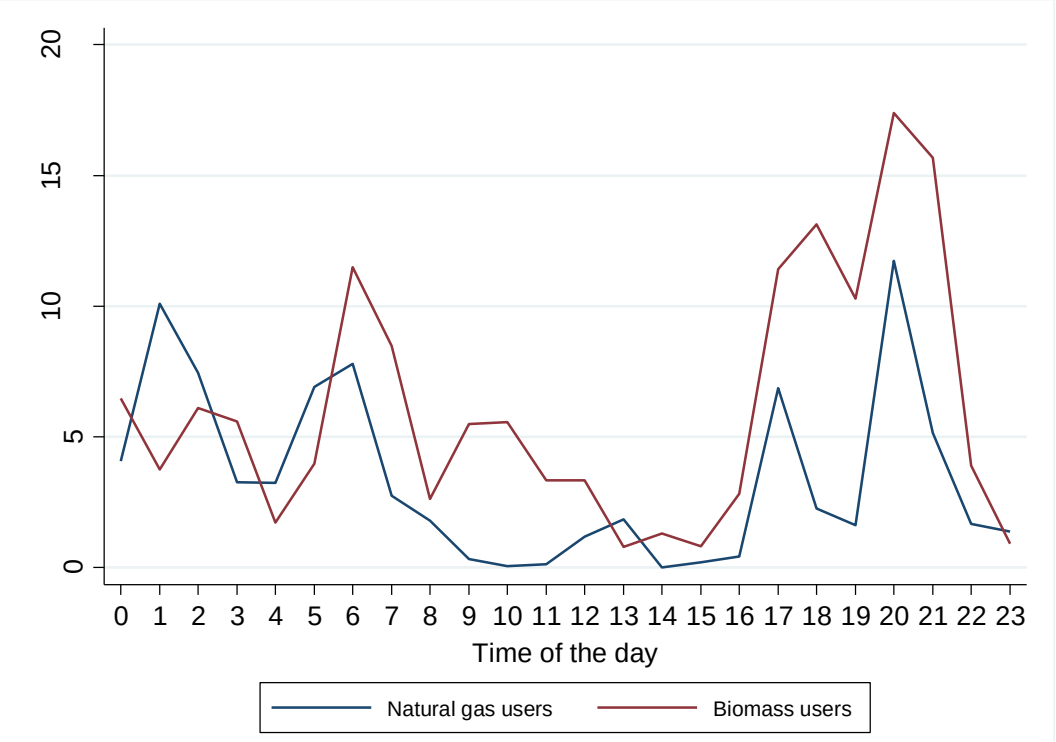


Figure 7. Hourly mean CO (ppm) concentration across all households by type of fuel used.

Daily mean concentrations of $PM_{2.5}$ ranged from 59 to 875 µg/m³ in households using biomass and from 25 to 172 µg/m³ in households cooking with natural gas. For CO, the corresponding ranges were 1.1 to 17.3 ppm for biomass-using households and 2.1 to 5.8 ppm for natural gas.

Figure 8 plots daily mean concentrations for CO against those for $PM_{2.5}$ across the 31 households with data on both pollutants. The $PM_{2.5}$ and CO concentrations were not correlated with each other in either biomass- (rho= -0.17, p=0.6) or natural gas-using households (rho=0.03, p=0.9).

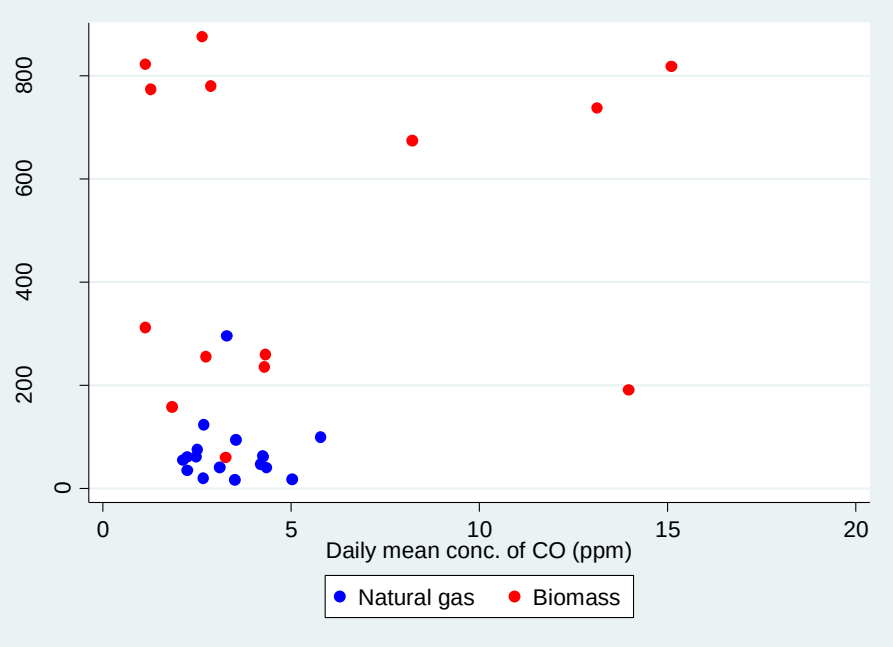


Figure 8. Scatterplot of daily mean concentrations of PM2.5 and CO in households using biomass and natural gas for cooking.

Determinants of PM2.5 and CO concentrations

Table 5-2 presents result from multivariate linear regression analyses relating 24-hour average concentrations of $PM_{2.5}$ and CO to type of fuel and stove (natural gas stove vs. biomass used with chimney stove vs. biomass used with traditional stove), ventilation of kitchen (closed/semi-open vs. open) and smoker(s) in household (environmental tobacco smoke). Effect estimates for the above factors were mutually adjusted in each of two models, one for $PM_{2.5}$ and one for CO.

In comparison with households using natural gas for cooking, $PM_{2.5}$ concentrations were significantly higher in those that used biomass, with either a chimney stove (mean difference 611.2, 95%CI: 359.2, 863.2 μg/m^3) or traditional three-stone stove (mean difference 389.4, 95% CI: 230.5, 548.4 μg/m^3). Open kitchens tended to have lower $PM_{2.5}$ concentrations than closed/semi-open kitchens (mean difference -88.3, 95%CI: -325.0, 148.4 μg/m^3), and smoking in the house was associated with higher $PM_{2.5}$ levels, although not significantly (mean difference 84.5, 95%CI: -65.4, 234.5 μg/m^3).

For CO, concentrations were significantly increased with use of biomass in a traditional stove (mean difference from natural gas 3.7, 95%CI, 0.8, 6.7 ppm), but not with use of biomass in a chimney stove (mean difference -0.8, 95%CI, -4.8, 3.1 ppm). Smoking in the house was associated with higher CO, although not to the point of statistical

significance. There was no major difference in concentration of CO according to whether kitchens were open or closed.

Table 5-2. Mutually adjusted multivariate linear regression coefficients for factors that might influence $PM_{2.5}$ and CO concentrations in kitchens.

	Mean difference in $PM_{2.5}$ with 95% CIs ($\mu g/m^3$)	Mean difference in CO with 95% CIs (ppm)
Natural gas stove	Reference	Reference
Biomass user with chimney stove	611 (359, 863)	-0.8 (-4.8, 3.2)
Biomass user with traditional stove	389 (231, 548)	3.7 (0.8, 6.7)
Closed/semi-open kitchen	Reference	Reference
Open kitchen	-88.3 (-325, 148)	0.6 (-3.1, 4.4)
Environmental tobacco smoke (ETS)		
No	Reference	Reference
Yes	84.5 (-65.4, 235)	2.1 (-0.7, 5.0)

5.3 Discussion

The results of the study indicate that in kitchens using biomass for cooking on a traditional three-stone stove, average airborne concentrations of CO, and especially $PM_{2.5}$ were significantly higher than in those using natural gas for a prolonged period of the day.

Use of biomass fuel had the main influence in determining the concentrations in kitchens. It was observed that even where biomass was used with a chimney stove, levels of $PM_{2.5}$ were clearly elevated and similar to those associated with traditional three-stone stoves, whereas CO concentrations were close to levels in houses using natural gas. This suggests that stoves with a chimney tend to reduce CO but have little influence on $PM_{2.5}$. Other studies have found that when well-designed standardized chimney stoves were introduced (in intervention trials), they reduced both PM and CO (Smith KR, 2010; McCracken J, 2011). However, another investigation found that when measurements were made in kitchens with home-made chimneys, neither PM nor CO

were reduced (Pollard SL, 2014). These apparent inconsistencies are probably due to different forms of chimneys and levels of ventilation in the kitchens studied. Therefore, research is needed to identify the designs of chimney and ventilation of kitchens that will be most effective.

Smoking in the household tended to be associated with higher concentrations of $PM_{2.5}$ and CO, but any effects on $PM_{2.5}$ and CO appeared to be much smaller than those of using biomass for cooking. It was expected that the levels of pollution produced by the burning of biomass fuel would be high compared with those from ETS since few women in the study area were active smokers and any contribution would be mainly from smoking by men, who culturally did not spend much time in kitchens. The added contribution from ETS may have been higher in living areas, where measurements were not made.

Furthermore, no clear reduction in pollutant levels was apparent in open as compared with more closed kitchens. The kitchens in rural areas vary in size, type, construction material and ventilation levels. I believe it is difficult to draw a clear distinction between open and closed kitchens, and that classification should be more graded, However, assessment would then require a larger sample of households. In an earlier study in Pakistan, kitchens with a thatched roof, which tended to be more open, had higher concentrations of pollutants, and that was suggested to be due to poor characterization of kitchens (Siddiqui AR, 2008).

Mainly because of technical problems with equipment, the number of households studied was fewer than planned, which limited the power to compare different types of kitchen, as described above. However, even with the reduced sample size, the large differences between fuel types were clearly apparent.

Although households were randomly selected for air monitoring from those participating in the survey of cardiovascular morbidity, the latter were recruited effectively by quota sampling (see Chapter 6). Nevertheless, there is no obvious reason why the study sample should have been systematically unrepresentative with regard to the study questions considered in this chapter.

The MicroPEM measures fine particles at concentrations ranging from 1 mg/m^3 to 10,000 mg/m^3. Its reported accuracy and precision were greater than 90% when it was validated against a standard gravimetric method considered as the gold standard (RTI, 2017).

The QRAE measures CO with electrochemical sensors at concentrations in the range of 0-1000ppm with smallest measurement at 1ppm. The lowest detectable exposure was

83% of that for methane, taken as standard for combustible gases (RAE systems, 2017).

Some measurements were missing because of equipment failure and temporary problems with electrical supply. However, the analyses were based only on households with sufficient measurements to characterize exposure levels reliably.

The study team visited the households and installed the equipment in the kitchens and directly observed the type of fuel, type of stove and type of kitchen. Therefore, the classification of these variables should have been accurate. Smoking in the household was reported by the woman who cooked in the house, and should also have been reported fairly accurately.

The average levels of $PM_{2.5}$ in houses using biomass were 50-70 fold higher than standards for ambient air in western countries. These levels were consistent with other studies conducted to measure $PM_{2.5}$ in kitchens of biomass users (Clark ML, 2013). The high concentrations in kitchens indicate a potential for high exposure among the women who cooked there, as they would spend at least 2-3 hours there per day, often at times when levels were more than 1000 $\mu g/m^3$. The concentrations were highest for the longest duration during the evening hours when most of the household members, including the women, would be at home.

Levels of CO were also higher in kitchens using biomass, but unlike $PM_{2.5}$ were lower when a chimney stove was used. This may be because CO readily diffuses in the air while PM is more static and remains in the kitchen for longer. The difference may have contributed to the lack of correlation between 24-hour average concentrations of $PM_{2.5}$ and CO in kitchens. Also, there were indications that cooking with gas produced CO but not $PM_{2.5}$. Thus, the levels of both pollutants varied immensely by the time of the day in houses using biomass fuel, with two peaks, which most likely corresponded with the main times of cooking. For CO, peaks in concentrations seemed to occur at the same times of the day in the kitchens using natural gas. Previous studies support the conclusion that appreciable quantities of CO are generated when natural gas is used for cooking (Mullen NA, 2016; Siddiqui AR, 2008).

Conclusion

The study found high average concentrations of CO and particularly $PM_{2.5}$ in the kitchens of biomass-users which was consistent with other studies. Ventilated kitchens tended to have somewhat lower levels of the pollutants, and houses with smokers somewhat higher concentrations. However, stove chimneys as used in the kitchens studied had no discernible impact on levels of $PM_{2.5}$. It follows that when considering possible impacts on health, the type of fuel used should on its own provide a good

index of potential for high personal exposures, with type of stove, type of kitchen and smoking in the household less influential.

The next chapter describes my cross-sectional study of the association of IAP with cardiovascular morbidity, which was carried out in women from a larger number of households, of which those included in the pollution monitoring study were a subset.

Chapter 6: Cross-sectional Survey of CHD and Use of Biomass Fuel

My cross-sectional survey of CHD and use of biomass fuel was carried out in Nawabshah district (recently renamed as Shaheed Benazirabad) in the province of Sindh, Pakistan. In this survey, I aimed to explore the association between cooking with biomass and CHD in a sample of women drawn from the general population. With this objective, I targeted women aged ≥40 years, who were actively involved in cooking using either biomass or cleaner fuels (natural gas). This cut-off in age was applied to ensure that participants would have sufficiently long exposure to cooking and a high enough prevalence of CHD. I focused on four health outcomes: three measures of CHD – angina (using WHO's Rose angina questionnaire), previous history of heart attack and definite or probable changes of CHD on electrocardiogram (ECG) – and also hypertension, which is an established risk factor for CHD and could lie on the causal pathway through which it is related to indoor air pollution.

Therefore, the objectives of the study were to compare the prevalence of high blood pressure, angina, previous history of heart attack, and electrocardiographic (ECG) changes indicative of CHD in women ≥40 years of age who used biomass fuel for cooking and in women of similar age who used natural gas for cooking.

6.1 Methods

Study Setting

The survey was conducted in villages surrounding the main urban area of Nawabshah district in the province of Sindh, Pakistan. These were selected to achieve a mix in the use of biomass fuel and natural gas for cooking within the study sample.

Selection of households and subjects

Households that might be suitable for study were identified by door to door visits in the villages, and trained field workers approached the head of the household to ask whether his family would be willing to assist with the study. Those who agreed were asked whether cooking was regularly undertaken by a woman ≥40 years of age, and if so, whether biomass fuel or natural gas had been used for cooking consistently over at least the past ten years. In this way, the study team identified quotas of the required numbers of households in each of the two categories of fuel use. The head of each eligible household was asked to complete a consent form, and to identify and introduce the woman of the household aged ≥40 years who had carried out the most

cooking in the house over the past 10 years. The study was explained to her, and she was invited to participate and to give signed consent.

A total of 24 villages were visited in order to recruit the required number of households for the survey. In 14 villages only biomass was used for cooking, while in three, all households used natural gas. In the other seven, both types of fuel were used. The number of households per village ranged from as few as three to as many as 210. Interviews were completed with women from a total of 1073 households, 536 of which used biomass fuel and 537 natural gas. No one refused to participate in the study, but 77 women could not be interviewed because they were not at home at the time when the survey team visited (mostly because they were engaged in agricultural work).

Inclusion criteria

Women of 40 years or older were eligible for inclusion if they were able to give consent, and had been cooking in the household for at least one year using only one of biomass fuel or natural gas.

Exclusion criteria

Women were excluded if they had poor mobility, were mentally incompetent and unable to give consent, or were known to have advanced kidney or liver disease.

Questionnaire, examination and measurements

A standardized questionnaire (appendix A) was used to collect information regarding: socio-economic and demographic characteristics, birth weight, smoking history, whether another member of the household was a regular smoker, relevant aspects of diet, physical activity, lifetime history of cooking using different types of fuel, any previous diagnosis of a "heart attack" by a doctor, symptoms of angina (through the Rose angina questionnaire), and any current use of medication for hypertension. In addition, measurements of height, weight, waist circumference, hip circumference and blood pressure were taken.

Socioeconomic status was characterized by the literacy of the participant (no literacy versus any literacy), the type of employment of her father during her childhood (manual or non-manual), the ownership and construction of her house ('pucca' i.e. made of concrete walls and roof or 'Katcha' i.e. made of thatched walls and roof), the income level of the household, and the number of household assets owned from a list

of seven. Birth weight was determined from participants' recall as being 'higher than normal vs. normal vs. lower than normal'.

The questions on smoking covered use of cigarettes, *bidi* (locally made cigarettes without filters) or a *hookah* (pipe) regularly (at least once a week for a month or more). The number of other people in the household who smoked provided a measure of domestic exposure to environmental tobacco smoke (ETS), which was defined by there being at least one other household member who smoked cigarettes, bidi, or a huqqa in the home.

Dietary questions covered the use of oil or ghee for cooking and eating, and weekly consumption of meat and eggs. The former was categorized to three levels: only or mostly use oil; mixed use of oil and ghee; only or mostly use ghee for cooking. Frequencies of consuming meat and eggs were each categorized to two levels: use at least once per week vs. less than once per week.

Level of physical activity was assessed through questions on the frequency per week of shopping, fetching water, washing clothes, collecting wood for cooking, agricultural work on a farm and any other regular heavy physical work. Each of these activities was categorized first to two levels: zero days per week or at least once per week. A composite physical activity score was then derived as the number of activities carried out at least once per week, with values ranging from 0 to 6.

Experience of angina was assessed with the World Health Organization's Rose angina questionnaire, which has already been described.

Previous diagnosis of "heart attack" by a doctor was ascertained through a single question: "In the past, have you ever been told by a health care provider that you had a 'heart attack'?"

Physical examination

Height, weight, and waist and hip circumference were measured using a stadiometer, digital weighing scale and measuring tape, following standardized methods.

Body mass index (BMI) (weight in kilograms per squared height in meters) and waist-to-hip ratio (WHR) were calculated from the above measurements. BMIs $<25 kg/m^2$ were considered normal, and those $\geq 25 kg/m^2$ as abnormally high (overweight or obese). A WHR of ≥ 0.85 was classed as abnormally high, while a WHR <0.85 was considered normal.

Three measurements of blood pressure were made at five-minute intervals, using an Omron upper arm blood pressure monitor, and mean values for systolic and diastolic blood pressure were derived.

Electrocardiography (ECG)

A 12-lead ECG was recorded according to a standard protocol, and coded for the presence of definite or probable CHD, using the Minnesota Code Manual of Electrocardiographic Findings, second edition (Prineas RJ, 2010). This corresponded to the presence of any of codes 1-1 to 1-3, 3-1, 4-1 to 4-4, 5-1 to 5-3, 7-1-1 and 9-2.

In order to check the repeatability of the coding, I and my supervisor (DC) each coded all of the ECGs independently. We used the same scanned ECG traces, without information about the type of cooking fuel used by the participant. Levels of agreement between the observers were assessed, using kappa statistics. Where differences occurred in the classification of an ECG trace, they were then resolved by discussion between the two observers.

Statistical analysis

The data were double-entered in Epidata 3.1 software (Christiansen TB, 2010) for validation. All discrepancies were corrected using the original data from the questionnaire.

Statistical analysis was carried out with Stata version 12.0 (Stata Corp LP 2012, Stata Statistical Software: Release 12.0, College Station TX, USA). As a first step, several variables were reclassified or combined, based on their distribution in the full study sample, and without knowledge of participants' use of biomass fuel. Thus, a combined index was derived for frequency of consuming meat and eggs with three levels: neither meat nor eggs as much as once per week; one of meat or eggs at least once per week; both meat and eggs at least once per week. Also scores for physical activity were categorized as a second step into three levels: low (0-1 activities); medium (2-3); high (4 or more). Similarly, BMI and WHR were combined as a single variable with three categories: normal BMI and normal WHR; one of BMI or WHP high; both BMI and WHP high.

Those women who had a mean systolic blood pressure of ≥140mm of Hg and/or mean diastolic blood pressure of ≥90 and/or regular use of medication for blood pressure were considered to have high blood pressure.

Use of biomass was classed to two main categories;

- Biomass user: Currently use firewood and/or cow dung for cooking.
- Non-biomass user: Currently do not use either firewood or cow dung for cooking.

In addition, two subsets of these main categories were distinguished:

- Long-term biomass user: Currently use firewood and/or cow dung for cooking and used firewood or cow dung for cooking for at least the past 10 years.
- Long-term non-biomass user: Currently do not use either firewood or cow dung for cooking and time since last used biomass for cooking ≥10 years.

Four outcome variables were considered:

- Hypertension
- Previous history of heart attack
- Angina
- Definite or probable CHD changes on ECG

Descriptive statistics were produced for women in each of the four categories of exposure, summarizing their demographic and socioeconomic status, current and past cooking arrangements, types and durations of fuel use, hours of cooking per day, types of stove and kitchen, and exposures to potentially confounding risk factors.

The prevalence of the main outcomes was determined for the study sample overall, and the relationship of ECG changes to angina and history of heart attack was explored.

Logistic regression analysis was then used to assess the association of each of the four outcome variables with use of biomass fuel for cooking and other possible risk factors. First, associations with each potential risk factor were determined after adjustment for age. The main exposure of interest (biomass or non-biomass user) was then carried forward into a mutually adjusted model along with all other risk factors which showed associations ($p \leq 0.1$) when examined individually. In addition, a second mutually adjusted model was fitted that compared long-term use and non-use of biomass for cooking.

Sample size

The size of the study sample was determined by a power calculation which assumed an outcome prevalence of at least 6% among users of natural gas [based on data for definite CHD – the prevalence of other outcomes was expected to be higher (Jafar TH,

2008)]. It was calculated that I would require 876 women (438 natural gas and 438 biomass users) for 80% power to detect an odds ratio of 2.0 for use of biomass fuel with a 5% level of statistical significance.

Ethical considerations

The study was approved by Ethics Review Committee of Aga Khan University, Karachi, Pakistan.

6.2 Results

Among the 1073 women who completed interviews, 44 indicated that they were in fact aged less than 40 years of age, and were therefore excluded from the analysis. An additional 151 women had not made meals regularly (at least one meal per day on most days of the week) during the past year and were also excluded. I further excluded 28 women who did not currently use firewood or cow dung for cooking, but whose time since last use of biomass was <2 years. This was done to ensure distinct exposure categories. Thus, further analysis was based on 850 women: 436 biomass users and 414 non-biomass users. Among them, 430 were long-term biomass users i.e. they had used firewood or cow dung for at least the last 10 years, and 263 were long-term non-biomass users i.e. they had last used biomass more than 10 years earlier.

Table 6-1 summarizes the demographic and socioeconomic characteristics of the participants in the study sample overall, and according to categories of exposure to biomass fuel.

Among the total sample of 850 women, approximately 62% were 40-49 years of age. Most were of poor socioeconomic status: 94% were illiterate; 77% lived in households with incomes of less than 10,000 PKR per month; 77% lived in katchas or semi-puccas; 80% had three or fewer of the household assets listed in the questionnaire; and 95% reported that their father had worked as a manual labourer during their childhood. Most (92%) lived in owned rather than rented houses.

Comparison of the biomass and non-biomass users indicated that the latter were marginally younger in age (63% versus 60% <50 yrs). Although most women in both exposure categories were poor, non-biomass users were socioeconomically more advantaged than biomass users with: higher literacy (9% versus 4%); higher household income per month (30% versus 20% >10,000 PKR); more ‘pucca’ (concrete) houses (34% versus 17%); and more household assets (27% versus 17% with ≥4 of the listed assets). There was, however, little difference in the prevalence of house ownership, or in the

proportion of women whose fathers had been manual labourers during their childhood. When the same characteristics were compared between long-term biomass and long-term non-biomass users, differences were similar but slightly larger.

Table 6-1.Demographic and socioeconomic characteristics of participants by exposure category.

Characteristic	All women (n=850)		Biomass user (n=436)		Non-biomass user (n=414)		Long-term biomass user (n=430)		Long-term non-biomass user (n=263)	
	n	*(%)*	*n*	*(%)*	*n*	*(%)*	*n*	*(%)*	*n*	*(%)*
Age (years)										
<50	525	(61.8)	263	(60.3)	262	(63.3)	257	(59.8)	166	(63.1)
≥50	325	(38.2)	173	(39.7)	152	(36.7)	173	(40.2)	97	(36.9)
Educational status										
No literacy	797	(93.8)	419	(96.1)	378	(91.3)	413	(96.1)	239	(90.9)
Any literacy	53	(6.2)	17	(3.9)	36	(8.7)	17	(4.0)	24	(9.1)
Household income/month										
≤10000PKR	651	(76.6)	351	(80.5)	300	(72.5)	347	(80.7)	185	(70.3)
>10000PKR	199	(23.4)	85	(19.5)	114	(27.5)	83	(19.3)	78	(29.7)
Household ownership										
Rented	70	(8.2)	25	(5.7)	45	(10.9)	25	(5.8)	20	(7.6)
Own	780	(91.8)	411	(94.3)	369	(89.1)	405	(94.2)	243	(92.4)
Construction of house										
Katcha/ semi-pucca	652	(76.7)	361	(82.8)	291	(70.3)	356	(82.8)	173	(65.8)
Pucca	198	(23.3)	75	(17.2)	123	(29.7)	74	(17.2)	90	(34.2)
Number of household assets										
Low (0-1)	268	(31.5)	140	(32.1)	128	(30.9)	139	(32.3)	84	(31.9)
Medium (2-3)	404	(47.5)	223	(51.2)	181	(43.7)	218	(50.7)	108	(41.1)
High (≥4)	178	(21.0)	73	(16.7)	105	(25.4)	73	(17.0)	71	(27.0)
Father's occupation in childhood										
Non-manual	39	(4.6)	19	(4.4)	20	(4.8)	18	(4.2)	16	(6.1)
Manual	811	(95.4)	417	(95.6)	394	(95.2)	412	(95.8)	247	(93.9)

Table 6-2 describes the current and past cooking arrangements of participants, including type and duration of fuel use, intensity of cooking, and type of stove and kitchen.

Even among the long-term non-biomass users, 88% had cooked with biomass fuels at some time in their life, and only a small percentage of women had never used biomass. When asked about the time since they had last used biomass, about 40% of non-biomass users reported between 2 and 9 years, and about 60% that it was at least 10 years.

Among the biomass users, almost all women had at some time used wood (99.8%) and cow dung (97%) for cooking. Moreover, the large majority had used wood (93%) and cow dung (88%) for longer than 20 years. In contrast, few had ever used kerosene (4%) or natural gas/liquid petroleum gas (LPG) as a cooking fuel.

Among the non-biomass users, more than 80% had used wood and/or cow dung as a fuel at some time in the past, many for 20 years or longer. However, most had cooked with natural gas/LPG for at least 10 years.

Although all participants currently carried out cooking, some 30% only did so for an hour or less per day. Most (approximately 60%) cooked for 2-3 hours per day. The average duration of cooking per day was similar in the biomass and non-biomass users.

Among the biomass users, 60% of women used open three-stone stoves, while about 40% had an improved stove with chimney. About 20% of biomass users and 30% of non-biomass users had closed kitchens (four walls – linked with the living room or separate). Where biomass was used for cooking, it was also more likely to be used to heat the home. However, about a quarter of non-biomass users reported use of biomass to heat their homes.

Table 6-2. Current and past cooking arrangements according to exposure category.

Characteristic	Biomass user (n=436)		Non-biomass user (n=414)		Long-term biomass user (n=430)		Long-term non-biomass user (n=263)	
	N	*(%)*	*n*	*(%)*	*n*	*(%)*	*n*	*(%)*
Ever used biomass for cooking	436	(100)	382	(92.3)	430	(100)	231	(87.8)
Years since last used biomass for cooking								
Current user	436	(100)	-	-	430	(100)	-	-
2-9	-	-	151	(39.5)	-	-	-	-
≥10	-	-	231	(60.5)	-	-	231	(100)
Ever used wood for cooking	435	(99.8)	358	(86.5)	429	(99.8)	218	(82.9)
Number of years used wood for cooking								
0	1	(0.2)	56	(13.5)	1	(0.2)	45	(17.1)
1-9	10	(2.3)	19	(4.6)	4	(0.9)	11	(4.2)
10-19	20	(4.6)	109	(26.3)	20	(4.7)	86	(32.7)
≥20	403	(92.4)	219	(52.9)	403	(93.7)	113	(43.0)
Not known	2	(0.5)	11	(2.7)	2	(0.5)	8	(3.0)
Ever used cow dung for cooking	422	(96.8)	358	(86.5)	416	(96.7)	216	(82.1)
Number of years used cow dung for cooking								
0	14	(3.2)	56	(13.5)	14	(3.3)	47	(17.9)
1-9	19	(4.4)	21	(5.1)	13	(3.0)	12	(4.6)
10-19	18	(4.1)	107	(25.8)	18	(4.2)	87	(33.1)
≥20	381	(87.4)	218	(52.7)	381	(88.6)	108	(41.1)
Not known	4	(0.9)	12	(2.9)	4	(0.9)	9	(3.4)
Ever used kerosene for cooking	16	(3.7)	26	(6.3)	16	(3.7)	17	(6.5)
Number of years used kerosene for cooking								
0	420	(96.3)	388	(93.6)	414	(96.3)	246	(93.5)
1-9	3	(0.7)	2	(0.5)	3	(0.7)	2	(0.8)
10-19	4	(0.9)	11	(2.7)	4	(0.9)	9	(3.4)
≥20	9	(2.1)	13	(3.2)	9	(2.1)	6	(2.3)
Ever used LPG/natural gas for cooking	17	(3.9)	413	(99.8)	15	(3.5)	263	(100)
Number of years used LPG/natural gas for cooking								
0	418	(95.9)	1	(0.2)	414	(96.3)	0	
1-9	12	(2.7)	159	(38.4)	11	(2.6)	15	(5.7)
10-19	3	(0.7)	202	(48.9)	3	(0.7)	199	(75.7)
≥20	2	(0.5)	51	(12.3)	1	(0.2)	49	(18.6)
Not known	1	(0.2)	1	(0.2)	1	(0.2)	0	
Average hours per day cooked in past year								
≤1	129	(29.6)	133	(32.1)	123	(28.6)	75	(28.5)
2-3	270	(61.9)	237	(57.3)	270	(62.8)	165	(62.7)
≥4	37	(8.5)	44	(10.6)	37	(8.6)	23	(8.8)
Type of stove used for cooking								

Characteristic	Biomass user (n=436)		Non-biomass user (n=414)		Long-term biomass user (n=430)		Long-term non-biomass user (n=263)	
	N	***(%)***	***n***	***(%)***	***n***	***(%)***	***n***	***(%)***
Gas/LPG	2	(0.5)	414	(100)	2	(0.5)	263	(100)
Biomass with chimney/improved stove	166	(38.1)	-	-	164	(38.1)	-	-
Biomass three brick open stove	267	(61.2)	-	-	263	(61.2)	-	-
Other	1	(0.2)	-	-	1	(0.2)	-	-
Type of kitchen								
Closed (four walls – linked with living room or separate)	88	(20.2)	116	(28.0)	86	(20.0)	79	(30.1)
Semi-open (less than four walls)	189	(43.3)	155	(37.5)	187	(43.5)	94	(35.7)
Open (no walls)	159	(36.5)	143	(34.5)	157	(36.5)	90	(34.2)
Heat home with biomass	237	(54.4)	106	(25.6)	236	(54.9)	74	(28.1)

Table 6-3 shows the distribution of the potentially confounding risk factors for CHD in the four categories of exposure to biomass. In comparison with non-biomass users, a higher proportion of women using biomass reported having been born with 'lower than normal' birth weight (27% vs 17-21%). The proportion who had experienced hunger during childhood was similar among biomass and non-biomass users, but was slightly higher among long-term biomass users than in long-term non-biomass users (59% versus 53%). More of the biomass users than non-biomass users had lost weight at some time during childhood (63% versus 56%).

Ever having smoked any of cigarettes, bidi or huqqa and domestic exposure to environmental tobacco smoke (i.e. at least one other household member smoking cigarettes, bidi or huqqa in the home) were each marginally more common among biomass users than non-users (11% vs. 9% and 38% vs. 35%).

A higher proportion of biomass-using women carried out regular physical work: 26% reported doing 5-6 physical activities more than once per week compared to 13% of non-biomass users and 9% of long-term non-biomass users.

More of the non-biomass users ate both meat and eggs at least once per week (28% versus 20%), and current nutritional status as assessed by BMI and WHR was higher among non-biomass using women (30% had both high BMI and high WHR as compared with 23% of biomass users).

Table 6-3. Distribution of risk factors across the four exposure categories.

Characteristic	Biomass user (n=436)		Non-biomass user (n=414)		Long-term biomass user (n=430)		Long-term non-biomass user (n=263)	
	n	*(%)*	*n*	*(%)*	*n*	*(%)*	*n*	*(%)*
Birthweight								
Lower than normal	117	(26.8)	77	(18.6)	114	(26.5)	54	(20.5)
Normal	239	(54.8)	254	(61.4)	237	(55.1)	156	(59.3)
Higher than normal	80	(18.4)	83	(20.0)	79	(18.4)	53	(20.2)
Hungry during childhood								
Never	174	(39.9)	173	(41.8)	173	(40.2)	122	(46.4)
≥1 yr	260	(59.6)	237	(57.2)	255	(59.3)	140	(53.2)
Not known	2	(0.5)	4	(1.0)	2	(0.5)	1	(0.4)
Lost weight during childhood								
No	162	(37.2)	182	(44.0)	160	(37.2)	119	(45.2)
Yes	274	(62.8)	232	(56.0)	270	(62.8)	144	(54.8)
Ever smoked regularly (any of cigarettes, bidi, huqqa)								
Never	390	(89.5)	378	(91.3)	384	(89.3)	240	(91.3)
Ever	46	(10.5)	36	(8.7)	46	(10.7)	23	(8.7)
Environmental tobacco smoke (at least one other household member smokes cigarettes, bidi or huqqa in the home)								
No	269	(61.7)	267	(64.5)	265	(61.6)	173	(65.8)
Yes	167	(38.3)	147	(35.5)	165	(38.4)	90	(34.2)
Physical activity score								
0-2	124	(28.5)	205	(49.5)	124	(28.8)	149	(56.7)
3-4	199	(45.6)	156	(37.7)	196	(45.6)	91	(34.6)
5-6	113	(25.9)	53	(12.8)	110	(25.6)	23	(8.7)
Consumption of meat or eggs								
Do not eat either meat or eggs as much as once per week	173	(39.7)	142	(34.3)	172	(40.0)	88	(33.5)
Eat one of meat or eggs as much as once per week	176	(40.3)	163	(39.4)	173	(40.2)	100	(38.0)
Eat both meat and eggs at least once per week	87	(20.0)	109	(26.3)	85	(19.8)	75	(28.5)
Current nutrition[a]								
BMI and WHR both normal	183	(42.0)	129	(31.1)	179	(41.6)	79	(30.0)
One of BMI or WHR high	151	(34.6)	160	(38.7)	149	(34.7)	101	(38.4)
Both BMI and WHR high	102	(23.4)	124	(30.0)	102	(23.7)	82	(31.2)
Not known		0	1	(0.2)			1	(0.4)

[a]BMI (kg/m²), <25=normal and ≥25= high; WHR, <0.85=normal and ≥0.85=high.

6.2.1 Distribution and inter-relationship of outcome measures:

Satisfactory ECG traces were obtained for 841 (98.9%) of the participants. Table 6-4 compares the classification of ECGs by the two observers.

Table 6-4. Classification of ECGs by two observers.

Observer 1 (Zafar Fatmi)	**Observer 2 (David Coggon)**	
	Negative	Positive
Negative	593	30
Positive	94	122

The overall agreement between the two observers was 85.2% (kappa = 0.57). Most disagreements related to judgements where the exceedance of a threshold in, for example, ST elevation, ST depression or the width (duration) of a Q wave was borderline. In some cases, it was questionable whether there was a small R wave or a QS pattern. Also, there was some disagreement about whether T waves were negative or flat.

Following discussion between the two observers, all of the discrepancies were reconciled, and it was finally agreed that 181 women (21.5%) showed changes indicative of definite or probable CHD. However, in 22 of these cases, it appeared that the abnormality had occurred only because the ECG leads had been placed incorrectly, and those traces were reclassified as normal. Thus in further analyses, 159 (19%) of women were considered to have definite or probable CHD on ECG.

Table 6-5 shows the prevalence of all of the main outcome measures that were investigated in the study. In total, 303 women (36%) were classed as having hypertension, two thirds of whom were taking regular medication for blood pressure. Fifty-seven (6.7%) reported a previous history of heart attack and 27% had symptoms indicative of angina based on Rose's questionnaire. As already mentioned, 19% of women had findings of definite or probable CHD on ECG.

Table 6-5. Prevalence of hypertension, history of heart attack, angina and coronary heart disease in study sample.

Characteristic	n=850	(%)
Hypertension		
Systolic hypertension (systolic BP≥140 mmHg)	135	(15.9)
Diastolic hypertension (diastolic BP≥90 mmHg)	104	(12.2)
Regular medication for high blood pressure	203	(23.9)
Hypertension (any of the above)	303	(35.7)
History of heart attack	57	(6.7)
Angina	228	(26.8)
Definite or probable CHD on ECG (n=841)[a]	159	(18.7)

[a]ECGs for 9 women were missing or could not be coded due to poor quality.

Table 6-6 shows the prevalence of definite or probable CHD on ECG according to symptoms of angina and history of heart attack. It was somewhat more frequent in participants who reported an earlier heart attack (26%) than in those who did not and had no symptoms of angina (19%). However, there was no association with angina in the absence of heart attack.

Table 6-6. Prevalence of definite or probable CHD changes on ECG according to history of heart attack and angina.

Other measure of CHD	Definite or probable CHD changes on ECG (n=841)[a]	
	Yes	No
	n (%)	n (%)
No history of heart attack or angina	154 (18.7)	671 (81.3)
History of angina	45 (19.8)	182 (80.2)
History of heart attack	14 (25.9)	40 (74.1)
History of angina or heart attack	54 (20.4)	211 (79.6)
History of angina and heart attack	5 (31.3)	11 (68.7)

[a]ECGs for 9 women were missing or could not be coded due to poor quality.

6.2.2 Association of outcome measures with use of biomass and other risk factors

Table 6-7 summarizes the associations of hypertension with use of biomass fuel for cooking and other possible risk factors. The first column gives odds ratios adjusted only for age, while the second column presents mutually adjusted risk estimates from a single model that included use of biomass and all of the risk factors that showed associations ($p \leq 0.1$) in the analyses adjusted only for age. The last column shows

findings from a similar analysis but restricted to women who were long-term users or non-users of biomass.

In the analyses that adjusted only for age, hypertension was associated ($p \leq 0.1$) with older age, a higher number of household assets, higher frequency of consuming meat and eggs, and overweight or obese. When these variables were carried forward to the mutually adjusted analysis, the association with consumption of meat and eggs was diminished, but the others remained. Thus, the risk of hypertension increased 40% with every 10-year increase in age, was 2.3 times higher in women with ≥4 household assets than in those with 0 or 1, and was increased 1.9-fold in women who had both high BMI and high WHR as compared with those whose BMI and WHR were normal. The findings for these risk factors from the fully adjusted model that was restricted to long-term users and non-users of biomass were similar. In the fully adjusted models neither biomass use nor long-term biomass use was significantly associated with hypertension (ORs 1.0 and 1.1).

Table 6-7. Association of hypertension with risk factors.

Risk factors	Adjusted only for age (n=850)		Fully adjusted[a] (n=850)		Fully adjusted and limited to long-term users and non-users of biomass[b] (n=693)	
	OR	(CI)	OR	(CI)	OR	(CI)
Age (per 10 year increase)	1.4	(1.2-1.6)	1.4	(1.2-1.7)	1.5	(1.2-1.7)
Educational status						
Illiterate	1.0		-		-	
Any literacy	0.6	(0.3-1.2)				
Household income/month					-	
<3000-10000PKR	1.0		-			
>10000PKR	1.0	(0.7-1.4)				
Household ownership					-	
Rented	1.0		-			
Own	0.8	(0.5-1.3)				
Construction of house					-	
Katcha/semi-pucca	1.0		-			
Pucca	0.9	(0.6-1.2)				
Number of household assets						
0-1	1.0		1.0		1.0	
2-3	1.7	(1.2-2.4)	1.6	(1.2-2.3)	1.8	(1.2-2.6)
≥4	2.4	(1.6-3.6)	2.3	(1.5-3.4)	2.7	(1.7-4.3)
Father occupation in women's childhood					-	
Non-manual	1.0		-			
Manual	1.2	(0.6-2.5)				
Birthweight						
Lower than normal	1.0				-	
Normal	1.0	(0.7-1.4)	-			
Higher than normal	1.0	(0.6-1.5)				

Risk factors	Adjusted only for age (n=850)		Fully adjusted[a] (n=850)		Fully adjusted and limited to long-term users and non-users of biomass[b] (n=693)	
Hungry during childhood					-	
Never	1.0		-			
Ever	0.9	(0.7-1.3)				
Lost weight during childhood					-	
No	1.0		-			
Yes	1.2	(0.9-1.6)				
Ever smoked regularly (any of cigarettes, bidi, huqqa)						
Never	1.0		-		-	
Ever	0.8	(0.5-1.3)				
Environmental tobacco smoke (at least one other household member smokes cigarettes, bidi or huqqa in the home)						
No	1.0		-			
Yes	0.8	(0.6-1.1)				
Consumption of meat or eggs						
Do not eat either meat or eggs as much as once per week	1.0				1.0	
Eat either meat or eggs as much as once per week	1.4	(1.0-1.9)	1.2	(0.9-1.7)	1.2	(0.8-1.7)
Eat both meat and eggs at least once per week	1.4	(1.0-3.1)	1.2	(0.8-1.8)	1.2	(0.8-1.9)
Current nutrition[c]						
Normal BMI and normal WHR	1.0		1.0		1.0	
Either BMI or WHR is high	1.2	(0.9-1.7)	1.2	(0.8-1.6)	1.2	(0.8-1.8)
High BMI and high WHR	2.0	(1.4-2.9)	1.9	(1.3-2.8)	1.8	(1.2-2.7)
Non-biomass user	1.0					
Biomass user	1.2	(0.9-1.5)	1.0	(0.8-1.4)		
Long-term non-biomass user	1.0				1.0	
Long-term biomass user	1.2	(0.9-1.7)			1.1	(0.8-1.6)

[a]Mutually adjusted risk estimates derived from a single regression model that included biomass use and all of the variables that were significant (p<0.1) in analyses adjusted only for age
[b]Mutually adjusted risk estimates derived from a single regression model that included biomass use and all of the variables that were significant (p<0.1) in analyses adjusted only for age, but was restricted to women who were long-term users or non-users of biomass
[c]Body mass index (BMI) (kg/m^2), <25=normal and ≥25= high; Waist-to-hip ratio (WHR), <0.85=normal and ≥0.85=high.

Using the same criteria for selection of variables as in the analyses for hypertension, similar models were developed with angina as the outcome. Table 6-8 summarizes the associations of angina with use of biomass fuel for cooking and other possible risk factors.

In the analyses that adjusted only for age, the odds of angina increased with age and regular smoking, and were significantly lower with more frequent consumption of meat and eggs. This pattern was maintained when risk estimates were mutually adjusted. Thus, the odds of angina increased by 30% per 10-year increase in age, and with ever

having smoked regularly (OR 2.0, 95%CI 1.2-3.2), and were significantly lower in women who ate both meat and eggs at least once per week (OR 0.5, 95%CI 0.3-0.7). There was, however, no association with use of biomass (OR 1.0, 95%CI 0.8-1.4). When analysis was restricted to long-term users and non-users of biomass, results were similar except that there was a suggestion of an association with exposure to biomass (OR 1.3, 95%CI 0.9-1.9).

Table 6-8. Associations of angina with risk factors.

Risk factors	Adjusted only for age (n=850)		Fully adjusted[a] (n=850)		Fully adjusted and limited to long-term users and non-users of biomass[b] (n=693)	
	OR	(CI)	OR	(CI)	OR	(CI)
Age (per 10 year increase)	1.3	(1.1-1.6)	1.3	(1.1-1.5)	1.3	(1.1-1.5)
Educational status						
Illiterate	1.0		-		-	
Any literacy	0.6	(0.3-1.3)				
Household income/month					-	
<3000-10000PKR	1.0		-			
>10000PKR	1.1	(0.8-1.6)				
Household ownership					-	
Rented	1.0		-			
Own	0.8	(0.5-1.3)				
Construction of house					-	
Katcha/semi-pucca	1.0		-			
Pucca	1.2	(0.8-1.7)				
Number of household assets					-	
0-1	1.0		-			
2-3	0.9	(0.6-1.3)				
≥4	1.0	(0.6-1.5)				
Father occupation in women's childhood					-	
Non-manual	1.0		-			
Manual	0.7	(0.3-1.4)				
Birthweight						
Lower than normal	1.0				-	
Normal	1.2	(0.8-1.8)	-			
Higher than normal	1.1	(0.7-1.8)				
Hungry during childhood					-	
Never	1.0		-			
Ever	0.8	(0.6-1.1)				
Lost weight during childhood					-	
No	1.0		-			
Yes	1.0	(0.8-1.4)				
Ever smoked regularly (any of cigarettes, bidi, huqqa)						
Never	1.0		1.0		1.0	
Ever	2.1	(1.3-3.3)	2.0	(1.2-3.2)	2.1	(1.3-3.6)
Environmental tobacco smoke (at least one other household member smokes cigarettes, bidi or huqqa in the home)						
No	1.0		-			
Yes	1.2	(0.9-1.6)				
Consumption of meat or eggs						
Do not eat either meat or eggs as much as once per week	1.0		1.0		1.0	
Eat either meat or	0.6	(0.4-0.8)	0.6	(0.4-0.8)	0.7	(0.5-1.0)

Risk factors	Adjusted only for age (n=850)		Fully adjusted[a] (n=850)		Fully adjusted and limited to long-term users and non-users of biomass[b] (n=693)	
eggs as much as once per week						
Eat both meat and eggs at least once per week	0.4	(0.3-0.7)	0.5	(0.3-0.7)	0.5	(0.3-0.8)
Current nutrition[c]						
Normal BMI and normal WHR	1.0					
Either BMI or WHR is high	0.8	(0.5-1.1)	-			
High BMI and high WHR	0.8	(0.5-1.2)				
Non-biomass user	1.0					
Biomass user	1.0	(0.7-1.3)	1.0	(0.8-1.4)		
Long-term non-biomass user	1.0				1.0	
Long-term biomass user	1.2	(0.9-1.7)			1.3	(0.9-1.9)

[a]Mutually adjusted risk estimates derived from a single regression model that included biomass use and all of the variables that were significant (p<0.1) in analyses adjusted only for age
[b]Mutually adjusted risk estimates derived from a single regression model that included biomass use and all of the variables that were significant (p<0.1) in analyses adjusted only for age, but was restricted to women who were long-term users or non-users of biomass
[c]Body mass index (BMI) (kg/m^2), <25=normal and ≥25= high; Waist-to-hip ratio (WHR), <0.85=normal and ≥0.85=high.

Table 6-9 shows findings from corresponding analyses with previous history of heart attack (diagnosed by a physician) as the outcome. Initial analyses with adjustment only for age indicated associations (p<0.1) with age, household income, increased number of household assets, and overweight or obese. After mutual adjustment, age remained a significant risk factor (OR 1.5, 95%CI 1.2-2.0) for each 10-year increase in age). The other associations, although still positive, were not significant at a 5% level. Nor was there an association with use of biomass (OR 1.2, 95%CI 0.7-2.2). In the mutually adjusted model for long-term use of biomass, results were very similar.

Table 6-9. Association of previous history of heart attack (diagnosed by a physician) with risk factors.

Risk factors	Adjusted only for age (n=850)		Fully adjusted[a] (n=850)		Fully adjusted and limited to long-term users and non-users of biomass[b] (n=693)	
	OR	(CI)	OR	(CI)	OR	(CI)
Age (per 10 year increase)	1.5	(1.2-2.0)	1.5	(1.2-2.0)	1.5	(1.2-2.0)
Educational status						
Illiterate	1.0		-		-	
Any literacy	1.5	(0.5-4.5)				
Household income/month						
<3000-10000PKR	1.0		1.0		1.0	
>10000PKR	1.6	(0.9-2.9)	1.4	(0.8-2.5)	1.6	(0.8-3.1)
Household ownership						
Rented	1.0		-		-	
Own	1.2	(0.4-3.4)				

Risk factors	Adjusted only for age (n=850)		Fully adjusted[a] (n=850)		Fully adjusted and limited to long-term users and non-users of biomass[b] (n=693)	
Construction of house					-	
Katcha/semi-pucca			-			
Pucca	1.3	(0.7-2.3)				
Number of household assets						
0-1	1.0		1.0		1.0	
2-3	1.4	(0.7-2.7)	1.3	(0.7-2.5)	1.8	(0.8-3.8)
≥4	2.1	(1.0-4.3)	1.8	(0.8-3.8)	2.1	(0.9-5.1)
Father occupation in women's childhood					-	
Non-manual	1.0		-			
Manual	1.0	(0.2-4.5)				
Birthweight						
Lower than normal	1.0				-	
Normal	1.0	(0.5-1.9)	-			
Higher than normal	0.7	(0.3-1.7)				
Hungry during childhood					-	
Never	1.0		-			
Ever	1.0	(0.6-1.7)				
Lost weight during childhood					-	
No	1.0		-			
Yes	1.1	(0.6-1.9)				
Ever smoked regularly (any of cigarettes, bidi, huqqa)						
Never	1.0		-			
Ever	0.9	(0.4-2.1)				
Environmental tobacco smoke (at least one other household member smokes cigarettes, bidi or huqqa in the home)						
No	1.0		-			
Yes	0.9	(0.5-1.6)				
Consumption of meat or eggs						
Do not eat either meat or eggs as much as once per week	1.0		-			
Eat either meat or eggs as much as once per week	1.2	(0.6-2.3)				
Eat both meat and eggs at least once per week	1.8	(0.9-3.5)				
Current nutrition[a]						
Normal BMI and normal WHR	1.0		1.0		1.0	
Either BMI or WHR is high	1.3	(0.6-2.5)	1.2	(0.6-2.5)	1.6	(0.7-3.4)
High BMI and high WHR	2.0	(1.0-4.0)	1.9	(0.9-3.7)	1.7	(0.8-3.6)
Non-biomass user	1.0		1.0		-	
Biomass user	1.4	(0.8-2.4)	1.2	(0.7-2.2)		
Long-term non-biomass user	1.0				1.0	
Long-term biomass user	1.5	(0.8-2.7)			1.3	(0.7-2.4)

[a]Body mass index (BMI) (kg/m^2), <25=normal and ≥25= high; Waist-to-hip ratio (WHR), <0.85=normal and ≥0.85=high.

Similar analyses were carried out for the fourth outcome – definite or probable CHD on ECG, and the results are summarized in Table 6-10. In analyses adjusted only for age,

household income was the only variable significantly associated with CHD on ECG, and it remained significant in the fully adjusted model (OR 1.6, 95%CI 1.1-2.4 for household income >10,000PKR). However, there was no association with use of biomass for cooking, either overall or in the long-term (ORs 0.8 and 0.9).

Table 6-10. Association of definite or probable CHD on ECG with risk factors.

Risk factors	Adjusted only for age (n=850)		Fully adjusted[a] (n=850)		Fully adjusted and limited to long-term users and non-users of biomass[b] (n=693)	
	OR	(CI)	OR	(CI)	OR	(CI)
Age (per 10 year increase)	1.1	(0.9-1.3)	1.1	(0.9-1.3)	1.0	(0.8-1.3)
Educational status						
Illiterate	1.0		-		-	
Any literacy	0.8	(0.4-1.7)				
Household income/month						
<3000-10000PKR	1.0		1.0		1.0	
>10000PKR	1.6	(1.1-2.3)	1.6	(1.1-2.4)	1.3	(0.8-2.0)
Household ownership					-	
Rented	1.0		-			
Own	1.4	(0.7-2.9)				
Construction of house					-	
Katcha/semi-pucca	1.0		-			
Pucca	1.0	(0.7-1.5)				
Number of household assets						
0-1	1.0		-			
2-3	1.0	(0.7-1.5)				
≥4	1.3	(0.8-2.1)				
Father occupation in women's childhood					-	
Non-manual	1.0		-			
Manual	1.0	(0.4-2.3)				
Birthweight						
Lower than normal	1.0				-	
Normal	1.1	(0.7-1.7)	-			
Higher than normal	1.1	(0.7-1.9)				
Hungry during childhood					-	
Never	1.0		-			
Ever	1.1	(0.8-1.6)				
Lost weight during childhood					-	
No	1.0		-			
Yes	0.8	(0.6-1.2)				
Ever smoked regularly (any of cigarettes, bidi, huqqa)						
Never	1.0		-		-	
Ever	1.0	(0.6-1.8)				
Environmental tobacco smoke (at least one other household						

Risk factors	Adjusted only for age (n=850)		Fully adjusted[a] (n=850)		Fully adjusted and limited to long-term users and non-users of biomass[b] (n=693)	
member smokes cigarettes, bidi or huqqa in the home)						
No	1.0				-	
Yes	0.9	(0.6-1.3)	-			
Consumption of meat or eggs						
Do not eat either meat or eggs as much as once per Week	1.0					
Eat either meat or eggs as much as once per week	0.9	(0.6-1.4)				
Eat both meat and eggs at least once per week	1.2	(0.7-1.8)				
Current nutrition[b]						
Normal BMI and normal WHR	1.0					
Either BMI or WHR is high	0.8	(0.5-1.2)	-			
High BMI and high WHR	1.1	(0.7-1.6)				
Non-biomass user	1.0		1.0			
Biomass user	0.8	(0.6-1.2)	0.8	(0.6-1.2)		
Long-term non-biomass user	1.0				1.0	
Long-term biomass user	0.9	(0.6-1.3)			0.9	(0.6-1.3)

[a]ECG were missing for 9 women or not codable due to poor quality.
[b]Body mass index (BMI) (kg/m^2), <25=normal and ≥25= high; Waist-to-hip ratio (WHR), <0.85=normal and ≥0.85=high.

6.3 Discussion

This study evaluated four outcomes. Three were measures of CHD (angina, previous history of heart attack and definite or probable CHD on ECG) and the fourth (hypertension) was a well-established risk factor for CHD, which might lie on the causal pathway through which pollutants from biomass fuel led to CHD. The study found no association between use of biomass fuel and any of the four outcomes, even when the comparison was with women who had not used biomass for at least the last 10 years. The strongest hint of an association was for angina in long-term users or non-users of biomass, but the elevation of risk was small (30%) and not statistically significant at a 5% level.

The choice of villages from which to recruit participants ensured a balance in the fuels currently used for cooking, and cooperation in the survey was good with high response rates from the households and women that were invited to take part. Inevitably, recruitment was to some extent opportunistic. However, there seems no reason to expect that the study sample would have been seriously unrepresentative in relation to the associations of hypertension and CHD with use of biomass and other risk factors.

Furthermore, results from the air monitoring that were reported in Chapter 5 indicate that the contrasts in exposure to PM and (to a lesser extent) CO between users and non-users of biomass are likely to have been substantial. Individual exposures may have been influenced by time spent cooking, whether biomass was burned in a closed or open kitchen, and the presence of smokers in the household (ETS). Nevertheless, the absence of associations with use of biomass is unlikely to reflect inadequate contrasts in exposure

Recruitment was intended to focus on households that had used the same fuel for cooking exclusively for at least 10 years. Villages were selected with this criterion in mind, and it was covered in preliminary inquiries that were addressed to local leaders. In practice, however, it turned out that where natural gas was available in villages, some participants had not yet switched to cleaner fuel, or had done so at a later date than other villagers. A pragmatic decision was therefore made to include women even if they had changed their cooking fuel within the past 10 years, provided that they had used their current fuel for at least a year. To check that this did not obscure associations, additional analyses were carried out with restriction to long-term users and non-users of biomass. However, still no associations with were found with the health outcomes.

The sample size achieved for the study was close to that planned, and the prevalence of the four outcomes was higher than had been assumed in the power calculations. Moreover, the upper confidence limits for the odds ratios relating to use of biomass were almost all <2. Thus, the absence of associations with biomass does not reflect a lack of statistical power, and is unlikely to be attributable to chance.

Ascertainment of current use of biomass is likely to have been highly accurate, and while there may have been some errors in recall of the times when biomass had been used in the past, it is difficult to conceive that any resultant misclassification would have obscured important associations with CHD. Generally, switches in the use of fuel were only in one direction – towards cleaner natural gas from biomass. The timing of changes was usually well recalled because in most instances the entire village received the new source of fuel in a particular year. However, the duration of using cow dung and firewood may not always have been remembered reliably, and switches between these types of fuel could also have occurred. Many women reported using cow dung and firewood for the same duration, and no attempt was made to analyse them separately.

Recall of some other exposures may also have been inaccurate – particularly those pertaining to childhood. If so, the errors would be expected to be non-differential with

respect to CHD, and therefore to bias risk estimates towards the null, possibly leading to uncontrolled residual confounding.

Assessment of BMI and WHR used standardized methods, and should have been reasonably reliable. The interviewers were trained in how to make the measurements, and they were given a 'dry-run' in the field before the start of data collection.

A greater concern is the possibility of error in the ascertainment of outcomes. Blood pressure was objectively measured according to a standardized protocol, and was taken as the average of three readings. Moreover, most of the women who were classed as having hypertension were taking treatment for the disorder, which supports the validity of its assessment. However, the diagnosis of CHD from ECGs showed only a weak relationship to history of medically diagnosed heart attack, and none at all to symptoms of angina. Between observer agreement in the classification of ECGs was reasonably good (kappa = 0.57), but it is notable that unlike angina and history of heart attack, CHD diagnosed from ECGs did not show the expected association with age. Thus, the diagnoses of hypertension, angina and past history of heart attack may have been more accurate than those based on ECG. Even so, it is unlikely that they were completely reliable.

Although the question to participants about history of heart attack referred specifically to diagnoses that had been given by a health professional, errors could have occurred in interpretation of the term "heart attack" (e.g. to include symptoms from dysrhythmias and acute heart failure as well as myocardial infarction). However, ascertainment of heart attack had been done by the same method in a previous study conducted in similar population and was found to be reasonably accurate (Jafar TH, 2005).

Also, while angina was determined through the well-established Rose questionnaire, there is a possibility that symptoms in some cases arose from other pathology. Previous research has suggested that the Rose angina questionnaire may not be as reliable among women as in men (Wicosky T, 1987).

To the extent that errors did occur in the ascertainment of angina and past heart attack, they are unlikely to have differed systematically in relation to use of biomass, and therefore would be expected to tend to obscure any true associations.

Because the study had a cross-sectional design, consideration must be given to the possibility of reverse causation. For risk factors related to childhood (e.g. birthweight,

father's occupation and education), this is less of a concern. However, it is plausible that characteristics such as diet, physical activity and time spent cooking could have changed as a consequence of CHD. Depending on the circumstances, this might bias associations either upwards or downwards.

Another limitation of the study was that it did not determine when past heart attacks had occurred. Even if not as a consequence of an earlier heart attack, some of the exposures studied (e.g. BMI and WHR) may have changed in the interval since such an attack occurred. If so, this might obscure true associations.

A further possible source of error was uncontrolled residual confounding. To minimize this problem, information was collected about a range of potentially confounding variables, and as in most studies of biomass fuel, socio-economic status tended to be higher in women using cleaner fuels (Khushk WA, 2005). However, although several socio-economic indicators were evaluated as possible factors for adjustment, residual confounding could still have occurred. To explain the absence of associations with biomass, such confounding would have to be inverse (i.e. the under-ascertained confounder would have to be less prevalent in women who used biomass than in non-users).

The study found expected associations with several established risk factors for CHD. Thus, the odds of hypertension, angina and previous history of heart attack were all higher with older age (by 30-50% for every 10-year increase), although this was not found for definite or probable CHD on ECG. The relationship of CHD to age is well documented in the literature (Castelli WP, 1984), and in women, the incidence of CHD increases rapidly after the menopause, reaching up to three times that in premenopausal women (Gordon T, 1978).

Two of the outcome measures – hypertension and previous history of heart attack – were significantly associated with affluence as measured by number of household assets. This relationship has also been observed before. In a population-based study in Pakistan, history of 'angina or heart attack' was estimated to have 3-fold higher prevalence among affluent participants than in those who were poor (Hameed K, 1995). This relationship, which is the inverse of that in western populations, accords with a higher prevalence of diabetes, hypertension and dyslipidaemias in more educated and affluent groups that was observed in a recent study in Karachi (Ali MK, 2016).

In further support of an effect of affluence, I found that high BMI and/or WHR was associated with greater risk of hypertension, and (non-significantly) with history of

heart attack. Obesity has been shown to increase the risk of hypertension in several studies (Hubert HB, 1983; Todd Miller M, 2008), and partly through this mechanism, also increases the risk and progression of CHD (Prospective Studies Collaboration, 2002). The INTERHEART study suggested that WHR (abdominal obesity) is a better marker of risk for CHD than BMI (Yusuf S, 2005), but the two were correlated in my study sample, and I opted to use a combined measure.

In contrast, I found that more frequent consumption of meat and eggs was associated with reduced risk of angina. This was unexpected given the known relationship of CHD to consumption of saturated fat (WHR, 2002), and may have been a chance finding. It did not extend to the other outcomes investigated. However, a recent large review suggests that the relationship may be inconsistent (Chowdhry R, 2014).

I also found an association of regular smoking with angina. Smoking has consistently been found to increase the risk of CHD in many studies (Huxley RR, 2011). However, in my study it was associated only with angina. This might be because intensity of tobacco use among female smokers in Pakistan population is relatively low (GATS, 2014),

Despite the finding of several expected associations, the failure to demonstrate more consistent relationships to known risk factors further calls into question the validity of the outcome measures in my study, and is an indication for caution in interpretation.

As described in Chapter 4, there were a priori reasons to expect associations between use of biomass and CHD. For the reasons discussed, perhaps the most likely explanation for the failure to demonstrate such associations is inaccuracy in the diagnosis of CHD. However, another possibility is that adverse effects of exposure to pollutants from the use of biomass persist many years after last exposure. In my survey, even among women who had not used biomass during the last 10 years, most had done so earlier, and often for a long time. Only a few participants (about 3.5%) overall had never used biomass, which was too few for meaningful risk estimates. The case-control study that is described in the next chapter offered a better opportunity to explore this question.

Summary and conclusions

This study evaluated the association of hypertension and three measures of CHD – angina, previous history of heart attack and definite or probable CHD on ECG - with use of biomass for cooking. I found no associations of biomass fuel use with CHD. However, the weak relationship of ECG abnormalities to the other two measures of

CHD, and the inconsistency of their associations with well-established risk factors, suggest that this may have been because of diagnostic misclassification. Alternatively, it could be that an effect was missed because most non-users of biomass had used it in the past, and risk remains elevated for many years after last exposure.

Chapter 7: Case-Control Study of ACS and Use of Biomass Fuel

My case-control study, which built on a pilot investigation that I had carried out before starting my PhD project (Fatmi Z, 2014), assessed the association between acute coronary syndrome (ACS) and use of biomass fuel. It focused on more definite and severe CHD than the cross-sectional survey, the cases being patients admitted to hospital.

7.1 Methods

Study setting

The study population comprised women living within defined parts of the catchment areas of two public sector tertiary care hospitals in Mirpurkhas and Nawabshah, both rural districts of the province of Sindh, Pakistan. Mirpukhas (population 0.9 million) is situated in the southern part of Sindh, while Nawabshah (population 1.1 million) is in the central part of the province. The two hospitals receive cardiac patients from the districts in which they are located and from adjacent villages. Patients and controls were eligible for study if they came from Mirpurkhas, Nawabshah, Badin, Jamshoro, Khairpur, Matiari, Nausheroferoze, Sanghar, Tando Allahyar, Tharparkar or Umerkot districts (see Figure 9). Within this population, there was mixed use of biomass fuel and natural gas for cooking.

Both hospitals provided tertiary care with well-established cardiology units delivering outpatient, inpatient and 24-hour emergency services. They also offered services in all other major medical specialties. The cardiac care unit of Civil Hospital Mirpurkhas had 50 beds, and the medical ward had 80 beds, of which approximately 50% were dedicated to female patients. Nawabshah hospital had three medical wards with 50 beds each, and one 50-bedded cardiac care unit (see Figure 9).

Data were collected over two years from February 2014 to January 2016.

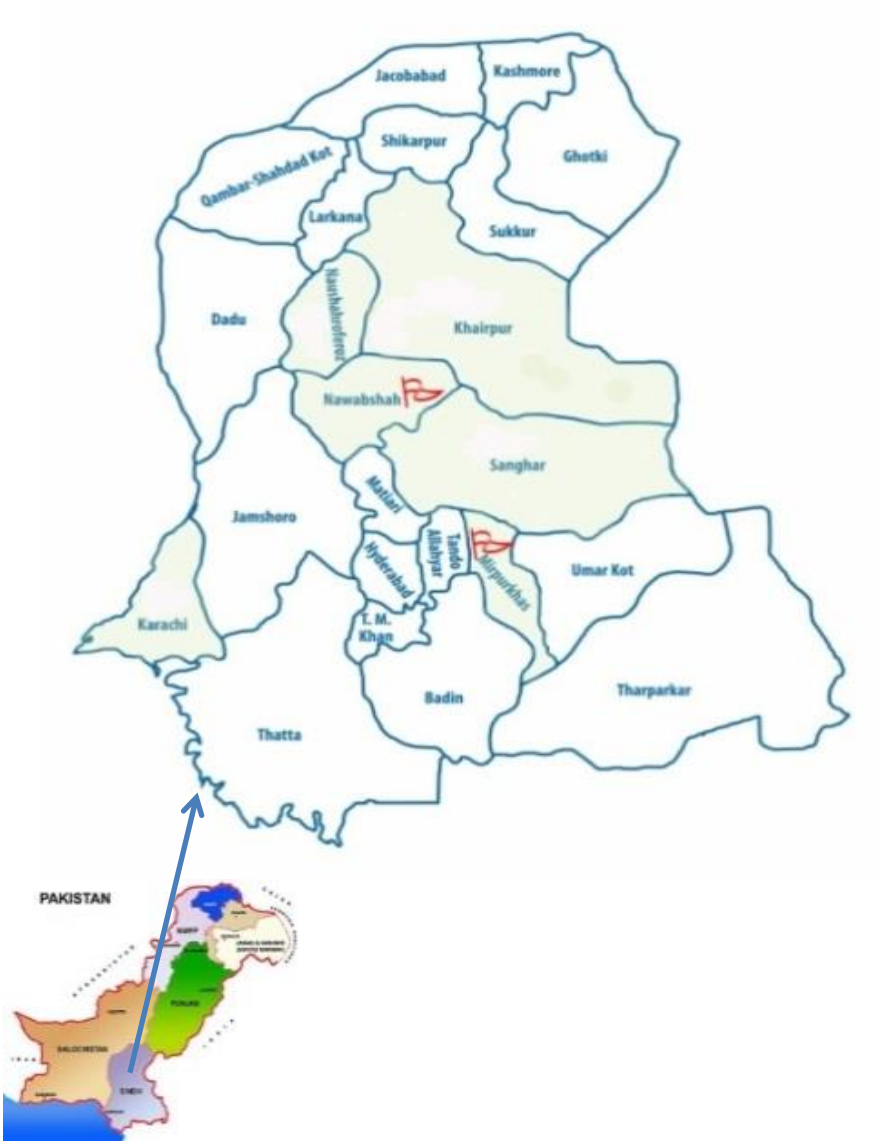


Figure 9. Province of Sindh, Pakistan, with location of study hospitals marked by flags.

7.1.1 Case definition

Case definition was based on the diagnostic criteria published by Mendis et al. (Mendis S, 2011), but with some simplification to reflect what was affordable and practical in a developing country. A patient was deemed to have ACS if she met any of the following criteria:

1. ECG changes of MI [ST segment elevation or pathological Q waves] plus at least one value above the upper reference limit for a cardiac biomarker [CK-MB or Troponin – I or Troponin – T] – (STEMI)
2. Pain or discomfort in the chest, jaw, left arm or epigastric area in combination with at least one value above the upper reference limit for a cardiac biomarker [CK-MB

or Troponin – I or Troponin – T], but with no ECG changes of MI [no ST segment elevation or pathological Q waves] – (NSTEMI)

3. Pain or discomfort in the chest, jaw, left arm or epigastric area in combination with ECG changes [ST segment elevation or pathological Q waves], but with no value above the upper reference limit for any cardiac biomarker [CK-MB or Troponin – I or Troponin – T] – (unstable angina).

Ascertainment and recruitment of cases

Women were eligible for inclusion as cases if they lived in the defined study area, and were admitted to the cardiac care unit at one of the study hospitals with a new episode of ACS (no previous episode in the past 28 days). Admissions were arranged, and diagnoses made, as part of routine care by the cardiologists and physicians of the hospital. The study team visited the cardiology ward each day and approached the nursing administrator to identify the new cases of MI admitted since their last visit (i.e. approximately in the last 24 hours). Those who potentially met the inclusion criteria and were considered sufficiently well by the nursing team that was caring for them, were told about the study, and invited to take part. Eligible cases who could not be included (because they were too ill or declined to take part) were documented. Those who were too unwell on the day of admission were tracked for up to three days, and approached if their condition improved. If a patient was not sufficiently well to be interviewed even after three days, she was not included in the study.

Ascertainment and recruitment of controls

For each case that was recruited, we (i.e. the study team which I trained and supervised) used a prescribed algorithm to select two matched controls of the same age to within 5 years, who had been admitted to the medical wards of the same hospital for reasons other than ACS. We first considered women admitted on the same day as the case, and if this did not give the two controls needed, we next tried to recruit from women admitted on the following day, and then on the previous day etc. If more than the required number of eligible controls was available from a given day, we chose the patient(s) whose age matched that of the case most closely. The women who were selected, provided they were considered sufficiently well by the clinical team that was caring for them, were told about the study and invited to take part. Controls who could not take part, or declined to do so, were replaced according to the same algorithm, and their exclusion was documented.

Data collection

Cases and controls were approached at their bedside by trained interviewers as soon as possible after they were identified, and after the time of the physician's daily visit (which was usually in the morning). With written informed consent, a standardised questionnaire (appendix B), similar to that employed in the pilot study, was used to elicit information on: socio-demographic characteristics; recent and past medical history; active and passive smoking; physical activity; key aspects of diet; lifetime use of different fuels for cooking; and house construction. In addition, permission was sought to access the patient's medical record in order to abstract information on diagnosis (including ECG recordings and cardiac biomarker measurements in cases) and height and weight. Subsequently, measurements of height, weight, and waist and hip circumference were made by the interviewers using a stadiometer, digital scales, and a tape measure, once the patient was stable and the physician gave permission.

Statistical analysis

Data were double entered in Epidata 3.1, and any inconsistencies were resolved by reference to the original questionnaires. Analysis was carried out with Stata version 12.

The distributions of variables from the questionnaire were explored in the study sample as a whole, and collinearity of risk factors was assessed by cross-tabulation. Several of the variables were then reclassified or combined. This was done without knowledge of their distribution by case-control status.

Use of biomass for cooking was classified as follows: never used biomass (firewood and/or cow dung) for cooking; last use of biomass for cooking >10 years ago; last use of biomass ≤10years ago, but no current use; live in the household which currently uses biomass but woman has stopped cooking; live in the household which currently uses biomass and the woman currently cooks.

Potentially confounding risk factors for ACS were specified as follows. Ethnicity was classified as a binary variable, 'Sindhi' vs. 'other ethnicity' (other minorities were merged together); literacy as 'no literacy' vs. 'any level of literacy'; household income per month as '<10,000PKR' vs. '≥10,000PKR'; house ownership as 'owned' vs. 'rented'; construction of the house as, 'Pucca' (concrete roof and walls) vs. 'Katcha/Semi-Pucca' (totally or partially made of thatch/wood); household assets as 'low' (0-1 assets), 'medium' (2-3 assets) or 'high' (4 or more assets), the assets considered being seven (as in the cross-sectional survey); birthweight as, 'high/normal' vs. 'lower than normal';

felt hungry during childhood and lost weight during childhood each as 'no' vs. 'yes'; overall exposure from smoking as, 'no exposure to active or to passive smoking in the home' vs. 'environmental exposure but never active smoking' vs. 'ever active smoker but no environmental exposure' vs. 'both active smoking and environmental exposure'. Specific dietary inquiry included the type of cooking fat used regularly in the house, which was categorized as 'use only or mostly oil' vs. 'half oil and half ghee' vs. 'only or mostly ghee' (oil was considered to contain less saturated fat and ghee more saturated fat). Frequency of consuming meat and eggs was classified as 'neither meat nor eggs consumed as much as once per week' vs. 'one of meat or eggs consumed as much as once per week' vs. 'both meat and eggs consumed at least once per week'; and current nutritional status was characterized by combining the body mass index (BMI) and waist to hip ratio (WHR), and categorized as 'both BMI and WHR normal' vs. 'one of BMI or WHR high' vs. 'both BMI and WHR high'.

Simple descriptive statistics were used to summarize the demographic and socio-economic characteristic of the cases and controls.

Conditional logistic regression was then used to quantify the associations of ACS with use of biomass fuel and other risk factors, the results being summarized by odds ratios (ORs) with associated 95% confidence intervals (CIs). Following univariate analyses, a multivariate model was fitted, which incorporated all of the potential risk factors.

Sample size and power

From my earlier pilot study (Fatmi Z, 2014), it was estimated that over 18 months I could recruit some 180 cases and 360 controls, and that the prevalence of current use of biomass fuel among controls would be approximately 55%. This would give a power of 80% to detect an odds ratio of 1.7 at a 5% level of statistical significance.

Ethical considerations

Approval for the study was provided by the Ethics Review Committee of Aga Khan University, Pakistan.

Written informed consent was obtained from patients before participation in the study, and to minimize any risk and discomfort to them, we approached them only when they were relatively stable and with permission from the clinicians caring for them. Their privacy was ensured by using the curtains around the bed during the interview.

There were no additional direct benefits to the patients enrolled in the study. They received usual care from the hospitals.

Questionnaires and abstracts from medical records were identified only by a study identification number, and not by patient name.

7.2 Results

I was able to conduct data collection for rather longer than the 18 months that originally had been planned, and it proved possible to recruit a total of 381cases and 762 controls. A further 40 women were eligible for inclusion as cases, but could not be enrolled because they were not well enough for interview during the three days after their admission (25, including 7 who died), were referred (or self-referred) to other hospitals (12), or the interviewers were absent for personal reasons (3). Controls were sought for each case recruited to the study, according to the prescribed algorithm described above. In most instances more than enough eligible controls were available. However, we could not always recruit two eligible controls for each case. A total of 65 of the controls who were selected for study could not be included. Among them, 24 were not sufficiently well, as judged by their physicians, to give interviews, and the others declined to take part in the study for various reasons.

Among the 1143 participants who were recruited, 3 cases and 11 controls were excluded because their interviews were insufficiently complete and they refused to answer further questions, or their diagnosis was not fully ascertained. An additional 11 women (all cases) had a history of ACS within the last 28 days, and therefore were excluded (since they were not considered to be newly incident cases), along with their matched controls. Five further participants (2 cases and 3 controls) were excluded because they were without any matched case or control. This left 364 cases of ACS and 727 controls for final analysis (see Figure 10).

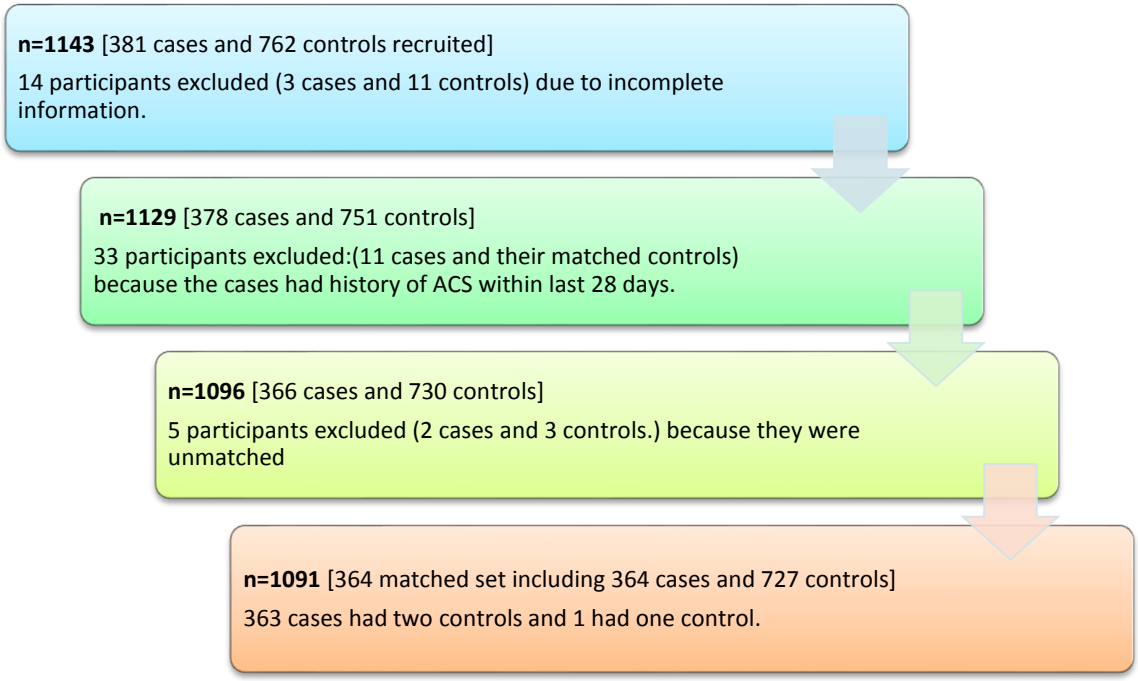


Figure 10. Summary of case and control recruitment.

Details of the clinical presentation of cases and controls recruited to the study are given in Tables 7-1 and 7-2 respectively.

Table 7-1. Diagnostic classification of cases.

Classification	n=364 (%)	ST or Q positive[a]	Pain[b]	Raised enzyme levels[c]
1. STEMI	91 (25.0)	91 (100)	91 (98.9)	91 (100)
2. NSTEMI	140 (38.5)	0	140 (100)	140 (100)
3. Unstable Angina	63 (17.3)	63 (100)[d]	63 (100)	0
4. Others	70 (19.2)	Not known[e]	70 (96.5)	Not known[e]

[a] *ECG changes included ST-segment elevation and pathological Q waves.*

[b] *Pain or discomfort in the chest, jaw, left arm or epigastric area.*

[c] *At least one value above the upper reference limit for a cardiac biomarker [CK-MB or Troponin – I or Troponin – T].*

[d] *16 ECGs had findings of either ST-depression or Negative T waves (but serial ECGs had positive findings which were not traceable).*

[e] *ACS classification could not be carried out independently by the researcher but diagnosis was confirmed by cardiologists and recorded by the nursing staff (this was mainly because the patient took her records with her when going for further treatment or they were considered her property as she had paid out-of-pocket for the diagnostic tests).*

Table 7-2. Diagnoses of women enrolled as controls in the study.

Diseases and symptoms	n=727	(%)
1. Chronic obstructive pulmonary disease; respiratory tract infection; bronchitis; asthma.	159	(21.9)
2. Diarrhea/gastroenteritis; epigastric pain/ulcer.	146	(20.1)
3. Hepatitis B-C; chronic liver disease.	116	(16.0)
4. Fever: Urinary tract infection; tuberculosis; low grade fever of unknown origin; high grade fever.	74	(10.1)
5. Anemia.	33	(4.5)
6. Hypertension; congestive cardiac failure; pericarditis.	25	(3.4)
7. Uncontrolled diabetes.	24	(3.3)
8. Cerebrovascular accident.	23	(3.2)
9. Kidney disease (chronic or acute renal failure).	17	(2.3)
10. Cholecystitis.	7	(1.0)
11. Cancers (any).	7	(1.0)
12. Anxiety/depression.	4	(0.5)
13. Miscellaneous diseases and symptoms.	92	(12.6)

Table 7-3 describes further characteristics of the cases and controls who were included in the main analysis. The mean age of the cases was 59.1 years (range 23 to 91 years) and that of controls 58.3 years (range 23 to 96 years). About 82% of the controls were matched to within 5 years of age (40% within 2 years), and the other 18% (133) were matched to between 5-15 years.

213 cases and 425 controls were from Mirpurkhas hospital and the rest from Nawabshah hospital.

The proportions from different ethnic populations and literacy rates were similar in cases and controls.

Cases were more affluent than controls: more lived in 'Pucca' houses (33% vs 21%), and they had a higher number of household assets (≥4 household assets: 31% vs 13%). However, more cases than controls had indications of poor nutrition in childhood: 11% cases vs 5% controls reported that they were born with lower than normal weight; 36% cases vs 25% controls had felt hungry at some time during childhood, and 27% cases vs 18% controls had lost weight during childhood.

The combination of active (ever) and environmental (currently in the home) exposure to smoking was slightly more common among cases than controls (12% vs 9%). Specific

dietary inquiry revealed that more women among the cases than controls used oil (as opposed to ghee) for cooking, and more ate both meat and eggs weekly.

Anthropometric measurements showed that a higher proportion of cases than controls had both high body mass index (BMI) and waist-to-hip ratio (WHR) ratio (33% vs 14%).

Table 7-3. Characteristics of study sample.

Characteristic	Cases	Controls
n (percentage)	***364 (%)***	***727 (%)***
Age (years)		
<50	60 (16.5)	131 (18.0)
50-59	96 (26.4)	197 (27.1)
60-69	138 (37.9)	271 (37.3)
≥70	70 (19.2)	128 (17.6)
Study hospital		
Mirpurkhas	213 (58.5)	425 (58.5)
Nawabshah	151 (41.5)	302 (41.5)
Ethnicity		
Sindhi	156 (42.9)	288 (39.6)
Other	208 (57.1)	439 (60.4)
Educational status		
No literacy	334 (91.8)	695 (95.6)
Any literacy	30 (8.2)	32 (4.4)
Household income/month		
<10000PKR	176 (48.3)	334 (45.9)
≥10000PKR	152 (41.8)	356 (49.0)
Refuse to answer/don't Know	36 (9.9)	37 (5.1)
Household ownership		
Own	337 (92.6)	673 (92.6)
Rented	27 (7.4)	54 (7.4)
Construction of house		
Katcha/ semi-pucca	244 (67.0)	572 (78.7)
Pucca	120 (33.0)	155 (21.3)
Number of household assets		
Low (0-1)	91 (25.0)	369 (50.8)
Medium (2-3)	159 (43.7)	262 (36.0)
High (≥4)	114 (31.3)	96 (13.2)
Birthweight		
High or normal	307 (84.3)	665 (91.5)
Low	40 (11.0)	38 (5.2)

Characteristic	Cases	Controls
n (percentage)	***364 (%)***	***727 (%)***
Not known	17 (4.7)	24 (3.3)
Hungry during childhood		
No	231 (63.5)	523 (71.9)
Yes	130 (35.7)	185 (25.5)
Not known	3 (0.8)	19 (2.6)
Lost weight during childhood		
No	246 (67.6)	569 (78.3)
Yes	99 (27.2)	132 (18.2)
Not known	19 (5.2)	26 (3.6)
Overall exposure from smoking		
None	165 (45.3)	331 (45.5)
Environmental but never active smoker	128 (35.2)	268 (36.9)
Ever active smoker but not environmental	24 (6.6)	63 (8.7)
Ever active smoker and environmental	47 (12.9)	65 (8.9)
Oil/Ghee use		
Only or mostly oil	182 (50.0)	219 (30.1)
Half oil and half ghee	58 (15.9)	129 (17.7)
Only or mostly ghee	122 (33.5)	377 (51.9)
Not known	2 (0.6)	2 (0.3)
Consumption of meat or eggs		
Do not eat either meat or eggs as much as once per week	207 (56.9)	478 (65.8)
Eat one of meat or eggs as much as once per week	84 (23.1)	137 (18.8)
Eat both meat and eggs at least once per week	73 (20.0)	111 (15.3)
Not known		1 (0.1)
Current nutrition		
BMI and WHR both normal	32 (8.8)	120 (16.5)
One of BMI or WHR high	210 (57.7)	494 (68.0)
Both BMI and WHR high	119 (32.7)	106 (14.5)
Not known	3 (0.8)	7 (1.0)
Biomass exposure		
Never used biomass	8 (2.2)	29 (4.0)
Past biomass user >10 years ago	103 (28.3)	136 (18.7)
Past biomass user ≤10 years ago	102 (28.0)	232 (31.9)
Current biomass user /stopped cooking	61 (16.8)	125 (17.2)
Current biomass user/currently cook	85 (23.4)	189 (26.0)
Not known	5 (1.4)	16 (2.2)

Table 7-4 shows associations of ACS with use of biomass fuel and potential confounders. When associations were mutually adjusted in a single conditional logistic

regression model, strongly positive associations were seen with high current nutrition (OR: 6.1; 95% CI, 3.3-11.3 for 'both BMI and WHR high' vs. 'both BMI and WHR normal'), and having more household assets (OR: 6.4; 95% CI, 3.8-10.9 for high number of household assets (≥4) vs. low number (0-1)). Conversely, however, risk was significantly reduced in women with a higher household income (OR: 0.5; 95% CI, 0.3-0.7), and those who only or mostly used ghee for cooking (OR: 0.5; 95% CI, 0.3-0.8 vs. those who mostly or only used oil**)**. There was also an increased risk in women of Sindhi ethnicity (OR: 1.5; 95% CI, 1.1-2.2), and those who reported low birthweight (OR: 2.7; 95% CI, 1.4-4.9), hunger during childhood (OR: 1.9; 95% CI, 1.1-3.3), and (although not significantly) loss of weight during childhood (OR: 1.5; 95% CI, 0.8-2.8). No clear association was apparent with smoking, although risk was highest in women who had been active smokers and lived with other smokers (OR: 1.6; 95% CI, 0.9-2.8).

After allowance for these potentially confounding factors, risk was lowest in women who had never used biomass for cooking, in comparison with whom the odds ratios for the other exposure categories ranged from 3.4 (95%CI 1.2-9.1) to 6.7 (95%CI 2.4-18.7). However, there was no indication that risk decreased with years since last use of biomass, indeed the highest risks were to those last exposed >10 years ago.

These risk estimates were generally similar to those from the univariate analyses, although odds ratios for use of biomass were lower in the univariate analysis, and there was also an association with more frequent consumption of meat and eggs, which disappeared in the adjusted analysis.

Table 7-4. Associations of acute coronary syndrome with use of biomass fuel and other risk factors

Risk factor	Unadjusted OR (95% CI)	Adjusted OR (95% CI)[a]
Ethnicity		
Others	1.0	1.0
Sindhi	1.2 (0.9-1.5)	1.5 (1.1-2.2)
Birthweight		
High or normal	1.0	1.0
Low	2.5 (1.5-4.1)	2.7 (1.4-4.9)
Hungry during childhood		
No	1.0	1.0
Yes	2.3 (1.6-3.4)	1.9 (1.1-3.3)
Lost weight during childhood		
No	1.0	1.0
Yes	2.4 (1.6-3.6)	1.5 (0.8-2.8)

Risk factor	Unadjusted OR (95% CI)	Adjusted OR (95% CI)[a]
Household income/month		
<10000PKR	1.0	1.0
≥10000PKR	0.8 (0.6-1.0)	0.5 (0.3-0.7)
Construction of house		
Katcha/ semi-pucca	1.0	1.0
Pucca	1.9 (1.4-2.5)	1.3 (0.8-1.9)
Number of household assets		
Low (0-1)	1.0	1.0
Medium (2-3)	2.8 (2.0-3.8)	2.9 (1.9-4.2)
High (≥4)	5.3 (3.6-7.8)	6.4 (3.8-10.9)
Overall exposure from smoking		
None	1.0	1.0
Environmental but never active smoker	1.0 (0.7-1.3)	1.1 (0.8-1.6)
Ever active smoker not environmental	0.8 (0.5-1.3)	0.8 (0.4-1.5)
Ever active smoker and environmental	1.4 (0.9-2.2)	1.6 (0.9-2.8)
Oil/Ghee use		
Only or mostly oil	1.0	1.0
Half oil and half ghee	0.5 (0.4-0.8)	0.6 (0.4-0.9)
Only or mostly ghee	0.4 (0.3-0.5)	0.5 (0.3-0.8)
Consumption of meat or eggs		
Do not eat either meat or eggs as much as once per week	1.0	1.0 1.0
Eat one of meat or eggs as much as once per week	1.7 (1.2-2.4)	1.0 (0.6-1.5)
Eat both meat and eggs at least once per week	1.9 (1.3-2.9)	1.1 (0.6-1.9)
Current nutrition[b]		
BMI and WHR both normal	1.0	1.0
One of BMI or WHR high	1.6 (1.0-2.5)	1.6 (1.0-2.7)
Both BMI and WHR high	4.9 (3.0-8.1)	6.1 (3.3-11.3)
Biomass exposure		
Never used biomass	1.0	1.0
Past biomass user >10 years ago	3.1 (1.3-7.2)	6.7 (2.4-18.7)
Past biomass user ≤10 years ago	1.7 (0.8-3.8)	3.4 (1.2-9.1)
Current biomass user /stopped cooking	1.7 (0.7-4.1)	3.6 (1.2-10.4)
Current biomass user/currently cook	1.5 (0.7-3.6)	4.8 (1.7-13.8)

[a] Mutually adjusted for all variables. Analysis was based on 364 matched sets with information on all variables.

[b] BMI (kg/m2), <25=normal and ≥25= high; WHR, <0.85=normal and ≥0.85=high.

7.3 Discussion

This case-control study found an expected increase in risk of ACS among women with lower than normal birthweight, those who were undernourished during childhood, and those who were overweight or obese during adulthood. After adjustment for childhood nutritional factors, current nutritional status (BMI and WHR) and other potentially confounding risk factors, there was markedly higher risk of ACS in women who had used biomass for cooking as compared to those who had never used it. However, risk did not appear to decline when women stopped using biomass, even after a long time.

The study had a large sample size which allowed the breakdown of exposure into multiple levels. The study population was clearly specified, coming from the districts in which the two participating hospitals were situated and also neighbouring districts which had well-defined boundaries. Moreover, it included a mix of households using either biomass or other fuels for cooking, which gave good heterogeneity of exposure. The hospitals had the largest public sector tertiary care cardiac care units in the region, and most women with ACS in the study population would have been admitted to one of the two hospitals.

I applied a clear case definition which corresponded to that used by the cardiologists working in the hospitals. Cases were only enrolled after the diagnosis had been made and confirmed by the cardiologists and nurses working in the cardiac units. Nurses from the same units were employed to conduct the interviews so as to have better access to the patients and their records, and to ensure reliability in diagnoses. The nurses who assisted in the study had been working in the cardiac units for a long time, and were well versed in the protocols followed for the diagnosis of ACS. Before, initiating the study I had several discussions with the heads of the units and nurses regarding case definition for ACS – both what were ideal and what could be applied pragmatically. The adopted case definition was based on those discussions.

All patients were provided with free treatment at the participating hospitals, and they did not have to pay for medical consultation or accommodation. However, diagnostic facilities and medicines were not uniformly free of charge. All patients were provided with free ECGs and measurements of CK-MB, but measurements of troponin-T and troponin-I was offered only by a nearby private laboratory, and were charged to the patients. Also, some of the patients were advised to have ECGs outside the hospital. Patients who could be diagnosed by ECG and CK-MB were not tested further, but where those tests were inconclusive, troponin-T or I might also be measured.

Photocopies of key parts of the hospital records (particularly ECGs) were collected after the patient was discharged from hospital. However, where diagnostic tests were charged to the patient, they were considered her property, and were not always found in the hospital records. Also, some patients were referred for further treatment elsewhere after their interviews had been completed, and took with them with their diagnostic records. Therefore, the hospital records obtained for the study were incomplete. In these circumstances diagnoses were accepted if they had been made by the physicians and senior nurses in the cardiac units, since the case definition corresponded to their standard diagnostic criteria.

Over the two-year period of data collection, 24 eligible cases were unable to take part in the study because they were too unwell for interview. Even if these women were suffering from more severe ACS, they were too few for their omission to make any major difference to risk estimates. Moreover, there are no reasons to believe that their distribution of exposure to biomass would have been totally different from that of the other cases. Our study hospitals were large public sector institutions at which most of the costs of treatment were covered. Therefore, they were readily accessible to most of the local population, and were widely used. It is possible that a few patients with ACS from the study area could afford to attend a private hospital and therefore did not get recruited into the study. Conversely some people may have been too poor even to cover the cost of entering the public sector hospital, and therefore resorted to treatment at home. However, the same would have applied to controls, and this therefore would be expected to have caused minimal, if any, bias.

The participation rate among controls was also very high. Moreover, women who were admitted to the medical wards of the study hospitals belonged to the same community as the cases and those recruited as controls had a broad mix of diagnoses. There is possibility that exposures to biomass in the controls were unrepresentatively high because some of them had diseases which themselves were caused by pollution from biomass (e.g. some respiratory problems, hypertension). This would lead to an underestimation of the risk of ACS from biomass, but any such bias will have been reduced by the inclusion of many other diagnoses in the control group.

Most exposures were assessed by questionnaire. Current use of biomass should have been readily distinguished from that of other cleaner fuels, and switching to cleaner fuel is generally a major event that would be recalled reliably. However, there is a possibility of some errors in recall of the durations of exposure to different types of fuel used for cooking, which if non-differential with respect to current diagnosis, would bias risk estimates towards the null.

Where exposure variables needed to be reclassified or combined, that was done based on their distribution in the overall sample without knowledge of that in cases and controls separately. This was to avoid bias in the reclassification.

Anthropometric measurements were made while the patient was still in hospital, provided she was sufficiently well. Field workers could not be blinded to participants' case/control status, but the measurement of BMI and WHR should not have been affected importantly by this. Nor should values have been affected much by the illness of the cases, which was recent in onset. However, some controls (e.g. those with cancer) may have lost weight because of their disease. If so, risk estimates for current nutrition would have been biased upwards.

My finding of an increased risk with poor nutrition in childhood and with overweight and obese in adulthood is consistent with previous research (Barker DJ, 1986; Barker DJP,1993; EARLYREAD, 2008). It has been hypothesised to result from 'programming', whereby poor nutrition early in life leads to permanent changes in metabolic function which then predispose to cardiac and other disease in adult life if the individual is later exposed to better nutrition (Harding JE, 2001).

Findings on specific aspects of current diet were less clear. Higher risk in women who consumed meat and eggs at least once per week disappeared after adjustment for other factors, and use mainly of ghee for cooking (considered to contain more saturated fats) carried a significantly lower risk than that of oil. Most previous research has suggested an increased risk of CHD with higher consumption of saturated fat (WHR, 2002). However, a recent large systematic review and meta-analysis to determine the association of CHD with dietary, circulating and supplemental fatty acids concluded that no association exists and the evidence did not clearly support cardiovascular guidelines that encourage high consumption of polyunsaturated fatty acids and low consumption of total saturated fats (Chowdhry R, 2014). My findings support the need for further investigation.

Smoking (both active and passive) is another well-established risk factor for ACS (Teo KK, 2006; Yusuf S, 2004). My study suggested increased risk in women who were exposed to both, but the finding was not statistically significant and there was no association with active smoking in absence of exposure also to ETS. Fewer women smoke in developing countries (Hitchman SC, 2011) and the female-to-male ratio of smoking is very low in Pakistan, where in a recent survey, only 2% of adult females

currently smoked daily, as compared with 20.6% of adult males (GATS, 2014). Thus, women's exposure to smoking in Pakistan will be predominantly environmental.

Risk was markedly elevated in women with a larger number of household assets, but significantly lower among those with higher household income. This divergent pattern of risk applied even in unadjusted analyses, suggesting that it did not simply reflect inter-confounding. An association with affluence is consistent with my earlier pilot study (Fatmi Z, 2014) and also with my cross-sectional study (Chapter 6). However, about 10% of cases compared to only 5% of controls declined to report their household income (Table 7-3), and risk of ACS was substantially higher in those who did not report their income. Thus, there may have been some bias from incomplete reporting of income. Interviewees were reluctant to provide answers to direct questions about their income, and better information may have been obtained when affluence was assessed in other ways such as number of household assets. Greater wealth, as indicated by more household assets, was associated with a substantially increased risk of ACS. Another possible reason for the divergent results is that people in the rural study population did not earn regular fixed salaries, and it was difficult for them to estimate their incomes per month when their economy was based on seasonal crops. Moreover, answering the question may have been particularly difficult for women as they generally were not one of the employed and earning members of their households.

Sindhi ethnicity was associated with increased risk compared to other ethnicities. This could be related to their urban lifestyle. The Sindhi ethnic group lived in more urban areas than the other less prevalent ethnicities.

After adjustment for other risk factors, ACS was strongly associated with ever having used biomass for cooking. Associations were stronger with adjustment than without, indicating negative confounding by higher current nutrition and other risk factors associated with affluence. Women who had never used biomass tended to be more affluent. Similar negative confounding occurred in my earlier pilot study (Fatmi Z, 2014).

There was no indication, however, that risk declined when women stopped using biomass. Thus, the highest odds ratio (relative to never users) was in those who had last used biomass for cooking more than 10 years earlier. A sustained increase in risk following cessation of exposure might explain the absence of association between CHD and use of biomass fuel in my cross-sectional survey. Little evidence is available from elsewhere with which to compare my findings on this. One cross-sectional study

conducted in China among 13,438 adults randomly selected from census records found no dose-response relationship of CHD to duration of using solid fuel for cooking (Lee M-S, 2012). In that study however, the reference was use of solid fuel for <10 years, and not never use. A previous intervention study aimed at reducing exposures to indoor air pollution from use of biomass did show some reduction in blood pressure in the short term (McCracken JP, 2007). However, the incidence of ACS was not assessed. Findings from ambient air pollution studies suggest that short term exposure to pollutants leads to increased hospital admission for coronary events such as myocardial infarction (Wang DZ, 2013; Li H, 2015; Franklin BA, 2015). However, the increased risk in those studies is likely to reflect, at least in part, a 'harvesting' phenomenon whereby death was brought forward in people who already had serious CHD, and would who otherwise have died fairly soon anyway. My finding suggests that air pollution from use of biomass causes persistent pathology and that if substantial exposure has occurred then risk remains elevated for a long time. If so, the benefits from interventions to reduce exposures will not be fully achieved in the short term.

Conclusion

My findings add to the weight of evidence for an importantly increased risk of CHD from use of biomass for cooking, and are a further encouragement to initiatives aimed at reducing exposures to the indoor air pollution that it produces. However, they suggest that the full benefits from better design of stoves or switching to other fuels may not accrue until many years after the changes are introduced.

Chapter 8: Overview of results and direction for future research

Globally in 2012, cooking with unclean fuels and inefficient technologies (traditional stoves) is estimated to have caused 4.3 million deaths, with a further 3.0 million deaths due to outdoor air pollution. Jointly this makes indoor and outdoor air pollution the largest single environmental health risk. The estimate for cooking was based mainly on the burden of respiratory disease due to use of biomass fuel. Ample evidence already exists for an association of biomass fuel use with respiratory illness, including lower respiratory infection among children (Torres-Duque C, 2008) and COPD (Kurmi OP, 2010) among adults; and there is strong evidence for greater risk of asthma among women (Mishra V, 2003) and tuberculosis (Lin HH, 2014), and an association of lung cancer with use of coal (Liu Q, 1993; Behera D, 2005; Kleinerman R, 2000). A few studies have also found associations of IAP with low birth weight (Martin WJ 2nd, 2013) and cataract (Pokhrel AK, 2005; Saha A, 2005). However, research evidence regarding household air pollution and coronary heart disease has been relatively lacking (Chapter 4; Fatmi Z, 2016). There has been a call to gather evidence on CHD and IAP so that the burden of disease from use of biomass fuel can be estimated more accurately. This would help policy makers and encourage further interventions to reduce risks.

Working in conditions of extreme air pollution for a considerable time every day potentially predisposes women to high risks to their health. Although, my cross-sectional study was inconclusive, the case-control study strongly indicated increased risk of ACS from use of biomass, especially after adjustment of potential confounders. Importantly, the risk appeared to be sustained and did not show a decline after stopping use of biomass for 10 years. This finding may have implications for intervention studies, as controls on exposure may need to be long term to achieve the full benefits from any reduced risk of CHD.

The evidence of impacts on respiratory health in women and children is already enough to warrant interventions aimed at reducing household air pollution from use of biomass fuels. The added risks of CHD further emphasise the importance of such interventions.

More research is needed to evaluate the outcomes of such interventions, both in the short and long term. However, it may not always be practical to assess long term effects through randomized controlled trials, and there is a case also for evaluation through prospective cohort studies.

The main low cost intervention that has been available until recently has been the improved stove (Lewis JJ, 2012). Interventions to reduce exposures to pollutants from biomass fuel have been tested in developing countries, using a variety of stoves. Most intervention has been done in Africa, Asia and South America. The Global Alliance for Clean Cookstoves is a public-private partnership organized by the UN Foundation to promote clean and efficient household cooking solutions in developing countries. The Alliance's 100 by '20 goal is that 100 million households adopt clean and efficient cookstoves and fuels by 2020 (Clean Cookstoves).

Exposure to pollutants is likely to vary according to type of biomass fuel (cow-dung vs crop residues vs wood etc.), type of stove and chimney, and also cooking practices. Intervention trials to reduce exposure using chimney stoves have produced mixed results. Useful reductions in exposure to smoke from chimneys were found only when the chimney was adequately designed and installed (McCracken J, 2011). In contrast, use of chimneys made by the community themselves (home-made chimneys) has been found to have no benefit in reducing exposures (Pollard SL, 2014). It seems that installation of chimneys requires expert input, including on the place of installation and wind direction.

Following on from the research for this thesis, I recently evaluated two small scale intervention programs to improve stoves in the provinces of Sindh and Punjab in Pakistan for their effectiveness in reducing IAP and short-term health effects among rural women (Jamali T, 2017). The health effects studied included respiratory and eye symptoms, lung function, blood pressure and burns. $PM_{2.5}$ and CO levels were significantly lower in kitchens with improved stoves. Moreover, there was a significantly lower frequency of respiratory health problems among users of improved stoves. Some variations in health gains were observed between the two programs, as well as a greater health benefit among women using closed kitchens. However, perhaps mainly due to the short duration of the interventions (3 months), we did not observe any reduction in blood pressure among women using improved stoves. These findings are encouraging in suggesting that low cost improved stoves can reduce exposures to pollutants. Also, there were clear benefits for respiratory health, and benefits were greatest when the improved stoves were used in closed kitchens where levels of pollution are likely to be highest.

My study suggests that longer term interventions are needed to evaluate the benefits of improved stoves in relation to coronary heart disease. A follow-up study to determine ACS as an outcome would not be feasible, because of the large sample size that would be needed. However, studies using cardiac biomarkers predictive of

coronary heart disease might be an option. There are several such biomarkers in use, including plasma level of C-reactive protein (CRP), which predicts future risk of myocardial infarction and stroke. In Guatemala, McCracken et al. (2007 & 2010) conducted an intervention trial with improved stoves, and showed that they led to reductions in blood pressure and CRP. However, every setting is different because of the differences in the fuel type, kitchen design and the behaviour of the cook. Therefore, I now plan to do a similar intervention trial looking at robust biomarkers of coronary heart disease as the primary outcome, in addition to blood pressure and respiratory outcomes. This could provide impetus to the efforts that are being made to reduce exposure to IAP globally and particularly in Pakistan. Furthermore, in these new trials I plan to introduce alternative renewable energy fuels such as solar cookers. The aim is to test local solutions which are feasible and affordable for majority of the population in Pakistan.

My hope is that this research will eventually impact on public health policy in Pakistan. Historically, IAP from use of biomass fuel use for cooking has not been considered a health hazard in Pakistan. Several small-scale interventions have been tested since the 1970s, though more to promote wood conservation than to protect health. A few public and private institutions have introduced improved stoves and renewable energy technologies, and across the country, more than 4000 biogas plants were installed by the Ministry of Petroleum and Natural Resources from 1974 to 1987. The program was implemented in a phased manner, but failed mainly due to withdrawal of government financial support, high costs of the technology, and lack of technical training in local communities.

The Pakistan Council for Renewable Energy Technologies (PCRET) of the Ministry of Science and Technology, Government of Pakistan, has developed biogas plants and solar thermal technologies to conserve wood and reduce exposure to IAP. PCRET has tested several types of stove in Pakistan, but only on a small scale. Improved stoves have shown success. However, households need encouragement to renew their old stoves once they wear, so as to maintain the benefit from the stoves. Solar cookers have also been developed and tested in rural areas of Pakistan. Current technologies need to be adopted for different situations in Pakistan, and high cost seems to be a barrier to use by poor people in rural areas.

In conclusion, several interventions have been tried, although many were directed more at conservation of wood than reducing IAP. IAP interventions are still at a nascent stage. It will require concerted effort from stakeholders to draw up a policy and an agenda for action. In the short term, improved stoves and renewable energy

technologies would be the main intervention to reduce the risks from IAP. However, in the longer run, switching to cleaner fuels such as liquid petroleum gas (LPG) or natural gas would be preferable. This may become possible with continued economic development.

Appendices

Appendix A : Questionnaire for cross-sectional study

کھانا پکانے کے طریقے اور صحت سے متعلق ریسرچ

مندرجہ زیل میں آپ کو اس ریسرچ کے حوالے سے مزید معلومات فراہم کی جائے گی

ریسرچ کا مقصد؟ کھانے پکانے کے کچھ طریقے عورتوں کی صحت پر اثرانداز ہوسکتے ہیں۔ ہمارا مقصد اس کو پتہ کرنا ہے۔ہم عورتوں کے کھانا پکانے کے مختلف طریقوں اور اس سے صحت پر ہونے والے اثرات کا جائزہ لے رہے ہیں۔

یہ ریسرچ کون کررہاہے؟ یہ ریسرچ ڈاکٹرظفر فاطمی کررہے ہیں جو کہ کمیونٹی ہیلتھ سائنسس ڈپارٹمنٹ آغا خان یونیورسٹی کراچی میں کام کرتے ہیں۔

میں اس ریسرچ میں کیوں شامل کی جارہی ہوں؟ اس ریسرچ میں40 سال یا اس سے زائد عمرکی خواتین جو اس علاقے میں رہتی ہیں شامل کی جارہی ہیں جو لکڑیاں، گوبر،فصلوں کی لکڑیاں یا گیس کھانا پکانے کے لئے استعمال کرتی ہیں۔

کیا اس ریسرچ میں مجھے شامل ہونا چاہئیے؟ ہم چاہتے ہیں کہ ذیادہ سے ذیادہ لوگ اس ریسرچ میں شامل ہوں تاکہ یہ ریسرچ اچھی طرح ہوسکے۔ لیکن اس ریسرچ میں آپ کا شامل ہونا یا نہ ہونا آپ کے اوپر ہے۔ اگر آپ اس ریسرچ میں شامل ہوتی ہیں تو بھی آپ کسی بھی وقت اس ریسرچ سے بغیر کوئی وجہ بتائے الگ ہوسکتی ہیں۔

اگر میں ریسرچ میں شامل ہوں تو میرے ساتھ کیا ہوگا؟ ہم آپ سے آپ کے گھر میں کھانے پکانے کے طریقوں کے بارے میں سوالات کریں گے اور بہت سے دوسرے معمولات کے سوالات جن سے آپ کی صحت متاثر ہوتی ہے۔اسکے علاوہ ہم آپ کے جسم، وزن اور قد کی پیمائش کریں گے۔ہم آپ کا ECG بھی کریں گے اور پھیپھڑوں کا ٹیسٹ بھی کریں گے۔کچھ گھروں کےباورچی خانہ میں ہم فضائی آلودگی کی پیمائش بھی کریں گے۔

میری دی گئی معلومات کو کون دیکھے گا؟ آپ کی بتائی ہوئی ذاتی معلومات کو ریسرچ ٹیم کے علاوہ کوئی اور نہیں دیکھے گا۔ اور اس کو بہت حفاظت سے دوسروں کی پہنچ سے دور رکھا جائے گا۔ جب اس ریسرچ کو شائع کیا جائے گا تو ہم خیال رکھیں گے کہ آپ کی دی گئی ذاتی معلومات ظاہر نہ ہو سکیں۔

اس ریسرچ میں شامل ہونے کے نقصانات؟ اس سوالنامہ کو پوچھنے کے لیے ہمیں تقریباً 40 منٹ لگیں گے۔ آپ کے جسم، وزن اور قد کی اور دوسری پیمائش بہت آسان اور بغیر کسی تکلیف کے ہوجائیگی۔ اس ریسرچ میں شامل ہونے کا بظاہر کوئی نقصان نہیں ہے۔

اس ریسرچ میں شامل ہونے کے فوائد؟ آپ کو اس ریسرچ میں شامل ہونے کا ذاتی کوئی فائدہ نہیں ہوگا۔ لیکن آپ اس ریسرچ میں شامل ہوکر بیماری کے بچاوء کی بہاری کوششوں میں مدد کرسکتی ہیں۔
اگر آپ کو مزید سوالات پوچھنے ہوں یا آپ کو کوئی اور مسلئہ اس ریسرچ کے متعلق ہو تو آپ ہمیں اس فون نمبر پر کال کرسکتی ہیں۔02134864834

راضی نامہ

کھانا پکانے کے طریقے اور صحت سے متعلق ریسرچ

میں تصدیق کرتی ہوں کہ میں نے اس ریسرچ کے حوالے سے معلومات پڑھ/سمجھ لی ہیں۔ اور یہ کہ میں اس ریسرچ میں رضاکارانہ طور پر شامل ہورہی ہوں۔ اور میں اگر اس ریسرچ سے الگ ہونا چاہوں تو کسی بھی وقت ہوسکتی ہوں اور ریسرچ سے الگ ہونے کی وجہ سے مجھ پر یا میرے حقوق پر کوئی اثر نہیں پڑے گا۔

رضاکار کا نام:

دستخط (یا انگوٹھے کا نشان):

تاریخ:

انٹرویو لینے والے کا نام:

دستخط:

تاریخ

Instruction to the interviewer: HAS THE PARTICIPANT SIGNED THE INFORMED CONSENT? DO NOT PROCEED TILL CONSENT FORM IS SIGNED.

انٹرویو لینے کے لئے ہدایت : کیا شرکت کنندہ نے راضی نامے پر دستخط کر دیے ہیں؟ جب تک راضی نامہ دستخط نہ ہو جائے آگے نہ بڑھیں

Participant ID

SECTION I: Identification details of the patient

Name نام	**First Name** پہلا نام	**Middle Name** درمیانی نام	**Surname** ذات/خاندانی نام
Husband's name (if married) شوہر کا نام (اگر شادی شدہ ہے تو)	**First Name** پہلا نام	**Middle Name** درمیانی نام	**Surname** ذات/خاندانی نام
Father' name (if unmarried) باپ کا نام (اگر غیر شادی شدہ ہے تو)	**First Name** پہلا نام	**Middle Name** درمیانی نام	**Surname** ذات/خاندانی نام
Address: پتہ			
Phone # فون نمبر	**Mobile:** موبائیل		**Landline:** لینڈ لائن

Participant ID

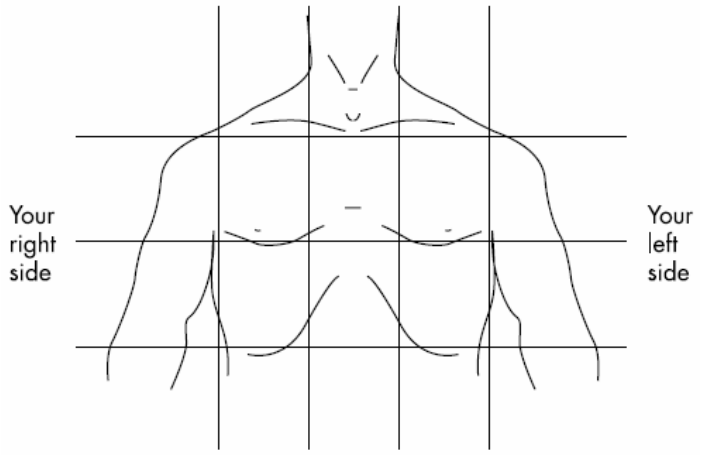
SECTION – II: Questionnaire

Interviewer's name and signature انٹرویولینے والے کا نام	**Name** نام	**Signature** دستخط
what is your mother tongue? آپکی مادری زبان کیا ہے؟ 1. Sindhi سندھی1 2. Urdu اردو2 3. Other [ ] کوئی اور3		
Date of interview [DD/MM/YY] انٹرویو کی تاریخ		

Part A: Socio-Demographic profile			
1.	Age *[in completed years]* عمر (مکمل سالوں میں لکھیں)		
2.	Date of Birth *[if available]* [DD/MM/YYYY] تاریخ پیدائش (اگر معلوم ہو)		
3.	What is your current marital status? ابھی آپکی ازدواجی حیثیت کیا ہے؟	1. Single .1 غیر شادی شدہ 2. Married .2 شادی شدہ 3. Separated/Divorced .3 طلاق یافتہ/علیحدگی 4. Widowed .4 بیوہ 5. Other [ ] .5 کوئی اور( )	
4.	What was your birth weight? پیدائش کےوقت آپکا وزن کیسا تھا؟	1. Lower than normal .1 نارمل سے کم 2. Normal .2 نارمل 3. Higher than normal .3 نارمل سے زیادہ	
5.	Have you lived most of your life in an urban or rural location? آپ کی زندگی کا سب سے زیادہ حصہ دیہی علاقے میں یا شہر میں گزرا؟	1. Rural .1 دیہی 2. Urban .2 شہری 3. Suburban .3 مضافاتی	
6.	During your childhood, did you ever feel hungry all the time because there was not enough food? کیا بچپن میں کبھی گھر میں کھانے کی کمی کی وجہ سے آپ کوبھوکا رہنا پڑتا تھا؟	0. No .0 نہیں 1. Yes .1 ہاں	
6a.	If yes, for how long in total did you feel hungry all the time because there was not enough food? اگر ہاں، تو آپ کو کتنے سارے عرصے اسطرح کھانے کی کمی کی صورت میں بھوکا رہنا پڑا تھا؟	1. Less than one month .1 ایک ماہ سے کم 2. 1-11 months .2 1-11 ماہ 3. 1-5 years .3 1-5 سال 4. More than five years .4 پانچ سال سے زیادہ	
7.	During your childhood, did you ever lose weight? کیا آپکو بچپن میں کبھی اپنے وزن کے کم ہونے کی شکایت ہوئی تھی؟	0. No .0 نہیں 1. Yes .1 ہاں	
8.	What is your religion? آپکا مذہب کیا ہے؟	1. Islam .1 اسلام	

		2. Other [ ] 2. کوئی اور ( ) 3. No response 3. جواب نہیں دیا	
9.	During your childhood, what was your father's main occupation (longest held job during your childhood)? **[Armed Forces, Legislators, Senior Officials and Managers, Professionals, Technicians and Associate Professionals, Clerks, Service Workers and Shop/Market Sales Workers]* ***[Agriculture and Fishery Workers, Crafts and Related Trade Workers, Plant and Machine Operators and Assemblers and Elementary Occupations]* آپکے بچپن کے دوران آپ کے والد صاحب کیا کام کرتے تھے؟ (وہ کام جو آپ کے بچپن کے دوران سب سے زیادہ عرصے تک کیا) (آرمی، پارلیمان، سرکاری آفیسر، منیجر، پروفیشنل، ٹیکنیشین، کلارک، شاپ)* (کھیتی باڑی، ملاح، بڑھئی، مشین آپریٹر، اور مزدوری)**	1. Non-manual work* 1. غیر مشقت والے کام 2. Manual work** 2. مشقت والے کام	
10.	What is your current educational status? ** [A woman, who is not able to write in any language irrespective of her reading capability.]* *** [A woman who is able to write in at least one language and has no formal education.]* آپ کی موجودہ تعلیم کتنی ہے؟ *(وہ عورت جو کسی بھی زبان میں لکھنے کی قابلیت نہ رکھتی ہوچاہے وہ پڑھنا جانتی ہو) **(وہ عورت جو کسی بھی زبان میں لکھنے کی قابلیت رکھتی ہواور کوئ باقاعدہ تعلیم حاصل نہیں کی ہو۔)	1. Illiterate* 1. غیر تعلیم یافتہ 2. Literate, no formal education** 2. تعلیم یافتہ،باقاعدہ تعلیم حاصل نہیں کی۔ 3. Class 1-5 (Primary) 3. کلاس 5- 1 (پرائمری) 4. Class 6-12 (Secondary/H secondary) (IT course, class XII or Intermediate) 4. کلاس12-6 (سیکنڈری، ھائی سیکنڈری، آئی ٹی کورس، انٹر میڈیٹ) 5. Graduate or postgraduate (B.A/B.Sc/B.Com/Diploma) 5. گریجویٹ اورپوسٹ گریجویٹ (بي اى، بي ايس سى، بي كام، ڈپلومہ) 6. Other [ ] 6. کوئی اور( )	
11.	Are you engaged in any other work (paid or unpaid), apart from housework? **[A woman who in engaged in teaching, nursing etc.]* ***[A woman who is engaged in fetching of water, fuel, fodder, agricultural work (sowing, cutting, ploughing on farms, rearing farm animals), construction work, weaving, domestic paid work in other homes etc.]* آپ گھر کے کام کے علاوہ کوئی اور کام کرتی ہیں جسکی آپکو تنخواہ ملتی ہو یا نہ ملتی ہو؟ (ٹیچر، نرس)* (پانی لا نا ،کھیتی باڑی،تعمیر کا کام، مزدوری)**	0. No 0. نہیں 1. Yes - Non-manual work* 1. ہاں - غیر مشقت والے کام 2. Yes - Manual work** 2. ہاں - مشقت والے کام	
12.	What is the total income of your household per month (Pakistani Rupees)? *[Please include income from all members and all sources who contribute to the household]* آپکےگھرکی مکمل ماہانہ آمدنی کتنی ہے ؟ (گھرکے تمام افراد کی آمدنی ملا کر بتائیں)	1. <3000 2. 3000-10,000 3. 10,001-20,000 4. 20,001-30,000 5. 30,001-40,000 6. 40,001-50,000 7. >50,000 8. Refuse to answer 8. جواب سے انکارکر دیا 9. Don't know 9. پتہ نہیں	
13.	How many people live on this income? اس تنخواہ پر کتنے لوگ گزارہ کرتے ہیں؟	*Actual number* اصل تعداد	
14.	Is the house in which you now live, owned by your family or rented? آپکا گھر جس میں آپ اب رھتی ھیں،آپکی اپنی ملکیت ہے یا کرایہ کا ہے؟	1. Owned 1. اپنی ملکیت 2. Rented 2. کرایہ پر	
15.	What is the construction of that house? آپکےگھرکی بناوٹ کیسی ہے؟	1. Pucca 1. پکا 2. Semi-pucca 2. آدھا کچہ،آدھا پکا 3. Katcha 3. کچا	
16.	What was the construction of the house in which you lived longest as a child? جس گھر میں آپ نے اپنے بچپن کا سب سے طویل عرصہ گزارا، اسکی بناوٹ کیسی تھی؟	1. Pucca 1. پکا 2. Semi-pucca 2. آدھا کچہ،آدھا پکا 3. Katcha 3. کچا	

17.	Which of the following do your household own? [0. No 1.Yes] آپ کے گھر میں ان میں سےکیا کیا چیزیں موجود ہیں؟ (0. نہیں 1. ہاں)	a. Tractor a. ٹریکٹر b. Car b. کار c. Motorcycle c. موٹر سائیکل d. Cycle d. سائیکل e. Television/LED/LCD/ LCD /LED/ e. ٹی وی f. Refrigerator f. فریج g. Telephone/ mobile g. ٹیلي فون یا موبائل فون	
18.	Apart from your husband and children, how many other people live in your household (e.g. parents, daughters in law, grandchildren)? آپکے شوہر اور بچے کے علاوہ کتنے اور لوگ آپکے ساتھ رہتے ہیں؟ (مثلا والدین، بہو، پوتا،پوتی)	*Number of people* افراد کی تعداد	
Part B: ROSE ANGINA QUESTIONNAIRE			
1.	Have you ever had any pain, pressure, or discomfort in your chest? کیا آپ کو کبھی سینے میں درد، دباو یا تکلیف محسوس ہوئی ہے؟	0. No 0. نہیں 1. Yes 1. ہاں *If no, skip to next section* اگر نہیں تو اگلے حصے پر جائیے	
2.	Do you get pain, pressure, or discomfort in your chest when you walk uphill or hurry? کیا آپ کو تیز چلنے یا اوپرچڑھائ کی طرف چڑھنے میں سینے میں دباو، درد یا تکلیف محسوس ہوتی ہے؟	0. No 0. نہیں 1. Yes 1. ہاں 2. Do not walk uphill or never hurries 2. اوپر نہیں چڑھتی یا تیز نہیں چلتی	
3.	Do you get it when you walk at an ordinary pace on the level? کیا آپ کویہ درد یا تکلیف محسوس ہوتی ہے جب آپ عام رفتار میں ہموار سطح پر چلتی ہیں؟	0. No 0. نہیں 1. Yes 1. ہاں 2. Do not walk on level ground 2.ہموار سطح پرنہیں چلتی ہوں	
4.	What do you do when you get it while you are walking? آپ کیا کرتی ہیں جب آپ کو چلنے میں یہ درد یا تکلیف محسوس ہوتی ہے؟	1. Stop or slow down 1. رک جاتی ہوں یا رفتار کم کرلیتی ہوں۔ 2. Carry on* 2.چلتی رہتی ہوں۔*	
**if the patient puts nitroglycerine under her tongue then mark option 1.*		اگر مریض زبان کے نیچے **NG** رکھتیں ہیں تو 1 پر نشان لگائیں۔	
5.	If you stand still, what happens to it? اگر آپ رُک جاتی ہیں تو درد یا تکلیف میں کیا فرق محسوس ہوتا ہے؟	1. Relieved 1. آرام آجاتا ھے 2. Not relieved 2. آرام نہیں آتا ھے	
6.	How soon? کتنی جلدی آرام آتا ہے؟	1. 10 minutes or less 1. دس منٹ یا اس سے کم وقت میں 2. More than 10 minutes 2. دس منٹ سے زیادہ وقت میں	
7.	Will you show me where it was? *(multiple options possible)* [0. No 1. Yes] کیا آپ بتائیں گی کہ وہ درد کہاں پر تھا؟	a. Sternum (upper and middle) a. سینے کی درمیانی ہڈی کے اوپری یا بیچ کے حصّے میں b. Sternum (lower) b. سینے کی درمیانی ہڈی کے نیچے کے حصّے میں c. Left anterior chest c. سینے کے بائیں حصّے میں d. Left arm d. بائیں ہاتھ میں e. Other e. اور کوئی If 'other', mark (x) on diagram below اگر کہیں اور تو (x) کا نشان تصویر پر لگائیں	

	(ایک سے زیادہ جوابات ہوسکتے ہیں)  		
Part C: Past medical history			
1.	In the past, have you ever been told by a doctor/nurse/LHV that you had a 'heart attack'? ماضی میں کیا آپ کو کسی ڈاکٹر یا کسی معالج نے بتایا ہے کہ آپکو دل کا دورہ پڑا ہے؟	0. No 0. نہیں 1. Yes 1. ہاں *If no, Skip to question 2* اگرنہیں، سوال نمبر *2* پر جائیں	
1a.	Were you ever admitted to hospital before because of a 'heart attack'? کیا آپ کبھی دل کے دورے کے باعث اسپتال میں داخل ہوئی ہیں؟	0. No 0. نہیں 1. Yes 1. ہاں	
1b.	Have you ever taken any regular medication for 'heart disease'? کیا آپ نے کبھی دل کے دورے کی دوا ئیں مستقل طور پر استعمال کی ہیں؟ (نسخہ کی مدد سے دیکھیں)	0. No 0. نہیں 1. Yes 1. ہاں (If yes, what medications) اگر ھاں ،کون سی دوائی _____ _____ _____	
2.	Have you ever been told by a doctor/nurse/LHV that you had high blood pressure? کیا آپکو کبھی کسی ڈاکٹر یا کسی معالج نے بتایا کہ آپکوبلڈ پریشرہے؟	0. No 0. نہیں 1. Yes 1. ہاں *If no, Skip to q3* اگر نہیں، سوال نمبر 3 پر جائیں.	
2b.	Have you ever taken any regular medication for high blood pressure? کیا آپ نے کبھی بلڈ پریشرکی دوا ئیں مستقل طور پر استعمال کی ہیں؟	0. No 0. نہیں 1. Yes 1. ہاں	
3.	Have you ever had high blood pressure during pregnancy? کیاحمل کے دوران کبھی آپکو بلڈ پریشرکی شکایت ہوئی ہے؟ (اگر غیر شادی شدہ ہیں تو یہ سوال نہ پوچھیں)	0. No 0. نہیں 1. Yes 1. ہاں 2.کبھی چیک نہیں کروایا	
4.	Have you ever been told by a doctor/nurse/LHV that you had diabetes mellitus (sugar)? کیا آپکو کبھی کسی ڈاکٹر یا کسی معالج نے بتایا کہ آپکوزیابیطس (شوگر) ہے؟	0. No 0. نہی 1. Yes ہاں. 1 *If no, skip to next section* اگر نہیں اگلے حصے پر جا ئیں	
4a.	What was your age when you were first told that you had diabetes? آپکی عمر کتنی تھی جب آپکوپہلی دفعہ بتایا گیا کہ آپکو زیابیطس(شوگر) ہے؟	*Age [in years]* عمر(سالوں میں لکھیں)	
4b.	Within the past month, have you had any of the following treatments for diabetes? [0. No 1. Yes] گذشتہ ماہ میں،آپ نے زیابیطس(شوگر) کے لئے ان میں سے کیا طریقہ علاج استعمال کیا؟ (0. نہیں 1. ہاں)	a. A special diet a. پرہیزی کھانا b. Insulin b. انسولین c. Pills c. گولیاں/ دوائیں	
Part D: Family history of Cardiovascular Diseases			

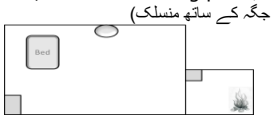
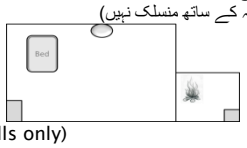
1.	Did your mother ever have a 'heart attack'? کیا آپکی والدہ کوکبھی دل کے دورہ کی شکایت ہوئ ہے؟	0. No 0. نہیں 1. Yes 1. ہاں	
2.	Did your father ever have a 'heart attack'? کیا آپکے والد کوکبھی دل کے دورہ کی شکایت ہوئی ہے؟	0. No 0. نہیں 1. Yes 1. ہاں	
Part E: Cough			
1.	Do you cough on <u>most days</u> for as much as <u>three months each year</u>? کیا ھر سال میں تین ماہ یا اس سے ذیادہ ایسے ہوتے ہیں جن کے ذیادہ تر دنوں میں آپ کھانستی رھتی ھیں ؟	0. No 0. نہیں 1. Yes 1. ہاں If no, skip to F section اگر نہیں، تواگلے حصے پر جائیں	
1a.	For how <u>many years</u> have you had this cough? گذشتہ کتنے سالوں سے آپ کو یہ کھانسی ہے ؟	Number of years سا لوں کی تعداد	
1b.	Do you cough like this even when you don't have a cold? کیا جب آپ کو ذکام نہ بھی ہوتو یہ کھانسی رہتی ہے ؟	0. No 0. نہیں 1. Yes 1. ہاں	
Part F: Phlegm (sputum production)			
1.	Do you bring up phlegm on <u>most days</u> for as much as <u>three months each year</u>? کیا ھر سال میں تین ماہ یا اس سے ذیادہ ایسے ہوتے ہیں جن کے ذیادہ تر دنوں میں آپ بلغم سینے سے نکالتی رھتی ھیں ؟	0. No 0. نہیں 1. Yes 1. ہاں If no, skip to G section اگر نہیں، تواگلے حصے پر جائیں	
1a.	For how <u>many years</u> have you had this phlegm? گذشتہ کتنے سالوں سے آپ سینے سے بلغم نکال رہی ہیں؟	Number of years سا لوں کی تعداد	
1b.	Do you bring up <u>phlegm</u> like this even when you don't have a cold? جب آپ کو زکام نہ بھی ہو تو آپ عموماً سینے سے بلغم نکالتی ہیں؟	0. No 0. نہیں 1. Yes 1. ہاں	
Part G: Wheezing/whistling			
1.	Have you had <u>wheezing</u> or <u>whistling</u> in your chest at any time in the <u>last 12 months</u>? کیا گذشتہ 12ماہ کے دوران کبھی بھی آپ کواپنے سینے سے سیٹی جیسی آوازیں آئی ہیں ؟	0. No 0. نہیں 1. Yes 1. ہاں *If no, skip to next section* اگر نہیں تو اگلے حصے پر جا ئیں	
2.	In the <u>last 12 months</u>, have you ever had an attack of wheezing or whistling that has made you feel <u>short of breath</u>? کیا گذشتہ 12ماہ میں سیٹی جیسی آوازوں کا ایسا دورہ ھے جن کے ساتھ آپ کو سانس میں دشواری کا سامنا ہوا ہے ؟	0. No 0. نہیں 1. Yes 1. ہاں	
Part H: Chest illnesses			
1.	Has a doctor/nurse/LHV ever told you that you have emphysema? کیا ڈاکٹر یا کسی معالج نے آپ کوکبھی بتایا ہے کہ آپ Emphysema میں مبتلا ہیں؟	0. No 0. نہیں 1. Yes 1. ہاں	
2.	Has a doctor/nurse/LHV ever told you that you have asthma, asthmatic bronchitis or allergic bronchitis? کیا ڈاکٹر یا کسی معالج نے آپ کوکبھی بتایا ہے کہ آپ کو دمہ، دمہ والا یا الرجکBronchitis ھے؟	0. No 0. نہیں 1. Yes 1. ہاں	
3.	Has a doctor/nurse/LHV ever told you that you have chronic bronchitis? کیا ڈاکٹر یا کسی معالج نے آپ کوکبھی بتایا ہے کہ آپ کوchronic bronchitis ھے؟	0. No 0. نہیں 1. Yes 1. ہاں	
4.	Has a doctor/nurse/LHV ever told you that you have chronic obstructive pulmonary disease (COPD)? کیا ڈاکٹر یا کسی معالج نے آپ کوکبھی بتایا ہے کہ آپ کوCOPDھے؟	0. No 0. نہیں 1. Yes 1. ہاں	
5.	Has a doctor/nurse/LHV ever told you that you have pneumonia (include bronchopneumonia)? کیا ڈاکٹر یا کسی معالج نے آپ کوکبھی بتایا ہے کہ آپ کونمونیہ یا broncho-pneumonia ھے؟	0. No 0. نہیں 1. Yes 1. ہاں	

6.	Has a doctor/nurse/LHV ever told you that you have asthma? کیا ڈاکٹر یا کسی معالج نے آپ کوکبھی بتایا ہے کہ آپ کودمہ ہے؟	0. No 0. نہیں 1. Yes 1. ہاں	
7.	Has a doctor/nurse/LHV ever told you that you have pulmonary tuberculosis? کیا ڈاکٹر یا کسی معالج نے آپ کوکبھی بتایا ہے کہ آپ کو پھیپھڑوں والی ٹی بی ہے؟	0. No 0. نہیں 1. Yes 1. ہاں	
Part I: Smoking [Cigarette/Bidi/Huqqa] and Chewable tobacco (Paan/related tobacco products)			
1a.	Have you ever smoked <u>cigarettes</u> regularly (at least once a week for a month or more)? کیا آپ نےکبھی باقاعدہ سگریٹ نوشی کی ہے؟ (ایک مہینہ یا اس سے زیادہ دورانیہ کے لئے جس میں آپ نے ہفتے میں کم از کم ایک یا اس سے زیادہ سگریٹ پی ہو)	0. No 0. نہیں 1. Yes 1. ہاں *[If no, skip to q2a]* (اگرنہیں سوال نمبر *2a* پر جائیں.)	
1b.	How old were you when you first started smoking <u>cigarettes</u> regularly? آپکی عمرکتنی تھی جب آپ نے باقاعدہ سگریٹ نوشی شروع کی؟	*Age [in years]* عمر(سالوں میں لکھیں)	
1c.	Do you still smoke <u>cigarettes</u> regularly? کیا آپ ابھی بھی باقاعدہ پرسگریٹ نوشی کرتی ہیں؟	0. No 0. نہیں 1. Yes 1. ہاں *[If yes, skip to q1e]* (اگرہاں، تو سوال *e1* پر جائیں)	
1d.	If you have stopped smoking <u>cigarettes</u> regularly, how old were you when you last smoked cigarettes regularly? اگر آپ نے سگریٹ پینا بند کر دی ہے تو آپ نے آخری دفعہ کس عمرتک باقاعدہ سگریٹ نوشی کی؟	*Age [in years]* عمر(سالوں میں لکھیں)	
1e.	On average over all the time that you smoked cigarettes regularly, how many <u>cigarettes</u> did you smoke per day? ذہن میں رکھتے ہوئے بتائیں تمام وقت میں جب آپ نے سگریٹ نوشی کی تو اوسطاایک دن میں کتنی سگریٹ پی؟	*Actual numbers* اصل تعداد لکھیں *[if <1 per day put 1]* (اگرایک دن میں ایک سے کم ہے تو ایک لکھیں)	
2a.	Have you ever smoked ***<u>bidi</u>*** regularly (at least once a week for a month or more)? کیا آپ نےکبھی باقاعدہ پر بیڑی پی ہے؟ (ایک مہینہ یا اس سے زیادہ دورانیہ کے لئے جس میں آپ نے ہفتے میں کم از کم ایک یا اس سے زیادہ بیڑی پی ہو)	0. No 0. نہیں 1. Yes 1. ہاں *[If no, skip to q3a]* (اگر نہیں،سوال *3a* پر جائیں.)	
2b.	How old were you when you first started smoking ***<u>bidi</u>*** regularly? آپکی عمرکتنی تھی جب آپ نے مستقل طور بیڑی پینی شروع کی؟	*Age [in years]* عمر(سالوں میں لکھیں)	
2c.	Do you still smoke ***<u>bidi</u>*** regularly? کیا آپ ابھی بھی مستقل طور پربیڑی پیتی ہیں؟	0. No 0. نہیں 1. Yes 1. ہاں *[If yes, skip to q2e]* (اگر ہاں، سوال *2e* پر جائیں-)	
2d.	If you have stopped smoking ***<u>bidi</u>*** regularly, how old were you when you last smoked *bidi* regularly? اگر آپ نے بیڑی پینا بند کر دی ہے تو آپ نے آخری دفعہ کس عمرتک باقاعدہ بیڑی پی تھی؟	*Age [in years]* عمر(سالوں میں لکھیں)	
2e.	On average over all the time that you smoked *bidi* regularly, how many ***<u>bidi</u>*** did you smoke per day? ذہن میں رکھتے ہوئے بتائیں تمام وقت میں جب آپ نے بیڑی استعمال کی تو اوسطاایک دن میں کتنی بیڑی پی ہوگی؟	*Actual numbers* اصل تعداد لکھیں *[if <1 per day put 1]* (اگر ایک دن میں ایک سے کم ہے تو ایک لکھیں)	
3a.	Have you ever smoked ***<u>huqqa</u>*** regularly (at least once a week for a month or more)? کیا آپ نےکبھی باقاعدہ حقہ پیا ہے؟ (ایک مہینہ یا اس سے زیادہ دورانیہ کے لئے جس میں آپ نے ہفتے میں کم از کم ایک یا اس سے زیادہ دفعہ حقہ پیا ہو).	0. No 0. نہیں 1. Yes 1. ہاں *[If no, skip to q4a]* (اگر نہیں سوال *4a* پر جائیں)	
3b.	How old were you when you first started smoking ***<u>huqqa</u>*** regularly? آپکی عمرکتنی تھی جب آپ نے باقاعدہ حقہ پینا شروع کیا؟	*Age [in years]* عمر(سالوں میں لکھیں)	
3c.	Do you still smoke ***<u>huqqa</u>*** regularly? کیا آپ ابھی بھی باقاعدہ حقہ پیتی ہیں؟	0. No 0. نہیں 1. Yes 1. ہاں *[If yes, skip to q3e]* (اگر ہاں، سوال *3e* پر جائیں.)	
3d.	If you have stopped smoking ***<u>huqqa</u>*** regularly, how old were you when you last smoked *huqqa* regularly? اگر آپ نے حقہ پینا بند کر دیا ہے تو آپ نے آخری دفعہ کس عمرمیں باقاعدہ حقہ پیا تھا؟	*Age [in years]* عمر(سالوں میں لکھیں)	

3e.	On average over all the time that you smoked *huqqa* regularly, how many times did you smoke *huqqa* per day? ذہن میں رکھتے ہوئے بتائیں تمام وقت میں جب آپ نے باقاعدہ حقہ استعمال کیا تو اوسطاایک دن میں کتنی دفعہ حقہ پیا ہوگا؟	*Actual numbers* اصل تعداد *[if <1 per day put 1]* (اگر ایک دن میں ایک سے کم ہے تو ایک لکھیں)	
4a.	Have you ever used any chewable tobacco *(paan containing tobacco or any other product containing chewed tobacco)* regularly (at least once a week for a month or more)? کیا آپ نےکبھی باقاعدہ چبانے/ کھانے والا تمباکو (مثلا تمباکو والا پان،پان مصالحہ) استعمال کیا ہے؟ [ایک مہینہ یا اس سے زیادہ دورانیہ کے لئے جس میں آپ نے ہفتے میں کم از کم ایک یا اس سے زیادہ دفعہ چبانے/ کھانے والا تمباکو(مثلا تمباکو والا پان،پان مصالحہ) استعمال کیا ہو]	0. No 0. نہیں 1. Yes 1. ہاں *[If no, skip to next section]* (اگر نہیں، اگلے سیکشن پر جائیں.)	
4b.	How old were you when you first started using chewable tobacco *(paan containing tobacco or any other product containing chewed tobacco)* regularly? آپکی عمرکتنی تھی جب آپ نے چبانے/ کھانے والا تمباکو (مثلا تمباکو والا پان،پان مصالحہ) استعمال کرنا شروع کیا؟	*Age [in years]* عمر(سالوں میں لکھیں)	
4c.	Do you still use chewable tobacco *(paan containing tobacco or any other product containing chewed tobacco)* regularly? کیا آپ ابھی بھی باقاعدہ چبانے/ کھانے والا تمباکو (مثلا تمباکو والا پان،پان مصالحہ) استعمال کرتی ہیں؟	0. No 0. نہیں 1. Yes 1. ہاں	
4d.	If you have stopped using chewable tobacco *(paan containing tobacco or any other product containing chewed tobacco)* regularly, how old were you when you last used chewable tobacco regularly? اگر آپ نے چبانے/ کھانے والا تمباکو(مثلا تمباکو والا پان،پان مصالحہ) استعمال کرنا بند کر دیا ہے تو آپ نے آخری دفعہ کس عمرمیں باقاعدہ چبانے/ کھانے والا تمباکو (مثلا تمباکو والا پان،پان مصالحہ، مین پوری) استعمال کیا؟	*Age [in years]* عمر(سالوں میں لکھیں)	
Part J: Environmental tobacco smoke			
1a.	How many of your household members (apart from you) smoke cigarettes? آپ کےعلاوہ آپ کے گھرکے کتنے افراد سگریٹ پیتے ہیں؟	*Actual numbers* اصل تعداد *[If 0, skip to q2a]* (اگر 0 تو سوال نمبر *2a* پر جائیں.)	
1b.	How many of your household members (apart from you) smoke cigarettes in the home? آپ کےعلاوہ آپ کے گھرکے کتنے افراد گھر کے اندر سگریٹ پیتے ہیں؟	*Actual number* اصل تعداد	
1c.	How often do other family members smoke cigarettes in the home? گھرکے دوسرے افراد کتنی دفعہ گھر کے اندر سگریٹ پیتے ہیں؟	0. Never 0. کبھی بھی نہیں 1. Some days 1. کبھی کبھی 2. Every day 2. روزانہ	
2a.	How many of your household members (apart from you) smoke *bidī*? آپ کےعلاوہ آپ کے گھرکے کتنے افراد بیڑی پیتے ہیں؟	*Actual numbers* اصل تعداد *[If 0, skip to q3a]* (اگر 0 تو سوال نمبر *3a* پر جائیں.)	
2b.	How many of your household members (apart from you) smoke *bidi* in the home? آپ کےعلاوہ آپ کے گھرکے کتنے افراد گھر کے اندر بیڑی پیتے ہیں؟	*Actual numbers* اصل تعداد	
2c.	How often do other family members smoke *bidi* in the home? گھرکے دوسرے افراد کتنی دفعہ گھر کے اندر بیڑی پیتے ہیں؟	0. Never 0. کبھی بھی نہیں 1. Some days 1. کبھی کبھی 2. Every day 2. روزانہ	
3a.	How many of your household family members (apart from you) smoke *huqqa*? آپ کےعلاوہ آپ کے گھرکے کتنے افراد حقہ پیتے ہیں ؟	*Actual numbers* اصل تعداد *[If 0, skip to next section]* (اگر 0 تواگلے سیکشن پر جائیں.)	
3b.	How many of your household members (apart from you) smoke *huqqa* in the home? آپ کےعلاوہ آپ کے گھرکے کتنے افراد گھر کے اندر حقہ پیتے ہیں؟	*Actual numbers* اصل تعداد	
3c.	How often do other family members smoke *huqqa* in the home? گھرکے دوسرے افراد کتنی دفعہ گھر کے اندر حقہ پیتے ہیں؟	0. Never 0. کبھی بھی نہیں 1. Some days 1. کبھی کبھی 2. Every day 2. روزانہ	
Part K: Physical activity			
1.	On average, how many days per week do you collect wood for cooking? *(write days per week; for less than one day per week put 0)* اوسطا،آپ ایک ہفتے میں کتنے دن کھانا پکانے کے لئے لکڑیاں جمع کرتی ہیں ؟ (ایک ہفتہ میں کتنے دن ہیں، لکھیں،اگر ایک دن سے کم ہو تو 0 لکھیں)		
2.	On average, how many days per week do you carry water for your household? *(write days per week; for less than one day per week put 0)* اوسطا،آپ ایک ہفتے میں کتنے دن گھر کے لے پانی بھرتی ہیں ؟ (ایک ہفتہ میں کتنے دن ہیں، لکھیں،اگر ایک دن سے کم ہو تو 0 لکھیں)		

3.	On average, how many days per week do you work in an agricultural farm? *(write days per week; for less than one day per week put 0)* اوسطا،آپ ایک ہفتے میں کتنے دن کھیتی باڑی کرنے جاتی ہیں ؟ (ایک ہفتہ میں کتنے دن ہیں، لکھیں،اگر ایک دن سے کم ہو تو 0 لکھیں)		
4.	On average, how many days per week do you wash clothes? *(write days per week; for less than one day per week put 0)* اوسطا،آپ ایک ہفتے میں کتنے دن کپڑے دھوتی ہیں ؟ (ایک ہفتہ میں کتنے دن ہیں، لکھیں،اگر ایک دن سے کم ہو تو 0 لکھیں)		
5.	On average, how many days per week do you go shopping or buying groceries from the market? *(write days per week; for less than one day per week put 0)* اوسطا،آپ ایک ہفتے میں کتنے دن سودا سلف لانے/بازار جاتی ہیں ؟ (ایک ہفتہ میں کتنے دن ہیں، لکھیں،اگر ایک دن سے کم ہو تو 0 لکھیں)		
6.	On average, how many days per week do you do any other heavy work? *(write days per week; for less than one day per week put 0)* [Specify:] اوسطا،آپ ایک ہفتے میں کتنے دن کوئی اور بھاری یا مشقت والا کام کرتی ہیں ؟ (ایک ہفتہ میں کتنے دن ہیں، لکھیں،اگر ایک دن سے کم ہو تو 0 لکھیں) (وضاحت کریں)_____		
7.	Have any of the above activities been reduced due to a health problem? کیا اوپر والے کاموں میں سے کوئ بھی کام آپ کی صحت کی خرابی کی وجہ سے کم ہوا ہے؟ [0. No 1. Yes] [0. نہیں 1. ہاں]		
8.	If yes, then what health problem: اگر ہاں ، تو کس قسم کی بیماری کی وجہ سے:		_____ _____
Part L: Dietary Questionnaire			
1.	What oil/fat do you use for cooking in your household? آپ اپنے گھر میں کھانا پکانے کے لئے تیل یا گھی میں زیادہ کس کا استعمال کرتی ہیں؟	1. Only oil 1. صرف تیل 2. Mostly oil 2. اکثر تیل 3. Half oil/Half ghee 3.آدھا تیل/ آدھا گھی 4. Mostly ghee 4. اکثر گھی 5. Only ghee 5. صرف گھی	
2.	On average, how many liters of ghee/oil does your household use per month? اوسطا، آپکے گھر میں ایک مہینے میں تقریبا کتنا لیٹر (کلو) گھی یا تیل استعمال ہوتا ہے؟	*Actual numbers and decimal [if applicable]* اصل مقدار اور اعشاریے لکھیں	
3.	On average, how often do you eat meat? اوسطا، آپ ایک ہفتہ میں تقریبا کتنی دفعہ گوشت کھاتی ہیں؟	1. Never to <1 times/wk 1. کبھی بھی نہیں/ ہفتے میں ایک دفعہ سے بھی کم 2. 1-2 times/week 2. ہفتے میں 2-1 دفعہ 3. 3-4 times/ week 3. ہفتے میں 4-3 دفعہ 4. >4 times/week 4. ہفتے میں 4 دفعہ سے ذیادہ	
4.	On average, how often do you eat eggs in a week? اوسطا، آپ ایک ہفتہ میں تقریبا کتنی دفعہ انڈہ کھاتی ہیں؟	1. Never to <1 times/wk 1. کبھی بھی نہیں/ ہفتے میں ایک دفعہ سے بھی کم 2. 1-2 times/week 2. ہفتے میں 2-1 دفعہ 3. 3-4 times/ week 3. ہفتے میں 4-3 دفعہ 4. >4 times/week 4. ہفتے میں 4 دفعہ سے ذیادہ	
Part M: Characteristics of fuel, stove type, cooking time and environment			
1a.	When did you last regularly make meals (at least one meal per day on most days of the week) in the house? آخری دفعہ آپ کب گھر میں باقاعدہ (ہفتہ کے زیادہ تر دنوں میں کم از کم ایک دفعہ) کھانا پکاتی تھیں؟	1. Past week 1.گزشتہ ہفتے 2. Not in past week, but in past year 2.گزشتہ ایک ہفتے میں نہیں ، لیکن گزشتہ ایک سال میں 3. More than a year ago (specify how many years ago: _____) 3ایک سال سے زیادہ (وضاحت کریں کتنے سال پہلے:)	
1b.	When was the ***last time*** you made a meal in the house? آخری دفعہ آپ نے گھر میں کب کھانا پکایا تھا؟	1. Within the past 24 hours گزشتہ 24 گھنٹوں کے اندر اندر 2. 1-3 days ago 1-3 دن کے درمیان 3. Longer than 3 days ago 3 دن سے پہلے	

1c.	On average, during the past year, ***how many hours per day*** did you cook? عام طورپر گزشتہ سال آپ نے دن میں تقریبا کتنے گھنٹے کھانا پکایا؟	Actual numbers اصل تعداد [If <1-hour write 1] (اگر 1 گھنٹے سے کم ہو تو 1 لکھیں)	
2a.	Have you ever used ***firewood*** for cooking? کیا آپ نے کبھی کھانا پکانے کے لئے لکڑیاں استعمال کی ہیں؟	0. No 0. نہیں 1. Yes 1. ہاں *[If no, skip to q3a]* (اگر نہیں، سوال نمبر *3a* پر جائیں).	
2b.	For how many years in total have you used firewood for cooking? آپ نے کھانا پکانے کے لے کتنے سال لکڑیوں کا استعمال کیا ہے؟	*Number of years* سالوں کی تعداد *[If <1 year write 1]* (اگر 1 سال سے کم ہو تو 1 لکھیں)	
2c.	Do you still use ***firewood*** for cooking? کیا آپ اب بھی کھانا پکانے کے لےلکڑیاں استعمال کرتی ہیں؟	0. No 0. نہیں 1. Yes 1. ہاں *[If yes, skip to q3a]* (اگر نہیں، سوال نمبر *3a* پر جائیں).	
2d.	If you have stopped, how many years ago did you last use ***firewood*** for cooking? اگر آپ نے استعمال ترک کردیا ہے تو آخری دفعہ کتنے سال پہلے کھانا پکانے کے لےلکڑیوں کا استعمال کیا تھا؟	*Actual [in years]* سالوں کی تعداد *[If <1 year write 1]* اگر 1 سال سے کم ہو تو 1 لکھیں)	
3a.	Have you ever used ***cow dung*** cooking? کیا آپ نے کبھی کھانا پکانے کے لئے گوبر(اوپلے) کا استعمال کیا ہے؟	0. No 0. نہیں 1. Yes 1. ہاں *[If no, skip to q4a]* (اگر نہیں، سوال نمبر *4a* پر جائیں).	
3b.	For how many years in total have you used ***cow dung*** for cooking? آپ نے کھانا پکانے کے لے کتنے سال گوبر(اوپلے) کا استعمال کیا ہے؟	*Number of years* سالوں کی تعداد *[If <1 year write 1]* اگر 1 سال سے کم ہو تو 1 لکھیں)	
3c.	Do you still use ***cow dung*** for cooking? کیا آپ اب بھی کھانا پکانے کے لئے گوبر(اوپلے) کا استعمال کرتی ہیں؟	0. No 0. نہیں 1. Yes 1. ہاں *[If yes, skip to q4a]* (اگر نہیں، سوال نمبر *4a* پر جائیں).	
3d.	If you have stopped, how many years ago did you last use ***cow dung*** for cooking? اگر آپ نے استعمال ترک کردیا ہے تو آخری دفعہ کتنے سال پہلے کھانا پکانے کے لئے گوبر(اوپلے) کا استعمال کیا تھا؟	*Actual [in years]* سالوں کی تعداد *[If <1 year write 1]* اگر 1 سال سے کم ہو تو 1 لکھیں)	
4a.	Have you ever used ***kerosene*** for cooking? کیا آپ نے کبھی کھانا پکانے کے لئے مٹی کا تیل استعمال کیا ہے؟	0. No 0. نہیں 1. Yes 1. ہاں *[If no, skip to q5a]* (اگر نہیں، سوال نمبر *5a* پر جائیں).	
4b.	For how many years in total have you used ***kerosene*** for cooking? آپ نے کھانا پکانے کے لے کتنے سال مٹی کا تیل استعمال کیا ہے؟	*Number of years* سالوں کی تعداد *[If <1 year write 1]* اگر 1 سال سے کم ہو تو 1 لکھیں)	
4c.	Do you still use ***kerosene*** for cooking? کیا آپ اب بھی کھانا پکانے کے لئے مٹی کا تیل استعمال کرتی ہیں؟	0. No 0. نہیں 1. Yes 1. ہاں *[If yes, skip to q5a]* (اگر نہیں، سوال نمبر *5a* پر جائیں.)	
4d.	If you have stopped, how many years ago did you last use ***kerosene*** for cooking? اگر آپ نے استعمال ترک کردیا ہے تو آخری دفعہ کتنے سال پہلے کھانا پکانے کے لئے مٹی کا تیل استعمال کیا تھا؟	*Actual [in years]* سالوں کی تعداد *[If <1 year write 1]* اگر 1 سال سے کم ہو تو 1 لکھیں)	
5a.	Have you ever used ***LPG/Natural Gas/Electricity*** for cooking? کیا آپ نے کبھی کھانا پکانے کے لئے گیس سلینڈر/ سوئی گیس یا بجلی کا چولہا استعمال کیا ہے؟	0. No 0. نہیں 1. Yes 1. ہاں *[If no, skip to q 6a]* (اگر نہیں، سوال نمبر *6a* پر جائیں).	
5b.	For how many years in total have you used ***LPG/Natural Gas/Electricity*** for cooking? آپ نے کھانا پکانے کے لے کتنے سال گیس سلینڈر/ سوئی گیس یا بجلی کا چولہا استعمال کیا ہے؟	*Number of years* سالوں کی تعداد *[If <1 year write 1]* اگر 1 سال سے کم ہو تو 1 لکھیں)	
5c.	Do you still use ***LPG/Natural Gas/Electricity*** for cooking? کیا آپ اب بھی کھانا پکانے کے لئے گیس سلینڈر/ سوئی گیس یا بجلی کا چولہا استعمال کرتی ہیں؟	0. No 0. نہیں 1. Yes 1. ہاں *[If yes, skip to q6a]* (اگر نہیں، سوال نمبر *6a* پر جائیں).	

5d.	If you have stopped, how many years ago did you last use <u>*LPG/Natural Gas/Electricity*</u> for cooking? اگر آپ نے استعمال ترک کردیا ہے تو آخری دفعہ کتنے سال پہلے کھانا پکانے کے لئے گیس سلینڈر/ سوئی گیس یا بجلی کا چولہا استعمال کیا تھا؟	*Actual [in years]* سال کی تعداد *[If <1 year write 1]* اگر 1 سال سے کم ہو تو 1 لکھیں)	
6a.	What type of stove is used for cooking in your house? آپکے گھر میں کھانا پکانے کے لئے کس قسم کاچولہا استعمال کیا جاتا ہے؟	1. Gas/LPG stove 1. گیس / LPG چولہا 2. With chimney/improved stove 2. چمنی / بہتر چولہے کے ساتھ 3. Three bricks - open stove 3. تین اینٹوں والا کھلا چولہا 4. Other type [ ] 4. کوئی اور	
6b.	For how many years have you used this type of stove? آپ نے کتنے سال یہ چولہا استعمال کیا ہے؟	*Actual [in years]* سال کی تعداد *[If <1 year write 1]* اگر 1 سال سے کم ہو تو 1 لکھیں)	
7a.	Do you ever heat your home? کیا آ پ کبھی اپنے گھر کو گرم کرتی ہیں؟	0. No 0. نہیں 1. Yes 1. ہاں *[If no, skip to q8a]* (اگر نہیں، سوال نمبر*8a* پر جائیں)	
7b.	Do you ever use biomass (firewood, cow dung etc.) fuel to heat your home? کیا آ پ اپنے گھر کو گرم کرنے کے لئےلکڑیاں، گوبر وغیرہ والا ایندھن استعمال کرتی ہیں؟	0. No 0. نہیں 1. Yes 1. ہاں	
7c.	On an average, how many days do you heat your home in a year? اوسطا،ایک سال میں آپ تقریبا کتنے دن اپنے گھرکو گرم کرتی ہیں؟	*Actual days* دن کی تعداد	
7d.	Over your whole life, for how many years in total have you lived in a home that was heated with biomass fuel? آپکی ابتک کی پوری زندگی کے دوران، آپ کتنے سال ایسے گھر میں رہی ہیں جہاں لکڑی یا گوبروالے ایندھن سے گھرکو گرم کیا جاتا تھا؟	*Actual in years* سال کی تعداد	
8a.	What type of kitchen does your household normally use for cooking? *[If more than one kitchen is used in the same household, then note the most commonly used kitchen]* آپکے گھرمیں عام طور پر کھانا پکانے کے لئے کس قسم کا باورچی خانہ استعمال کیا جاتا ہے؟ (اگر گھر میں ایک سے زیادہ باورچی خانے استعمال کئے جاتے ہوں تو جو سب سے زیادہ استعمال ہوتا ہو،اس کے بارے میں لکھیں) (تصویر کی مدد سے پوچھیں) 1. Closed combined (multipurpose room) 1. بند مشترکہ کمرہ (کثیر مقاصد والا کمرہ)  2. Closed linked (sheltered with four walls, linked with living place) 2. بند جُڑا ہوا (چار دیواری کے ساتھ چھت، رہنے کی جگہ کے ساتھ منسلک)  3. Closed separate (sheltered with four walls, not linked with living place) 3. بند علیحدہ (چار دیواری کے ساتھ چھت، رہنے کی جگہ کے ساتھ منسلک نہیں)  4. Three walls (sheltered with three walls only) 4. تین دیواریں (صرف تین دیواروں کے ساتھ ہی)  5. Two walls (sheltered with two walls only) 5. دو دیواریں (صرف دو دیواروں کے ساتھ ہی)  6. One wall (sheltered with one wall only) 6. ایک دیوار (ایک دیوار کے ساتھ)  7. No walls (shelter without walls) 7. دیواروں کے بغیر (صرف چھت دیواروں کے بغیر)	

	 8. Open air (without walls or shelter) 8. کھلی جگہ  9. Other (specify):_____ 9. کوئی اور(وضاحت کریں)		
8b.	What type roof does the kitchen have? آپ کے باورچی خانے کی چھت کس چیز کی بنی ہوئی ہے؟	1. Concrete 1. سیمنٹ 2. Bricked / Tiled 2. اینٹوں کی / ٹائیل 3. Thatched 3. مٹی کی لیپ سے 4. No roof 4. کوئی چھت نہیں 5. Others (specify)[ ] 5. کوئی اور(وضاحت کریں)	
8c.	Is there any chimney/eaves in the kitchen? کیا آپ کے باورچی خانے میں کوئی چمنی یا روشندان ہے؟	0. No 0. نہیں 1. Yes 1. ہاں	
Part N: Occupational exposures			
1.	Have you ever worked for a year or more in any dusty job? کیا آپ نے کبھی ایک سال یا اس سے زیادہ دھول مٹی والی نوکری کی ہے؟	0. No 0. نہیں 1. Yes 1. ہاں *If no, skip to next section* اگر نہیں تو اگلے حصے پر جائیں	
2.	Specify jobs/industries (write all) کام کی نوعیت (تمام کام لکھیں)	1._____ 2._____ 3._____ 4._____	
3.	Total number of years employed in this (these) occupation(s)? ان/ اس ملازمت (ملازمتوں) کا مکمل دورانیہ کتنا تھا؟	Number of years سالوں کی تعداد	

Part O: Anthropometric Measurements				
1.	Height (in cm) قد (سینٹی میٹر میں)			
2.	Weight (Kg) وزن (کلوگرام میں)			
3.	Waist circumference (cm) کمر کا ناپ (سینٹی میٹر میں)			
4.	Hip circumference (cm) کولہے کا ناپ (سینٹی میٹر میں)			
5.	Leg length (cm) ٹانگ کی لمبائی (سینٹی میٹر میں)			

Blood pressure measurements **بلڈ پریشر**	**Systolic blood pressure (mmHg)**	**Diastolic blood pressure (mmHg)**
1st		
2nd (after 5 minutes)		
3rd (after 10 minutes)		
Part P: Attach and scan ECG here		

Appendix B : Questionnaire for Case-control study [Case form]

ڈپارٹمنٹ آف ڪميونٽي هيلٿ سائنس آغا خان يونيورسٽي ڪراچي

ڪاڏي پڇائڻ جئ طريقن ۾ صحت جي باري ۾ تحقيق

توهان کي هن ريسرچ جي باري ۾ ڏ ني وجي پئي.
ريسرچ جو مقصد ؟ ڪاڏي پڇائڻ جا ڪجهه طريقا عورتن جي صحت تي اثر انداز ٿيندا آهن. اسان جو مقصد اهي اثر انداز آهن. ڪاڏي پڇائڻ جي مختلف طريقن ۾ ان جو صحت تي پوند ڙ اثرن جو جائذو وٺنداسي.
هيءَ ريسرچ ڪير ڪري رهيوآهي؟ هيءَ ريسرچ ڈڪٽر ظفر فاطمي ڪري رهيا آهن جيڪي ڪميونٽي هيلٿ سائنسز ڈپارٽمينٽ ۾ ڪم ڪند آهن.

مون کي هن ريسرچ ۾ ڇو شامل ڪيو پيو وحيي؟ هيءَ ريسرچ نواب شا ه ۾ ميرپور خاص جي اسپتالن ۾ مختلف مرضن جي ڪري ڏخل عورتن تي ڪئي پئي وجي. تومان جو مرض بہ انهن مرضن ۾ شامل آهي.

چامون کي هن ريسرچ ۾ شامل ٿيڻ گهر جي؟ اسان چاميون ٿا تہ وڌکان وڌ يک ماڻهو هن ريسرچ ۾ شامل ٿين تہ جيئن ريسرچ سڻي طرح سان ٿي سگهي. هن ريسرچ ۾ شامل ٿيڻ يا نہ ٿيڻ توهان جي مٿان آهي . جيڪڈهن توهان ريسرچ ۾ شامل ٿيو ٿا نہ تڈهن بہ توهان ڪنهن بہ وقت هن ريسرچ مان ڪوئي بہ وجهہ ٻڌائڻ بغير الگ ٿي سگهو ٿا.

جيڪڈهن مان ريسرچ ۾ شامل ٿيندس تہ مون سا چا ٿيندو؟ اسان توهان کان توهان جي گهر ۾ ڪاڏي پڇائڻ جي طريقن ۾ ٻين معمولات جي باري ۾ سوال پڇندا سي، جيڪي توهان جي صحت تي اثر انداز ٿي سگهن ٿا . ان کان علاوه جڈهن توهان جي طبيعت بهتر ٿيندي تہ اسان توهان جي جسم، وزن ۾ قد جي ماپ ڪنڈاسي. اسان توهان جي اجازت سان اسپتال ۾ ٿيند ڙٽيسٽ جي معلومات وٺندسي.

منهنجي ڈنل معلومات ڪير ڪير ڈ سندو؟ توهان جي بڌيل ذا تي معلومات ريسرچ ٽيم کان ڪو ئي علاوه ٻيو بہ نہ ڈسندو. جڈ هن ريسرچ ڪي شايع ڪيو وبيندو تہ اسان رڪند سي تہ توهان جي ذا تي معلومات ظاهر نہ ڪئي وحئي.

هن ريسرچ ۾ شامل ٿيڻ جا نقصانات ؟ هن ريسرچ ۾ شامل ٿيڻ جا بظاهر کوئي نقصان نہ آهن. هي سوالنامو پڇڻ ۾ يقر ياً 30 منٽ لڳندا ۾ توهان جي جسم وزن ۾ قد جي پيمائش انتهائي آسان ۾ بغيرڪنهن تڪليف جي ڪئي ويندي.
هن ريسرچ ۾ شامل ٿيڻ جا فائدا؟ هن ريسرچ ۾ شامل ٿيڻ سان توهان کي ذاتي ڪوئي فا ئدو نہ پهپندو. پر هن ريسرچ ۾ شامل ٿي توهان بيماري کان بچاء جي ڪوشش ۾ اسان جي مدد ڪري سگهوٿا.

هن ريسرچ جي با ري ۾ و ڈ يک معلومات لاءِ توهان هن فون نمبر تي رابطو ڪري سگهو ٿا.
021-34864834

راضي نامو

ڪاڏي پڇا ڪ جي طر يقن ۾ صحت جي باري ۾ تحقيق

مان تصديق ڪيان ٿي تہ مان هن ريسرچ جي حوالي سان معلومات پڙهي / سمجهي آهي.
مان هن ريسرچ ۾ رضاڪارا ٿہ طور تي شامل ٿي رهي آهيان ۽ اهو تہ جيڪڏهن مان چاهيان تہ ڪنهن بہ وقت هن ريسرچ کان الگ ٿي سگهان ٿي ۽ ريسرچ سان الگ ٿيڻ جي صورت ۾ مون تي يا منهنجي حقن تي ڪوئي اثر نہ پوندو.

رضاڪار جو نالو: _____

دستخط (يا اگوٺي جو نشان): _____

تاريخ: _____

انٽرويو وٺڻ واي جو نالو: _____

دستخط: _____

تاريخ: _____

Instruction to the interviewer: HAS THE PARTICIPANT SIGNED THE INFORMED CONSENT? DO NOT PROCEED TILL CONSENT FORM IS SIGNED.
[Questionnaire for CASES]

Participant ID ☐☐☐ - ☐☐ - ☐☐

SECTION I: Identification details of the patient

Name نالو	*First Name* پهريون نالو	*Middle Name* وچون نالو	*Surname* ذات
Husband's name (if married) مڙس جو نالو (اگر شادي شده آهي ته)	*First Name* پهريون نالو	*Middle Name* وچون نالو	*Surname* ذات
Father' name (if unmarried) پئي جو نالو	*First Name* پهريون نالو	*Middle Name* وچون نالو	*Surname* ذات
Address: ايدريس	☐		1. ميرپورخاص 2. نوابشاه 3. بدين 4. چامشورو 5. خيرپور 6. مٹياري 7. نوشيروفيروز 8. سانگهڙ 9. ٹاندو الله يار 10. ٹرپارکر 11. عمرڪوٽ
Phone # فون نمبر	Mobile: موبائيل		Landline: لينڈ لائن

Participant ID ☐☐☐ - ☐ - ☐☐

Interviewer's name and signature انٽرويو ونڊ واري جو نالو	**Name** نالو	**Signature** دستخط

What is your mother tongue?
توهان جي مادر زبان ڪهڙي آهي

4. Sindhi
سنڌي
5. Urdu
اردو
6. Other [ ]
ٻئي ڪا

☐

Date of interview [DD/MM/YY]
انٽرويو جي تاريخ ☐☐ / ☐☐ / ☐☐

Time of interview [HR: MIN]
انٽرويو جو وقت ☐☐ : ☐☐

Date of admission [DD/MM/YY]
داخلا جي تاريخ ☐☐ / ☐☐ / ☐☐

Time of admission [HR: MIN]
داخلا جو وقت ☐☐ : ☐☐

Mode of admission
داخلا جو ذريعو

1. Emergency
1. ايمرجنسي
2. OPD
2. او پي ڊي

☐

Participant ID ☐☐☐ - ☐ - ☐☐

SECTION – II: Questionnaire

Part A: Socio-Demographic profile and lifetime exposure			
1.	Age *[in completed years]* عمر (سالن ۾)	☐☐	*Not sure [ask the attendant]* اگر ياد نه آهي ته گهر وارن کان پڇو
2.	Date of Birth *[if available]* [DD/MM/YYYY] تاريخ پيدائش	☐☐ / ☐☐ / ☐☐☐	
3.	What is your height? *[in feet and inches]* توهان جو قد ڪيترو آهي.(فٽ ۽ انچن ۾) [ ] know dont	☐ . ☐ Feet فٽ Inches انچ	
4.	What is your weight? *[in Kgs]* توهان جو وزن (ڪلو ۾) [ ] know dont	☐☐☐	
5.	What is your current marital status? توهان جي ازدواجي حيثيت	1. Single .1 غير شادي شده 2. Married .2 شادي شده 3. Separated/Divorced .3 طلاق يافته 4. Widowed .4 بيوه	☐
6.	What was your birth weight? توهان جي وزن پيدا هڻڻ وقت	1. Higher than normal .1 نارمل کان وڌيڪ 2. Normal .2 نارمل 3. Lower than normal .3 نارمل کان گهٽ	☐
7.	Which language do you speak at home? توهان گهر ۾ ڪهڙي زبان ڳالهندا آهيو	1. Urdu .1 اردو 2. Sindhi .2 سنڌي 3. Other [ ] .3 ٻئي ڪا	☐
8.	Where were you born? توهان جي جاءِ پيدائش	1. Sindh rural [except Karachi/Hyderabad] .1 سنڌ ٻهراڙي (ڪراچي ۽ حيدرآباد کان علاوه) 2. Sind urban [Karachi/Hyderabad] .2 سنڌ شهري (ڪراچي ۽ حيدرآباد) 3. Other [ ] .3 ٻئو ڪو	☐
9.	During your childhood, did you ever feel hungry all the time because there was not enough food? ڄڻ‌ڏهن توهان ننڍا هئا ڇا توهان کي هر وقت بک لڳندي هئي، ڇا ڪاڻ ڪاڏو هئو	1. Yes .1 ها 0. No .0 نه	☐
10.	During your childhood, did you ever lose weight? ننڍپڻ ۾ توهان وزن ڪڏهن گهٽ ٿيو هئو	1. Yes .1 ها 0. No .0 نه	☐
11.	What is your religion? توهان جو مذهب ڪهڙو آهي.	1. Islam .1 اسلام 2. Other [ ] .2 ٻئو ڪو( ) 3. No response .3 جواب ڪونه ڏنو	☐
12.	During your childhood, what was your father's main occupation (i.e. longest held job during your childhood)? **[Agriculture and Fishery Workers, Crafts and Related Trade Workers, Plant and Machine Operators and Assemblers and Elementary Occupations]* ***[Armed Forces, Legislators, Senior Officials and Managers, Professionals, Technicians and Associate Professionals, Clerks, Service Workers and Shop/Market Sales Workers]* ننڍ ۾ توهان جي والد صاحب جو سب بنيادي ڏنڏو ڇا هئو(اهو ڏنڏو جنهن سان سڀ کا وڌيڪ عرصو لاڳاپيل رهيا).	1. Manual work* .1 هٿ جو ڪم 2. Non-manual work** .2 آفس 3. Father did not work during Childhood .3 ڪم نه ڪندا هئا 4. Father died before patient was born or did not live with family .4 مريض جي جنمڻ کان پهريون ئي والد جو انتقال ٿئي ويو هويا پنهنجي گهر وارن سان گڏ ڪونه رهندا هئا	☐

13.	What is your current educational status? ** [A woman, who is not able to write in any language irrespective of her reading capability.]* *** [A woman who is able to write in at least one language and has no formal education.]* توهان جي موجوده تعليم ڪيتري آهي. * (هڪ عورت، جياڪ ڪنهن به زبان ۾ لکڻ جي قابل نا هجي.) ** (هڪ عورت جيڪا ڪنهن به هڪ زبان ۾ لکي سگهي ته اها نارمل تعليم نه آهي)	1. Illiterate* 1. اڻپڙهيل 2. Literate, no formal education** 2. تعليم يافته فارمل تعليم نه آهي. 3. Class 1-5 (Primary) 3. ڪلاس 1-5 (پرائمري) 4. Class 6-12 (Secondary/H secondary) (IT course, class XII or Intermediate) 4. ڪلاس 6-12 (سيڪنڊري، هائي سيڪنڊري، آئي ٽي ڪورس، ڪلاڪ 12 يا انٽر ميڊيٽ). 5. Graduate and post graduate (B.A/B.Sc/B.Com/Diploma) 5. گريجوئٽ ۽ پوسٽ گريجوئٽ (بي اي، بي ايس سي، بي ڪام، ڊپلومه) 6. Other [ ] 6. ٻئي ڪا	
14.	Are you engaged in any other work (paid or unpaid), apart from your housework in your own home? ** [A woman who is engaged in fetching of water, fuel, fodder, agricultural work (sowing, cutting, ploughing of farms, rearing farm animals), construction work, weaving, domestic paid work in other homes etc.]* *** [A woman who in engaged in teaching, nursing etc.]* *چا توهان پنهنجي گهر ۾ گهرو ڪم ڪان علاوه ڪو ٻيو ڪم ڪندا آهيو(پيسن تي يا بنا پيسن تي).*	0. No 0. نه 1. Yes – Manual work* 1. ها هڏ جو ڪم 2. Yes – Non-manual work** 2. ها بغير هڏ جو	
15.	What is the total income of your household per month? [Please include income from all members and all sources who contribute to the household] توهان جي گهر جي ڪل ماهوار ڪمائي ڪيتري آهي؟ (گهر جي سڀ ڀاتين ۽ سڀ ذريعن کي ملائي)	1. <3000 2. 3000-10,000 3. 10,001-20,000 4. 20,001-30,000 5. 30,001-40,000 6. 40,001-50,000 7. >50,000 8. Refuse to answer 8. جواب ڪونه ڏنو 9. Don't know 9. خبر نه آهي.	
16.	How many people live on this income? گهر جا ڪيترا ڀاتي هن ڪمائي تي رهندا آهن؟	*Actual number* اصلي نمبر	
17.	Was the main house in which you lived during the last year, owned by your family or rented? گذريل سال توهان جنهن گهر ۾ گذريو، اهو توهان جو پنهنجو آهي يا ڪرائي جو؟	1. Owned 1. پنهنجو 2. Rented 2. ڪرائي جو	
18.	What is the construction of that house? اهو گهر چا جو ٺهيل آهي.	1. Katcha 1. ڪچو 2. Semi-pucca 2. ڪچو پڪو 3. Pucca 3. پڪو	
19.	What was the construction of the house in which you lived longest as a child? اهو گهر چا جو ٺهيل هوجنهن ۾ توهان سڀ کان وڌيڪ وقت گذاريو جڏهن توهان ننڍا هئا	1. Katcha 1. ڪچو 2. Semi-pucca 2. ڪچو پڪو 3. Pucca 3. پڪو	
20.	Which of the following do your household own? توهان جي گهر ۾ هنڌين مان ڪهڙي شيءَ آهي. [1. Yes 0. No] (1. ها 0. نه)	1. Tractor 1. ٽريڪٽر 2. Car 2. ڪار 3. Motorcycle 3. موٽر سائڪل 4. Cycle 4. سائيڪل 5. Television 5. ٽي وي 6. Refrigerator 6. فرج 7. Telephone/ mobile 7. ٽيلي فون يا موبائل فون	*Write '0' for No and '1' for Yes for each corresponding item.*
21.	Apart from your husband and children, how many other people live in your household (e.g. parents, daughters in law, grandchildren)? توهان جي گهر واري ۽ ٻارن کان علاوه، گهر ۾ ٻيا ڪيترا ڀاتي رهندا آهن.(والدين، ننڍن، پوتا، ڏوٽرا)	Number of people ماڻهن جو تعداد	
Part B: Presenting Complaints			

1.	During the 24 hours before you came into hospital, did you suffer from discomfort or pain in: اسپتال اچڻ کان 24 ڪلاڪ پهريون ڇا توهان کي تڪليف هئي. 1. Your chest 1. ڇاتي ۾(سيني ۾) 2. Your left shoulder, arm or hand 2. کاٻي ڪلهي، ٻانهن يا هٿ ۾. 3. Your jaw 3. جاڙي ۾. 4. The upper part of your stomach 4. معدي جي مٿيئن حصي ۾. [1. Yes 0. No] (0. نه 1. ها)		*Write '0' for No and '1' for Yes for each corresponding item.*
1a.	How long in total did you have any such pain/discomfort in the 24 hours before you came into hospital? توهان کي گذريل 24 ڪلاڪن ۾ اهڙو سور يا تڪليف توهان کي ڪل ڪيتري دير تائين رهي(اسپتال اچڻ کان پهريون) 1.≤20 minutes 1. 20 يا 20 منٽن کان گهٽ 2. >20 minutes 2. 20 منٽن کان وڌيڪ 3. Not applicable (no pain or discomfort) 3. سور نه هيو (ضرورت ناهي)		
2.	In the past, have you ever been told by a health care provider that you had a 'heart attack'? [If no, Skip to next section (Part C)] ڇا ماضي ۾ ڪڏهن ڪنهن ڊاڪٽر توهان کي ٻڌايو ته توهان کي دل جو دورو پيو آهي. [1. Yes 0. No] (0. نه 1. ها)		
3.	Were you ever admitted to hospital before because of a 'heart attack'? ڇا ڪڏهن توهان دل جي دوري سبب اسپتال ۾ داخل ٿيا آهيو. [1. Yes 0. No] (0. نه 1. ها)		
4.	How long ago you were last admitted to hospital because of a 'heart attack'? ڪيترو وقت پهريون توهان آخري دفعو دل ۾ تڪليف سبب اسپتال ۾ داخل رها. 1.Within the last 28 days; 1. گذريل 28 ڏينهن ۾ 2. More than 28 days ago; 2. 28 ڏينهن کان وڌيڪ 3. Not applicable (never previously admitted because of a 'heart attack') 3. پهريون ڪڏهن دل جي تڪليف سبب داخل نه ٿيو آهيان.		
Part C: Previous History of Blood Pressure and Diabetes Mellitus			
1a.	Have you ever been told by a health care provider that you had high blood pressure? ڇا ڪڏهن ڊاڪٽر (معالج) توهان کي بلڊ پريشر وڌڻ جي ٻڌايو.	1. Yes .1 ها 0. No .0 نه *[If no, Skip to q1c]* اگر نه *1 c* نمبر وڃو	
1b.	Have you ever taken any regular medication for high blood pressure? ڇا توهان بلڊ پريشر جي باقاعدگي سان دوا ڪائيندا آهيو.	1. Yes .1 ها 0. No .0 نه	
1c.	Have you ever had high blood pressure during pregnancy? ڇا پيٽ (حمل) سان هڻ وقت بلڊ پريشر وڌيو آهي.	1. Yes .1 ها 0. No .0 نه	
2a.	Have you ever been told by a health care provider that you had diabetes mellitus (sugar)? ڇا ڪڏهن ڪنهن ڊاڪٽر توهان کي شوگر جي تشخيص ڪئي.	1. Yes .1 ها 0. No .0 نه *[If no, skip to q3a]* تي وڃو.*3a* اگر نه ته سوال نمبر	

2b.	What was your age when you were first told that you had diabetes? جڏهن توهان کي شوگر جي خبر پئي ته ان وقت توهان جي عمر ڪيتري هئي	Age *[in years]* عمر [سالن ۾]	
2c.	Within the past month, have you had any of the following treatments for diabetes? گذريل مهيني توهان شوگر جي لاءِ ڪهڙو علاج ڪيو. [1. Yes, 0. No] (1. هان 0. نه)	1. A special diet 1. پرهيز وارو کاڌو 2.Insulin 2. انسولين 3. Pills 3. گوريون	*Write '0' for No and '1' for Yes for each corresponding item.*
3a.	Have you ever been told by a health care provider that you had chronic bronchitis or emphysema (COPD)? ڪڏهن ڪنهن معالج توهان کي پراڻي ڦڦڑن جي بيماري جي تشخيص ڪئي (دم COPD)	1. Yes 1. ها 0. No 0. نه *[If no, skip to 4]* اگر نه سوال نمبر 4 تي وڃو	
3b.	Do you take regular medications for chronic bronchitis or emphysema (COPD)? چا توهان ڦڦڑن جي بيماري لاءِ باقاعده دوا کائيندا آهيو.	1. Yes 1. ها 0. No 0. نه	
4.	Have you ever been told by a health care provider that you had lung cancer? چا ڪڏهن ڪنهن ڊاڪٽر توهان کي ڦڦڑن جي ڪينسر جي تشخيص ڪئي.	1. Yes 1. ها 0. No 0. نه	
Part D: Family history of Cardiovascular Diseases			
1.	Did your mother ever have a 'heart attack'? چا توهان جي والده کي ڪڏهن دل جو دورو پيو آهي.	1. Yes 1. ها 0. No 0. نه	
2.	Did your father ever have a 'heart attack'? چا توهان جي والد کي ڪڏهن دل جو دورو پيو آهي.	1. Yes 1. ها 0. No 0. نه	
Part E: Smoking [Cigarette/Bidi/Huqqa] and Chewable tobacco (Paan/related tobacco products)			
1a.	Have you ever smoked <u>cigarettes</u> regularly (at least once a week for a month or more)? چا توهان ڪڏهن باقاعدگي سان سگريٽ پيئندا آهيو(گهٽ ۾ گهٽ هفتي ۾ هڪ مهيني ڇا وڌيڪ عرصي تائين)	1. Yes 1. ها 0. No 0. نه *[If no, skip to q2a]* اگر نه ته سوال نمبر *2a* تي وڃو.	
1b.	How old were you when you first started smoking <u>cigarettes</u> regularly? توهان ڪيتري عمر ۾ سگريٽ پيئڻ شروع ڪيو.	Age *[in years]* عمر [سالن ۾]	
1c.	Do you still smoke <u>cigarettes</u> regularly? چا توهان هاڻي به سگريٽ پيئندا آهيو.	1. Yes 1. ها 0. No 0. نه *[If No, skip to q1e]* اگر نه ته *1e* تي وڃو	
1d.	If you have stopped smoking <u>cigarettes</u> regularly, how old were you when you last smoked cigarettes regularly? توهان ڪيتري عمر م سگريٽ پيئڻ ڇڏي ڏني	Age *[in years]* عمر [سالن ۾]	
1e.	On average over all the time that you smoked cigarettes regularly, how many <u>cigarettes</u> did you smoke per day? توهان هڪ ڏينهن ۾ ڪيترا سيگريٽ پيئندا آهيو.	*Actual numbers [if <1 per day put 1]* تعداد لکو	
2a.	Have you ever smoked ***<u>bidi</u>*** regularly (at least once a week for a month or more)? چا توهان ڪڏهن باقاعدگي سان بيڙي پيتي. (گهٽ ۾ گهٽ هفتي ۾ هڪ دفعو، مهيني يا وڌيڪ عرصي تائين)	1. Yes 1. ها 0. No 0. نه *[If no, skip to q3a]* اگر نه ته *3a* تي وڃو.	
2b.	How old were you when you first started smoking ***<u>bidi</u>*** regularly? توهان ڪيتري عمر ۾ بيڙي پيئڻ شروع ڪئي؟	Age *[in years]* عمر [سالن ۾]	
2c.	Do you still smoke ***<u>bidi</u>*** regularly? چا توهان هاڻي به بيڙي پيئندا آهيو.	1. Yes 1. ها 0. No 0. نه *[If No, skip to q2e]*	

		تي وڃو.*2e* اگر نه ته	
2d.	If you have stopped smoking ***bidi*** regularly, how old were you when you last smoked *bidi* regularly? توهان ڪيتري عمر ۾ بيڙي پيئڻ ڇڏي ڏني.	Age *[in years]* عمر [سالن ۾]	
2e.	On average over all the time that you smoked *bidi* regularly, how many ***bidi*** did you smoke per day? توهان هڪ ڏينهن ۾ ڪيترين بيڙين پيئندا آهيو؟	*Actual numbers* *[if <1 per day put 1]* تعداد لکو (اگر هڪ کان گهٽ آهي ته هڪ لکو)	
3a.	Have you ever smoked ***huqqa*** regularly (at least once a week for a month or more)? ڇا توهان ڪڏهن باقاعدگي سان حقو پيتو آهي.	1. Yes .1 ها 0. No .0 نه*[If no, skip to q4a]* (اگر نه سوال *4a* تي وڃو)	
3b.	How old were you when you first started smoking ***huqqa*** regularly? توهان ڪيتري عمر ۾ حقو پيئڻ شروع ڪيو؟	Age *[in years]* عمر [سالن ۾]	
3c.	Do you still smoke ***huqqa*** regularly? ڇا توهان اڃا تائين حقو پيئندا آهيو؟	1. Yes .1 ها 0. No .0 نه*[If no, skip to q3e]* اگر نه ته سوال *3e* تي وڃو.	
3d.	If you have stopped smoking ***huqqa*** regularly, how old were you when you last smoked *huqqa* regularly? توهان ڪيتري عمر ۾ حقو پيئڻ ڇڏي ڏنو؟	Age *[in years]* عمر [سالن ۾]	
3e.	On average over all the time that you smoked ***huqqa*** regularly, how many times did you smoke ***huqqa*** per day? توهان ڏينهن ۾ ڪيترا دفعه حقو پيئندا آهيو؟	*Actual numbers* *[if <1 per day put 1]* تعداد لکو	
4a.	Have you ever used any chewable tobacco ***(paan containing tobacco or any other product containing chewed tobacco)*** regularly (at least once a week for a month or more)? ڇا توهان ڪڏهن چبائڻ وارو تماڪ (پان گهٽڪو مين پڙي) باقاعدگي سان استعمال ڪيو آهي. (گهٽ ۾ گهٽ هفتي ۾ هڪ دفعو، هڪ مهيني يا وڌيڪ عرصي لاءِ)	1. Yes .1 ها 0. No .0 نه *[If no, skip to next section (Part F)]* اگر نه ته سيڪشن *F* تي وڃو	
4b.	How old were you when you first started using chewable tobacco ***(paan containing tobacco or any other product containing chewed tobacco)*** regularly? توهان ڪيتري عمر ۾ چبائڻ وارو تماڪ (پان گهٽڪو، مين پڙي) کائڻ شروع ڪئي.	Age *[in years]* عمر [سالن ۾]	
4c.	Do you still use chewable tobacco ***(paan containing tobacco or any other product containing chewed tobacco)*** regularly? توهان اڃان تائين چبائڻ وارو تماڪ (پان گهٽڪو، مين پڙي) کائيندا آهيو.	1. Yes .1 ها 0. No .0 نه*[If no, skip to Part F]* اگر نه ته وڃو *Part F* تي.	
4d.	If you have stopped using chewable tobacco ***(paan containing tobacco or any other product containing chewed tobacco)*** regularly, how old were you when you last used chewable tobacco regularly? اگر توهان چبائڻ وارو تماڪ (پان گهٽڪو مين پڙي) کائڻ ڇڏي ڏني آهي ته ڪهڙي عمر ۾ ڇڏي آهي.	Age *[in years]* عمر [سالن ۾]	
4e.	On average over all the time that you smoked ***huqqa*** regularly, how many times did you smoke ***huqqa*** per day? توهان ڏينهن ۾ ڪيترا ڪڏهن چبائڻ وارو تماڪ (پان گهٽڪو مين پڙي) استعمال ڪيو آهي ؟	*Actual numbers* *[if <1 per day put 1]* تعداد لکو	
Part F: Environmental tobacco smoke			
1a.	How many of your household members (apart from you) smoke cigarettes? توهان کان علاوه گهر جا ٻيا ڪيترا پاتي سگريٽ پيئندا آهن؟	*Actual numbers* *[If 0, skip to q2a]* اگر 0 تو سوال نمبر *2a* تي وڃو.	
1b.	How many of your household members (apart from you) smoke cigarettes in the home? توهان کان علاوه گهر جا ڪيترا پاتي گهر جي اندر سگريٽ پيئندا آهن.	*Actual numbers* اصل نمبر	

1c.	How <u>often</u> do other family members smoke cigarettes in the home? گهر جا ٻيا پاڻي ڪيترا دفعه گهر جي اندر سگريٽ پيئندا آهن؟	2. Every day 2. روزانو 1. Some days 1. ڪڏهن ڪڏهن 0. Never 0. ڪڏهن به نه	
2a.	How many of your household members (apart from you) smoke *bidi*? توهان کان علاوه گهر جا ڪيترا پاڻي ٻيڙي پيئندا آهن؟	*Actual numbers* اصل نمبر *[If 0, skip to q3a]* اگر 0 تو سوال نمبر *3a* تي وڃو.	
2b.	How many of your household members (apart from you) smoke *bidi* in the home? توهان جي گهر جا ڪيترا پاڻي گهر جي اندر ٻيڙي پيئندا آهن؟	*Actual numbers* تعداد لکو	
2c.	How often do other family members smoke *bidi* in the home? گهر جا ٻيا ڪيترا دفعه گهر اندر ٻيڙي پيئندا آهن؟	2. Every day .2 روزانو 1. Some days 1. ڪڏهن ڪڏهن 0. Never 0. ڪڏهن به نه	
3a.	How many of your household family members (apart from you) smoke *huqqa*? توهان کان علاوه گهر جا ٻيا ڪيترا پاڻي حقو پيئندا آهن؟	*Actual numbers* تعداد *[If 0, skip to next section (Part G)]* اگر 0 تو سيڪشن *G*تي وڃو.	
3b.	How many of your household members (apart from you) smoke *huqqa* in the home? توهان کان علاوه گهر جا ڪيترا پاڻي گهر اندر حقو پيئندا آهن؟	*Actual numbers* تعداد لکو	
3c.	How often do other family members smoke *huqqa* in the home? گهر جا ٻيا پاڻي ڪيترا دفعه گهر جي اندر حقو پيئندا آهن؟	0. Never 0. ڪڏهن به نه 1. Sometimes 1. ڪڏهن ڪڏهن 2. Most of the time 2. هر وقت	
Part G: Physical activity			
1.	On average, how many days per week do you collect wood for cooking? *(write days per week; for less than one day per week put 0)* توهان هڪ هفتي ۾ تقريبا گهٽا ڏينهن ڪاٺيون ڪرڻ ويندا آهيو؟ (ڏينهن لکو هفتي جا اگر هفتي ۾ هڪ ڏينهن کان گهٽ هجي ته 0 وجهو)		
2.	On average, how many days per week do you fetch water for your household? *(write days per week; for less than one day per week put 0)* توهان هڪ هفتي ۾ تقريبا گهٽا ڏينهن گهر لاءِ پاڻي پرڻ ويندا آهيو؟ (ڏينهن لکو هفتي جا اگر هفتي ۾ هڪ ڏينهن کان گهٽ هجي ته 0 وجهو)		
3.	On average, how many days per week do you work in an agricultural farm? *(write days per week; for less than one day per week put 0)* توهان هفتي ۾ گهٽا ڏينهن ٻنيءَ ۾ ڪم ڪندا آهيو. (ڏينهن لکو هفتي جا اگر هفتي ۾ هڪ ڏينهن کان گهٽ هجي ته 0 وجهو)		
4.	On average, how many days per week do you wash clothes? *(write days per week; for less than one day per week put 0)* توهان هفتي ۾ تقريبا گهٽا ڏينهن ڪپڑا ڌوئيندا آهيو. (ڏينهن لکو هفتي جا اگر هفتي ۾ هڪ ڏينهن کان گهٽ هجي ته 0 وجهو)		
5.	On average, how many days per week do you go shopping or buying groceries from the market? *(write days per week; for less than one day per week put 0)* توهان هفتي ۾ گهٽا ڏينهن خريداريءَ(ڪپڑا، سيڈو) لاءِ ويندا آهيو؟ (ڏينهن لکو هفتي جا اگر هفتي ۾ هڪ ڏينهن کان گهٽ هجي ته 0 وجهو)		
6.	On average, how many days per week do you do any other heavy work? *(write days per week; for less than one day per week put 0)* توهان هفتي ۾ گهٽا ڏينهن ٻيو وزي ڪم ڪندا آهيو. (ڏينهن لکو هفتي جا اگر هفتي ۾ هڪ ڏينهن کان گهٽ هجي ته 0 وجهو) [Specify:] (وضاحت ڪيو_____)		
Part H: Dietary Questionnaire			
5.	What oil/fat do you use for cooking in your household? گهر ۾ ڪاڌي پچائڻ لاءِ ڪهڑو تيل استيمال ڪندا آهيو.	1. Only oil 1. رڳو تيل 2. Mostly oil 2. اڪثر ڪيل تيل 3. Half oil/Half ghee 3. اڌ تيل اڌ گيهه 4.Mostly ghee 4. اڪثر ڪري گيهه 5.Only ghee 5. رڳو گيهه	
6.	On average, how many liters of ghee/oil does your household use per month? توهان جي گهر ۾ هڪ مهيني اندر تقريبا ڪيترا ليٽر (ڪلو) گيهه يا تيل استيمال ٿيندو آهي؟	Actual numbers and decimal, *(if applicable)* مقدار لکو	.

7.	On average, how often do you eat meat? توهان ڪيترا دفعه گوشت کائيندا آهيو؟	1. Never to <1 times/wk 1. ڪڏهن به نه ، هفتي ۾ هڪ دفعي کان گهٽ 2. 1-2 times/week 2. هفتي ۾ 2-1 دفعه 3. 3-4 times/ week 3. هفتي ۾ 4-3 دفعه 4. >4 times/week 4. هفتي ۾ 4 کان وڌيڪ دفعه	
8.	On average, how often do you eat eggs in a week? توهان هفتي ۾ گهٽا دفعا اندا کائيندا آهيو؟	1. Never to <1 times/wk 1. ڪڏهن به نه . هفتي ۾ هڪ دفعي کان گهٽ 2. 1-2 times/week 2. هفتي ۾ 2-1 دفعه 3. 3-4 times/ week 3. هفتي ۾ 4-3 دفعه 4. >4 times/week 4. هفتي ۾ 4 کان وڌيڪ دفعه	
Part I: Characteristics of fuel, stove type, cooking time and environment			
1a.	Have you ever used *firewood etc.* cooking? چا توهان ڪڏهن ڪاڏي پچائڻ لاءِ ڪائيون استعمال ڪندا آهيو؟	1. Yes 1. ها 0. No 0. نه *[If no, skip to q2a]* اگر نه ته سوال نمبر *2a* تي وڃو	
1b.	For how many years in total have you used *firewood etc.* for cooking? توهان ڪيترا سال ڪائيون استعمال ڪيون آهن؟	*Number of years* سالن جي تعداد *[If <1 year write 1]* اگر 1 سال کان گهٽ ته 1 وجهو	
1c.	Do you still use *firewood* etc. for cooking? چا توهان هاڻي به ڪائيون استعمال ڪيو پيا؟	1. Yes 1. ها 0. No 0. نه *[If no, skip to q2a]* اگر نه ته سوال نمبر *2a* تي وڃو	
1d.	If you have stopped, how many years ago did you last use *firewood etc.* for cooking? اگر توهان استعمال ڪرڻ ڇڏي ڏنو آهي ته ڪيترا سال پهريون توهان آخري دفعو ڪائيون استعمال ڪيون	*Actual [in years]* سالن جي تعداد	
2a.	Have you ever used *cowdung etc.* cooking? چا توهان ڪڏهن ردّ پچاءُ لاءِ چيڀا استعمال ڪيا؟	1. Yes 1. ها 0. No 0. نه *[If no, skip to q3a]* اگر نه ته سوال نمبر *3a* تي وڃو	
2b.	For how many years in total have you used *cowdung* etc. for cooking? توهان ڪيترن سالن تائين چيڀا استعمال ڪيا؟	*Number of years* سالن جي تعداد *[If <1 year write 1]* اگر 1 سال تائين ته 1 لکو	
2c.	Do you still use *cowdung* etc. for cooking? چا توهان اڃا تائين چيڀا استعمال ڪندا آهيو؟	1. Yes 1. ها 0. No 0. نه *[If no, skip to q3a]* اگر نه ته سوال نمبر *3a* تي وڃو	
2d.	If you have stopped, how many years ago did you last use *cowdung* etc. for cooking? اگر استعمال ڪرڻ ڇڏي ڏنو آهي ته ڪيترا سال پهريون توهان آخري دفعو چيڀا استعمال ڪيا؟	*Actual [in years]* سالن جي تعداد *[If <1 year write 1]* اگر 1 سال کان گهٽ ته 1 لکو	
3a.	Have you ever used *kerosene* for cooking? چا توهان ڪڏهن ردّ پچاءُ جي لاءِ گاسليٽ استعمال ڪيو آهي؟	1. Yes 1. ها 0. No 0. نه *[If no, skip to q4a]* اگر نه ته سوال نمبر *4a* تي وڃو	
3b.	For how many years in total have you used *kerosene* for cooking? توهان ڪيترا سال ردّ پچاءُ لاءِ گاسليٽ استعمال ڪيو؟	*Number of years* تعداد سالن ۾ *[If <1 year write 1]* اگر 1 سال کان گهٽ ته 1 لکو	
3c.	Do you still use *kerosene* for cooking? چا توهان هاڻي به ردّ پچاءُ لاءِ گاسليٽ استعمال ڪندا آهيو؟	1. Yes 1. ها 0. No 0. نه *[If yes, skip to q4a]* اگر ها سوال نمبر *4a* تي وڃو	
3d.	If you have stopped, how many years ago did you last use *kerosene* for cooking? اگر استعمال ڪرڻ ڇڏي ڏنو آهي ته ڪيترا سال پهريون آخري دفعو ردّ پچاءُ لاءِ گاسليٽ استعمال ڪيو؟	*Actual [in years]* سالن جي تعداد *[If <1 year write 1]* اگر 1 سال کان گهٽ ته 1 لکو	
4a.	Have you ever used *LPG/Natural Gas/Electricity* for cooking? چا توهان ڪڏهن ردّ پچا لاءِ LPG/ گيس يا بجلي جو استعمال ڪيو آهي؟	1. Yes 1. ها 0. No 0. نه *[If no, skip to q 5]* اگر نه ته سوال نمبرتي وڃو	
4b.	For how many years in total have you used *LPG/Natural Gas/Electricity* for cooking? توهان ڪيترا سال LPG/ گيس يا بجلي جو استعمال ڪيو؟	*Number of years* سالن جي تعداد *[If <1 year write 1]* اگر 1 سالن کان گهٽ ته 1 لکو	
4c.	Do you still use *LPG/Natural Gas/Electricity* for cooking? چا توهان ردّ پچاءُ لاءِ هن وقت تائين LPG/ گيس يا بجلي استعمال ڪندا آهيو؟	1. Yes 1. ها 0. No 0. نه *[If yes, skip to q5]* اگر وا ته سوال نمبر5 تي وڃو	

4d.	If you have stopped, how many years ago did you last use <u>*LPG/Natural Gas/Electricity*</u> for cooking? توهان ڪيترا سال پهريون LPG/ گيس / بجلي جو استعمال بند ڪيو؟	*Actual [in years]* سالن جي تعداد *[If <1 year write 1]* اگر 1سال کان گهٽ ته 1 لکو	
5.	On average, during the past year, <u>*how many hours*</u> per day did you cook? توهان گذريل سال ڏينهن ۾ تقريبا گهڻا ڪلاڪ ردّ پچاءُ ڪيو؟	*Actual numbers* تعداد *[If <1 hour write 1]* اگر 1 ڪلاڪ کان گهٽ ته 1 لکو	
6a.	What type of stove is used for cooking in your house? توهان جي گهر ۾ ردّ پچاءُ لاءِ ڪهڙو چلهو استعمال ٿيندو آهي؟	1. Three bricks - open stove 1. ٽن سرن وارو کليل چلهو. 2. Stove with chimney 2. چمنيءَ وارو چلهو 3. Other type [ ] 3. ٻيو ڪجه (وضاحت ڪريو)	
6b.	For how many years have you used this type of stove? توهان ڪيترن سالن کان مٿيون چلهو استعمال ڪيو پيا؟	*Actual* تعداد *[If <1 year write 1]* اگر 1 سال کان گهٽ ته 1 لکو	
7a.	Do you ever heat your home? چا توهان پهنجي گهر ۾ گرمائش لاءِ باهه بارينداآهيو؟	11. Yes 1. ها 0. No 0. نه *[If no, skip to q8a]* اگر نه ته سوال نمبر *8a* تي وڃو	
7b.	Do you use biomass (firewood, cowdung etc.) fuel to heat your home? چا توهان گرمائش لاءِ بايوماس (ڪاٺيون، چيڙا) استعمال ڪندا آهيو؟	1. Yes 1. ها 0. No 0. نه	
7c.	On an average, how many days do you heat your home in a year? توهان هڪ سال ۾ تقريبا گهڻا ڏينهن گهر ۾ گرمائش لا باهه بارينداآهيو؟	*Actual days* تعداد ڏينهن جو	
7d.	Over your whole life, for how many years in total have you lived in a home that was heated with biomass fuel?	*Actual in years*	
8a.	What type of kitchen does your household normally use for cooking? توهان جي گهر ۾ ردّ پچا ءِ ڪهڙي قسم جو رڌڻو استعمال ٿيندو آهي؟ *[If more than one kitchen is used in the same household, then note the most commonly used kitchen]* (اگر هڪ کان وڌيڪ ڌڌڻو استعمال ٿيندو آهي ته گهڻو استعمال ٿيندڙ رڌڻو لکو)	1. Closed combined (multipurpose room) 2. Closed separate (sheltered with four walls, linked with living place) 3. Closed separate (sheltered with four walls, not linked with living place) 4. Closed (sheltered with three walls only) 5. Open air (sheltered with two walls only) 6. Open air (sheltered with one wall only) 7. Open air (with shelter without walls) 8. Open air (without walls and shelter) 9. Others (specify)	
8b.	What type roof does the kitchen have? رڌڻي جي ڇت چا جي ٺهيل آهي؟	1. Concrete 1. سيمنٽ 2. Bricked / Tiled 2. سرون / ٽائيل 3. Thatched 3. ڪ ۾ مٽيءَ جي 4. Others (specify) 4. ٻيو ڪجه	
8c.	Is there any chimney in the kitchen? چا رڌڻو ۾ بخار ٺهيل آهي؟	1. Yes 1. ها 0. No 0. نه	

SECTION - III **Participant ID**
PATIENT'S RECORD and MEASUREMENTS

Part A: Electrocardiographic (ECG) findings [in first acceptable ECG carried out after symptoms developed]	
• ST segment changes [ST elevation of >1 mm (one small square) in ≥2 contiguous leads] *[≥2 of lead I, aVL, v5, v6 ; or≥2 of lead II, III, aVF; or at least two adjacent leads from V1 to V6.]* *(if possible get a xerox copy).* [1. Present 0. Absent]	
• Pathological Q waves [> 0.04 seconds in width (one small square) and greater than 2mm (two small squares) in depth] 1. Present 0. Absent	
Part B: Cardiac biomarkers [record the highest level (including units) with dates if more than one level of the same biomarker is available since the onset of symptoms]	
CK-MB *(write units here)* [ ]	.
Record the date when blood was drawn for CK-MB *[DD/MM/YY]*	/ /
Troponin – I (write units here) [ ]	.
Record the date when blood was drawn for Troponin – I *[DD/MM/YY]*	/ /
Troponin – T *(write units here)* [ ]	.
Record the date when blood was drawn for Troponin-T *[DD/MM/YY]*	/ /

Part E: Anthropometric Measurements		
6.	Height (cm) قد (سينٽي ميٹر م)	
7.	Weight (Kg) وزن (ڪلو م)	
8.	Waist circumference (cm) چيله (سينٽي ميٹر م)	
9.	Hip circumference (cm) سڌر جي (ماپ سينٽي ميٹر)	
10.	Leg length (cm) ٽنگ جي لمبائي (سينٽي ميٹر)	

References

Alam DS, Chowdhury MAH, Siddique AT, Ahmed S, Hossain MD, Pervin S et al. Adult cardiopulmonary mortality and indoor air pollution: a10-year retrospective cohort study in a low-income rural setting. Global Heart 2012; 7:215-21.

Alexander D, Larson T, Bolton S, Vedal S. Systolic blood pressure changes in indigenous Bolivian women associated with an improved cookstove intervention. Air Qual Atmos Health 2015; 8:47-53.

Ali MK, Bhaskarapillai B, Shivashankar R, Mohan D, Fatmi Z, Pradeepa R, Masood Kadir M, Mohan V, Tandon N, Narayan KM, Prabhakaran D; CARRS investigators. Socioeconomic status and cardiovascular risk in urban South Asia: The CARRS Study. Eur J Prev Cardiol. 2016 Mar;23(4):408-19.

Alpert JS, Thygesen K, Antman E, Bassand JP. Myocardial infarction redefined-a consensus document of The Joint European Society of Cardiology/American College of Cardiology Committee for the redefinition of myocardial infarction. J Am Coll Cardiol. 2000;36(3):959-69.

Angerås O, Albertsson P, Karason K, Råmunddal T, Matejka G, James S, et al. Evidence for obesity paradox in patients with acute coronary syndromes: a report from the Swedish Coronary Angiography and Angioplasty Registry. Eur Heart J. 2013;34(5):345-353.

Antoniades C, Antonopoulos AS, Tousoulis D, Marinou K, Stefanadis C. Homocysteine and coronary atherosclerosis: from folate fortification to the recent clinical trials. Eur Heart J. 2009;30(1):6-15.

Assmann G, Schulte H, von Eckardstein A, Huang Y. High-density lipoprotein cholesterol as a predictor of coronary heart disease risk. The PROCAM experience and pathophysiological implications for reverse cholesterol transport. Atherosclerosis 1996; 124(suppl): 11–20.

Austin MA, Hokanson JE. Epidemiology of triglycerides, small dense low-density lipoprotein, and lipoprotein(a) as risk factors for coronary heart disease. Med Clin North Am. 1994;78(1):99-115.

Azizi BH, Zulkifli HI, Kasim S. Indoor air pollution and asthma in hospitalized children in a tropical environment. J Asthma 1995; 32(6):413-8.

Banerjee A, Mondal NK, Das D, Ray MR. Neutrophilic inflammatory response and oxidative stress in premenopausal women chronically exposed to indoor air pollution from biomass burning. Inflammation 2012; 35:671-83.

Barker DJ, Osmond C. Infant mortality, childhood nutrition, and ischaemic heart disease in England and Wales. Lancet. 1986;1(8489):1077-81.

Barker DJ, Gluckman PD, Godfrey KM, Harding JE, Owens JA, Robinson JS. Fetal nutrition and cardiovascular disease in adult life. Lancet. 1993;341(8850):938-41.

Barker DJP, Winter PD, et al. Weight in infancy and death from ischaemic heart disease. Lancet 1989; ii:577–580.

Bass EB, Follansbee WP, Orchard TJ. Comparison of a supplemented Rose Questionnaire to exercise thallium testing in men and women. J Clin Epidemiol. 1989;42(5):385-94.

Baumgartner J, Schauer JJ, Ezzati M, Lu L, Cheng C, Patz JA et al. Indoor air pollution and blood pressure in adult women living in rural China. Environ Health Perspect 2011; 119:1390-5.

Baumgartner J, Zhang Y, Schauer JJ, Huang W, Wang Y, Ezzati M. Highway proximity and black carbon from cookstoves as a risk factor for higher blood pressure in rural China. PNAS 2014; 111:13229-34.

Baumgartner J, Zhang Y, Schauer JJ, Ezzati M, Patz JA, Bautista LE. Household air pollution and children's blood pressure. Epidemiology 2012; 23:641-642.

Baweja PS, Sandesara PB, Ashraf MJ. Asymptomatic coronary artery disease in type II diabetes. Mo Med. 2014;111(1):73-9.

Behera D, Aggarwal G. 2010. Domestic cooking fuel exposure and tuberculosis in Indian women. Indian Journal of Chest Diseases and Allied Sciences.

Behera D, Balamugesh T. Indoor air pollution as a risk factor for lung cancer in women. J Assoc Physicians India. 2005;53:190-2.

Berlin JA, Colditz GA. A meta-analysis of physical activity in the prevention of coronary heart disease. American Journal of Epidemiology, 1990, 132(4):612–628.

Bhopal R, Unwin N, White M, Yallop J, Walker L, Alberti KG, Harland J, Patel S, Ahmad N, Turner C, Watson B, Kaur D, Kulkarni A, Laker M, Tavridou A. Heterogeneity of coronary heart disease risk factors in Indian, Pakistani, Bangladeshi, and European origin populations: cross-sectional study. BMJ. 1999;319(7204):215-20.

Bhopal R. What is the risk of coronary heart disease in South Asians? A review of UK research. J Public Health Med. 2000;22(3):375-85. Review.

Bonjour S, Adair-Rohani H, Wolf J, Bruce NG, Mehta S, Prüss-Ustün A, Lahiff M, Rehfuess EA, Mishra V, Smith KR. Solid fuel use for household cooking: country and regional estimates for 1980-2010. Environ Health Perspect. 2013;121(7):784-90.

Brien SE, Ronksley PE, Turner BJ, Mukamal KJ, Ghali WA. Effect of alcohol consumption on biological markers associated with risk of coronary heart disease: systematic review and meta-analysis of interventional studies. BMJ. 2011;342:d636.

Brook RD, Franklin B, Cascio W, Hong Y, Howard G, Lipsett M, Luepker R, Mittleman M, Samet J, Smith SC Jr, Tager I. Air pollution and cardiovascular disease: a statement for healthcare professionals from the Expert Panel on Population and Prevention Science of the American Heart Association. Circulation 2004; 109:2655–71.

Bruce N, Perez-Padilla R, Albalak R. Indoor air pollution in developing countries: a major environmental and public health challenge. Bull World Health Organ. 2000;78(9):1078-92. Review.

Burroughs Peña M, Romero KM, Velazquez EJ, Davila-Roman VG, Gilman RH, Wise RA et al. Relationship between daily exposure to biomass fuel smoke and blood pressure in high-altitude Peru. Hypertension 2015; 65:1134-40.

Buturak A, Genç A, Ulus ÖS, Guygu E, Ökmen AŞ Uyarel H. Evaluation of the effects of chronic biomass fuel smoke exposure on peripheral endothelial functions: an observational study. Anadolu Kardiyol Derg 2011;11:492-7.

Caravedo, M A, Painschab MS, Davila-Roman VG, De Ferrari A, Gilman RH et al. Lack of association between chronic exposure to biomass fuel smoke and markers of right ventricular pressure overload at high altitude. Am Heart J 2014; 168:731-8.

Castelli WP. Epidemiology of coronary heart disease: The Framingham study. American Journal of Medicine 1984, page 4.

Chowdhury R, Warnakula S, Kunutsor S, Crowe F, Ward HA, Johnson L, Franco OH, Butterworth AS, Forouhi NG, Thompson SG, Khaw KT, Mozaffarian D, Danesh J, Di Angelantonio E. Association of dietary, circulating, and supplement fatty acids with coronary risk: a systematic review and meta-analysis. Ann Intern Med. 2014;160(6):398-406.

Christiansen TB and Lauritsen JM. (Ed.) EpiData - Comprehensive Data Management and Basic Statistical Analysis System. Odense Denmark, EpiData Association, 2010-. http://www.epidata.dk

Chung A, Chang DP, Kleeman MJ, Perry KD, Cahill TA, Dutcher D, McDougall EM, Stroud K. Comparison of real-time instruments used to monitor airborne particulate matter. J Air Waste Manag Assoc. 2001;51(1):109-20.

Clark ML, Bachand AM, Heiderscheidt JM, Diaz-Sanchez D, Carter JD, Neas LM et al. Use of dried blood spots to measure the impact of an indoor cookstove intervention on changes in systemic inflammation. Epidemiology 2012;23: S280.

Clark ML, Peel JL, Balakrishnan K, Breysse PN, Chilrud SN, Naeher LP et al. Health and household air pollution from solid fuel use: the need for improved exposure assessment. Environ Health Perspect 2013;121:1120-8.

Clark ML, Bazemore H, Reynolds SJ, Heiderscheidt JM, Conway S, Bachand AM et al. A baseline evaluation of traditional cook stove smoke exposures and indicators of cardiovascular and respiratory health among Nicaraguan women. Int J Occup Environ Health 2011; 17:113-21.

Colditz GA, Stampfer MJ, Willett WC, Rosner B, Speizer FE, Hennekens CH. A prospective study of parental history of myocardial infarction and coronary heart disease in women. Am J Epidemiol. 1986; 123:48–58.

Conroy RM, Pyorala K, Fitzgerald AP, Sans S, Menotti A, De Backer G, et al. Estimation of ten-year risk of fatal cardiovascular disease in Europe: the SCORE project. Eur Heart J. 2003; 24:987-1003.

Crampin AC, Glynn JR, Floyd S, Malema SS, Mwinuka VK, Ngwira BMM, et al. Tuberculosis and gender: Exploring the patterns in a case-control study in Malawi. Int J Tuberc Lung Dis. 2004; 8:194-203.

Crawford MH, DiMarco JP, Paulus WJ, editors. Cardiology. 3rd Edition. Philadelphia: Mosby; 2009.

Crow RS, Prineas RJ, Hannan PJ, Grandits G, Blackburn H. Prognostic associations of Minnesota Code serial electrocardiographic change classification with coronary heart disease mortality in the Multiple Risk Factor Intervention Trial. Am J Cardiol. 1997;80(2):138-44.

Crow RS, Prineas RJ, Jacobs D, Blackburn H. A new classification system for interim myocardial infarction from serial electrocardiographic changes. Am J Cardiol 1989; 64:454–461.

Dauchet L, Amouyel P, Dallongeville J. Fruits, vegetables and coronary heart disease. Nat Rev Cardiol. 2009;6(9):599-608.

Davutoglu V, Zengin S, Sari I, Yildrim C, Al B, Yuce M et al. Chronic carbon monoxide exposure is associated with the increases in carotid intima-media thickness and C-reactive protein level. Tohoku J Exp Med 2009;219:201-6.

de Hartog JJ, Ayres JG, Karakatsani A, Analitis A, Brink HT, Hameri K, Harrison R, Katsouyanni K, Kotronarou A, Kavouras I, Meddings C, Pekkanen J, Hoek G. Lung function and indicators of exposure to indoor and outdoor particulate matter among asthma and COPD patients. Occup Environ Med. 2010;67(1):2-10.

De Schutter A, Lavie CJ, Milani RV. The impact of obesity on risk factors and prevalence and prognosis of coronary heart disease-the obesity paradox. Prog Cardiovasc Dis. 2014;56(4):401-8.

Dockery DW, Pope CA, Xu X, Spengler JD, Ware JH, Fay ME et al. An association between air pollution and mortality in six US cities. N Engl J Med 1993; 329:1753-9.

Dockery DW, Pope CA, Xu X, Spengler JD, Ware JH, Fay ME, Ferris BG Jr, Speizer FE. An association between air pollution and mortality in six U.S. cities. N Engl J Med 1993; 329: 1753–1759.

Dodani S. Excess coronary artery disease risk in South Asian immigrants: can dysfunctional high-density lipoprotein explain increased risk? Vasc Health Risk Manag. 2008; 4(5):953-61.

Dutta A, Mukherjee B, Das D, Banerjee A, Ray MR. Hypertension with elevated levels of oxidized low-density lipoprotein and anticardiolipin antibody in the circulation of premenopausal Indian women chronically exposed to biomass smoke during cooking. Indoor Air 2011; 21:165-176.

Dutta A, Ray MR, Banerjee A. Systemic inflammatory changes and increased oxidative stress in rural Indian women cooking with biomass fuels. Toxicol Appl Pharmacol 2012; 261:255-62.

EARLYREAD Collaboration. Birth weight and risk of type 2 diabetes: A quantitative systematic review of published evidence. Journal of the American Medical Association, 2008, 300:2885–2897.

Echalar F, Gaudichet A, Cachier H, Artaxo P. Aerosol emissions by tropical forest and savanna biomass burning: Characteristic trace elements and fluxes. Geophysical Research Letters 1995; 22(22):3039-3042.

Edmondson D, Kronish IM, Shaffer JA, Falzon L, Burg MM. Posttraumatic stress disorder and risk for coronary heart disease: a meta-analytic review. Am Heart J. 2013;166(5):806-14.

Enstrom JE, Kabat GC. Environmental tobacco smoke and coronary heart disease mortality in the United States-a meta-analysis and critique. Inhal Toxicol. 2006;18(3):199-210.

Ezzati M, Kammen D. Indoor air pollution from biomass combustion and acute respiratory infections in Kenya: an exposure-response study. Lancet. 2001 Aug 25;358(9282):619-24. Erratum in: Lancet 2001;358(9287):1104.

Ezzati M, Kammen DM. Quantifying the effects of exposure to indoor air pollution from biomass combustion on acute respiratory infections in developing countries. Environ Health Perspect. 2001;109(5):481-8.

Fatmi Z, Coggon D, Kazi A, Naeem I, Kadir MM, Sathiakumar N. Solid fuel use is a major risk factor for acute coronary syndromes among rural women: a matched case-control study. Public Health 2014; 128:77-82.

Firdaus G, Ahmad A. Indoor air pollution and self-reported diseases – a case study of NCT of Delhi. Indoor Air 2011;21: 410-416.

Fischbacher CM, Bhopal R, Unwin N, et al. The performance of the Rose angina questionnaire in South Asian and European origin populations: a comparative study in Newcastle, UK. Int J Epidemiol. 2001;30: 1009-1016.

Fischbacher CM, Hunt S, Alexander L. How physically active are South Asians in the United Kingdom? A literature review. J Public Health (Oxf). 2004;26(3):250-8. Review.

Franklin BA, Brook R, Arden Pope C 3rd. Air pollution and cardiovascular disease. Curr Probl Cardiol. 2015 May; 40(5):207-38. doi: 10.1016/j.cpcardiol.2015.01.003. Epub 2015 Jan 3. Review.

Friedman LM, Byington RP. Assessment of angina pectoris after myocardial infarction: comparison of 'Rose Questionnaire' with physician judgment in the Beta-Blocker Heart Attack Trial. Am J Epidemiol. 1985;121(4):555-62.

Fullerton DG, Bruce N, Gordon SB. Indoor air pollution from biomass fuel smoke is a major health concern in the developing world. Trans R Soc Trop Med Hyg 2008;102:843-51.

Gao Y-T, Blot WJ, Zheng W et al. Lung cancer among Chinese women. Int. J. Cancer 1987; 40: 604–9.

Garcia-Sancho MC, Garcia-Garcia L, Baez-Saldana R, Ponce-De-Leon A, Sifuentes-Osornio J, Bobadilla-Del-valle M, et al. Indoor pollution as an occupational risk factor for tuberculosis among women: A population-based, gender oriented, case-control study in southern Mexico. Rev Invest Clin. 2009; 61:392-398.

Goldbourt U, Yaari S, Medalie JH. Isolated low HDL cholesterol as a risk factor for coronary heart disease mortality. A 21-year follow-up of 8000 men. Arterioscler Thromb Vasc Biol 1997; 17 (1): 107–113.

Gordon SB, Bruce NG, Grigg J, Hibberd PL, Kurmi OP, Lam KB, Mortimer K, Asante KP, Balakrishnan K, Balmes J, Bar-Zeev N, Bates MN, Breysse PN, Buist S, Chen Z, Havens D, Jack D, Jindal S, Kan H, Mehta S, Moschovis P, Naeher L, Patel A, Perez-Padilla R, Pope D, Rylance J, Semple S, Martin WJ 2nd. Respiratory risks from household air pollution in low and middle income countries. Lancet Respir Med. 2014;2(10):823-860.

Gordon T, Kannel WB, Hjortland MC, McNamara PM. Menopause and coronary heart disease. The Framingham Study. Ann Intern Med. 1978; 89:157–61.

Hameed K, Kadir M, Gibson T, Sultana S, Fatima Z, Syed A. The frequency of known diabetes, hypertension and ischaemic heart disease in affluent and poor urban populations of Karachi, Pakistan. Diabet Med. 1995;12(6):500-3.

Harding JE. The nutritional basis of the fetal origins of adult disease. Int J Epidemiol. 2001; 30:15–23.

He FJ, MacGregor GA. A comprehensive review on salt and health and current experience of worldwide salt reduction programmes. J Hum Hypertens. 2009;23(6):363-84.

He FJ, MacGregor GA. Salt, blood pressure and cardiovascular disease. Curr Opin Cardiol. 2007;22(4):298-305.

Heidenreich PA, Alloggiamento T, Melsop K, McDonald KM, Go AS, Hlatky MA. The prognostic value of troponin in patients with non-ST elevation acute coronary syndromes: a meta-analysis. J Am Coll Cardiol. 2001;38(2):478-85.

Hitchman SC, Fong GT. Gender empowerment and female-to-male smoking prevalence ratios. Bull World Health Organ. 2011;89(3):195-202.

Howard G, Thun MJ. Why is environmental tobacco smoke more strongly associated with coronary heart disease than expected? A review of potential biases and experimental data. Environ Health Perspect. 1999;107 Suppl 6:853-8.

Howard G, Thun MJ. Why is environmental tobacco smoke more strongly associated with coronary heart disease than expected? A review of potential biases and experimental data. Environ Health Perspect. 1999;107 Suppl 6:853-8.

Hubert HB, Feinleib M, McNamara PM, Castelli WP. Obesity as an independent risk factor for cardiovascular disease: a 26-year follow-up of participants in the Framingham Heart Study. Circulation 1983; 67:968–77.

Humphrey LL, Fu R, Rogers K, Freeman M, Helfand M. Homocysteine level and coronary heart disease incidence: a systematic review and meta-analysis. Mayo Clin Proc. 2008;83(11):1203-12.

Huxley RR, Woodward, M. Cigarette smoking as a risk factor for coronary heart disease in women compared with men: a systematic review and meta-analysis of prospective cohort studies. Lancet. 2011;378(9799):1297-305.

Jafar TH, Jafary FH, Jessani S, Chaturvedi N. Heart disease epidemic in Pakistan: women and men at equal risk. Am Heart J. 2005;150(2):221-6.

Jafar TH, Qadri Z, Chaturvedi N. Coronary artery disease epidemic in Pakistan: more electrocardiographic evidence of ischaemia in women than in men. Heart. 2008;94(4):408-13.

Jamali T, Fatmi Z, Shahid A, Khoso A, Kadir MM, Sathiakumar N. Evaluation of short-term health effects among rural women and reduction in household air pollution due to improved cooking stoves: quasi experimental study. Air Qual Atmos Health. 2017;10(7): 809-819. https://doi.org/10.1007/s11869-017-0481-0

Joint ESC/ACCF/AHA/ WHF Task Force for the Universal Definition of Myocardial Infarction. Third Universal Definition of Myocardial Infarction. Expert consensus document. Journal of the American College of Cardiology 2012; 60(10): 1-18.

Jousilahti P, Patja K, Salomaa V.Environmental tobacco smoke and the risk of cardiovascular disease. Scand J Work Environ Health. 2002;28 Suppl 2:41-51.

Kaji DA, Belli AJ, McCormack MC, Matsui EC, Williams DL, Paulin L, Putcha N, Peng RD, Diette GB, Breysse PN, Hansel NN[1]. Indoor pollutant exposure is associated with heightened respiratory symptoms in atopic compared to non-atopic individuals with COPD. BMC Pulm Med. 2014; 14:147.

Kan X, Chiang C-Y, Enarson DA, Chen W, Yang J, Chen G. Indoor solid fuel use and tuberculosis in china: A matched case-control study. BMC public health. 2011; 11:498.

Kaur S, Cohen A, Dolor R, Coffman CJ, Bastian LA. The impact of environmental tobacco smoke on women's risk of dying from heart disease: a meta-analysis. J Womens Health (Larchmt). 2004;13(8):888-97.

Kim C, X-O Shu, Hosgood HD, Bassif BA, Seow WJ, Xiang Y et al. Past use of coal for cooking is associated with all-cause mortality in the prospective Shanghai Women's Health Study. Cancer Res 2014;74 (19 Suppl): Abstract nr 2184.

Kinra S, Rameshwar Sarma KV, Ghafoorunissa, Mendu VV, Ravikumar R, Mohan V, Wilkinson IB, Cockcroft JR, Davey Smith G, Ben-Shlomo Y. Effect of integration of supplemental nutrition with public health programmes in pregnancy and early childhood on cardiovascular risk in rural Indian adolescents: Long-term follow-up of Hyderabad nutrition trial. British Medical Journal 2008; 337:1–10.

Kinra S, Rameshwar Sarma KV, Ghafoorunissa, Mendu VV, Ravikumar R, Mohan V, Wilkinson IB, Cockcroft JR, Davey Smith G, Ben-Shlomo Y.
Effect of integration of supplemental nutrition with public health programmes in pregnancy and early childhood on cardiovascular risk in rural Indian adolescents: long term follow-up of Hyderabad nutrition trial. BMJ. 2008;337:a605.

Kivimäki M, Virtanen M, Elovainio M, Kouvonen A, Väänänen A, Vahtera J. Work stress in the etiology of coronary heart disease--a meta-analysis. Scand J Work Environ Health. 2006;32(6):431-42.

Kleeman, M. J., Schauer, J. J., and Cass, G. R. 1999. Size and composition distribution of fine particulate matter emitted from wood burning, meat charbroiling, and cigarettes. Environ. Sci. Technol. 1999; 33(20):3516–3523.

Kleinerman R, Wang Z, Lubin J, Zhang S, Metayer C, Brenner A. Lung cancer and indoor air pollution in rural china. Ann Epidemiol. 2000;10(7):469.

Ko Y, Lee CH, Chen MJ et al. Risk factors for primary lung cancer among non-smoking women in Taiwan. Int. J. Epidemiol. 1997; 26:24–31.

Koo LC, Lee N, Ho JH. Do cooking fuels pose a risk for lung cancer? A case-control study of women in Hong Kong. Ecol. Dis.1983; 2:255–65.

Kosmas CE, Christodoulidis G, Cheng JW, Vittorio TJ, Lerakis S. High-density lipoprotein functionality in coronary artery disease. Am J Med Sci. 2014;347(6):504-8.

Kurmi OP, Semple S, Simkhada P, Smith WC, Ayres JG. COPD and chronic bronchitis risk of indoor air pollution from solid feul: a systematic review and meta-analysis. Thorax. 2010; 65(3):221-8.

Lavie CJ, Milani RV. Obesity and cardiovascular disease: The Hippocrates paradox? J Am Coll Cardiol. 2003;42(4):677-679.

Law MR, Morris JK, Wald NJ. Environmental tobacco smoke exposure and ischaemic heart disease: an evaluation of the evidence. BMJ 1997; 315:973-980.

Lee CH, Ko YC, Cheng LS et al. The heterogeneity in risk factors of lung cancer and the differences of histologic distribution between genders in Taiwan. Cancer Causes Control 2001; 12:289–300.

Lee M-S, Hang J-Q, Zhang F-Y, Dai H-L, Su L, Christiani DC. In-home solid fuel use and cardiovascular disease: a cross-sectional analysis of the Shanghai Putuo study. Environ Health 2012,11:18.

Li H, Chen R, Meng X, Zhao Z, Cai J, Wang C, Yang C, Kan H. Short-term exposure to ambient air pollution and coronary heart disease mortality in 8 Chinese cities. Int J Cardiol. 2015 Oct 15; 197:265-70. doi: 10.1016/j.ijcard.2015.06.050. Epub 2015 Jun 23.

Libby, P., Ridker, P. M., Maseri, A. Inflammation and atherosclerosis. Circulation 2002;105: 1135–1143.

Lin HH, Suk CW, Lo HL, Huang RY, Enarson DA, Chiang CY. Indoor air pollution from solid fuel and tuberculosis: a systematic review and meta-analysis. Int J Tuberc Lung Dis. 2014;18(5):613-21.

Lissowska J, Bardin-Mikolajczak A, Fletcher T, Zaridze D, Szeszenia-Dabrowska N, Rudnai P et al. Lung cancer and indoor pollution from heating and cooking with solid fuels: the IARC international multicentre case-control study in Eastern/Central Europe and the United Kingdom. Am J Epidemiol. 2005;162(4):326-33.

Liu Q, Sasco AJ, Riboli E et al. Indoor air pollution and lung cancer in Guangzhou, People's Republic of China. Am. J. Epidemiol. 1993; 137: 145–54.

Liu Y, Lee K, Perez-Padilla R, Hudson NL, Mannino DM. Outdoor and indoor air pollution and COPD-related diseases in high- and low-income countries. Int J Tuberc Lung Dis. 2008;12(2):115-27.

Lloyd-Jones D, Adams RJ, Brown TM, Carnethon M, Dai S, De Simone G, et al. Executive summary: heart disease and stroke statistics–2010 update: a report from the American Heart Association. Circulation. 2010; 121:948–54.

Luepker RV, Apple FS, Christenson RH, Crow RS, Fortmann SP, Goff D, Goldberg RJ, Hand MM, Jaffe AS,Julian DG, Levy D, Manolio T, Mendis S, Mensah G, Pajak A, Prineas RJ, Reddy KS, Roger VL, Rosamond WD, Shahar E, Sharrett AR, Sorlie P, Tunstall-Pedoe H; AHA Council on Epidemiology and Prevention; AHA Statistics Committee; World Heart Federation Council on Epidemiology and Prevention; European Society of Cardiology Working Group on Epidemiology and Prevention; Centers for Disease Control and Prevention; National Heart, Lung, and Blood Institute. Case definitions for acute coronary heart disease in epidemiology and clinical research studies: a statement from the AHA Council on Epidemiology and Prevention; AHA Statistics Committee; World Heart Federation Council on Epidemiology and Prevention; the European Society of Cardiology Working Group on Epidemiology and Prevention; Centers for Disease Control and Prevention; and the National Heart, Lung, and Blood Institute. Circulation. 2003;108(20):2543-9.

Marckmann P, Grønbaek M. Fish consumption and coronary heart disease mortality. A systematic review of prospective cohort studies. Eur J Clin Nutr. 1999;53(8):585-90.

Marenberg ME, Risch N, Berkman LF, Floderus B, de Faire U. Genetic susceptibility to death from coronary heart disease in a study of twins. N Engl J Med. 1994;330(15):1041-6.

Martin WJ 2nd, Glass RI, Araj H, Balbus J, Collins FS, Curtis S, Diette GB, Elwood WN, Falk H, Hibberd PL, Keown SE, Mehta S, Patrick E, Rosenbaum J, Sapkota A, Tolunay HE, Bruce NG. Household air pollution in low- and middle-income countries: health risks and research priorities. PLoS Med. 2013;10(6):e1001455. doi: 10.1371/journal.pmed.1001455.

McCracken J, Smith KR, Stone P, Diaz A, Arana B, Schwartz J. Intervention to lower household wood smoke exposure in Guatemala reduces ST-segment depression on electrocardiograms. Environ Health Perspect 2011;119:1562-8.

McCracken JP, Smith KR, Díaz A, Mittleman MA, Schwartz J. Chimney stove intervention to reduce long-term wood smoke exposure lowers blood pressure among Guatemalan women. Environ Health Perspect 2007;115:996-1001.

McDonald JD, Zielinska B, Fujita EM, Sagebiel JC, Chow JC, Watson JG. Fine Particle and Gaseous Emission Rates from Residential Wood Combustion. Environ. Sci. Technol. 2000; 34 (11):2080–2091.

McKeigue PM, Miller GJ, Marmot MG. Coronary heart disease in south Asians overseas: a review. J Clin Epidemiol. 1989;42(7):597-609. Review.

Mendis S, Thygesen K, Kuulasmaa K, Giampaoli S, Mähönen M, Ngu Blackett K, Lisheng L; Writing group on behalf of the participating experts of the WHO consultation for revision of WHO definition of myocardial infarction. World Health Organization definition of myocardial infarction: 2008-09 revision. Int J Epidemiol. 2011;40(1):139-46.

Mirza UK, Ahmad N, Majeed T. An overview of biomass energy utilization in Pakistan. Renewable and sustainable energy reviews 2008; 12(7):1988–96.

Mishra V. Effect of indoor air pollution from biomass combustion on prevalence of asthma in the elderly. Environ Health Perspect. 2003;111(1):71-8.

Mitter SS, Islami F, Pourshams A, Khademi H, Kamangar F, Abnet CC et al. Use of biomass fuels for cooking and heating is associated with increased non-communicable disease mortality: Golestan cohort study. Circulation 2012;125: AP042.

Mohamed N, Ng'ang'a L, Odhiambo J, Nyamwaya J, Menzies R. Home environment and asthma in Kenyan schoolchildren: a case-control study. Thorax. 1995;50(1):74-8.

Morrison C, Woodward M, Leslie W, Tunstall-Pedoe H. Effect of socioeconomic group on incidence of, management of, and survival after myocardial infarction and coronary death: analysis of community coronary event register. BMJ 1997;314(7080):541-6.

Mortaz E, Barnes PJ, Heidarnazhad H, Adcock IM, Masjedi MR. Immunological Features of Chronic Obstructive Pulmonary Disease (COPD) Induced by Indoor Pollution and Cigarette Smoke. Tanaffos. 2012;11(4):6-17.

Mullen NA, Li J, Russell ML, Spears M, Less BD, Singer BC. Results of the California Healthy Homes Indoor Air Quality Study of 2011-2013: impact of natural gas appliances on air pollutant concentrations. Indoor Air. 2016 Apr;26(2):231-45.

Murabito JM, Pencina MJ, Nam BH, D'Agostino RB Sr, Wang TJ, Lloyd-Jones D, Wilson PW, O'Donnell CJ. Sibling cardiovascular disease as a risk factor for cardiovascular disease in middle-aged adults. JAMA 2005;294(24):3117-23.

Murray CJ, Vos T, Lozano R, Naghavi M, Flaxman AD, Michaud C et al. Disability-adjusted life years (DALYs) for 291 diseases and injuries in 21 regions, 1990–2010: a systematic analysis for the Global Burden of Disease Study 2010. Lancet 2012; 380:2197-223.

Murray ET, Diez Roux AV, Carnethon M, Lutsey PL, Ni H, O'Meara ES. Trajectories of neighborhood poverty and associations with subclinical atherosclerosis and associated risk factors: the multi-ethnic study of atherosclerosis. Am J Epidemiol. 2010;171(10):1099-108.

Myocardial infarction redefined--a consensus document of The Joint European Society of Cardiology/American College of Cardiology Committee for the redefinition of myocardial infarction. Eur Heart J. 2000;21(18):1502-13.

Naeher LP, Brauer M, Lipsett M, Zelikoff JT, Simpson CD, Koenig JQ, Smith KR. Woodsmoke health effects: a review. Inhal Toxicol. 2007;19(1):67-106. Review.

Naeher LP, Smith KR, Leaderer BP, Neufeld L, Mage DT. Carbon monoxide as a tracer for assessing exposures to particulate matter in wood and gas cookstove households of highland Guatemala. Environ Sci Technol. 2001;35(3):575-81.

National Institute of Population Studies, Pakistan. Pakistan demographic and health survey 2012-2013. Calverton, MD: ICF International Inc.; 2013.

Neupane M, Basnyat B, Fischer R, Froeschl G, Wolbers M, Rehfuess EA. Sustained use of biogas fuel and blood pressure among women in rural Nepal. Environ Res 2015;136: 343-351.

Nishtar S, Wierzbicki AS, Lumb PJ, Lambert-Hammill M, Turner CN, Crook MA, Mattu MA, Shahab S, Badar A, Ehsan A, Marber MS, Gill J. Waist-hip ratio and low HDL predict the risk of coronary artery disease in Pakistanis. Curr Med Res Opin. 2004;20(1):55-62.

Nogueira JB. Hypertension, coronary heart disease and stroke: should the blood pressure J-curve be a concern? Rev Port Cardiol. 2013;32(2):139-44.

Oguma Y, Shinoda-Tagawa T. Physical activity decreases cardiovascular disease risk in women: Review and metaanalysis. American Journal of Preventative Medicine 2004; 26(5):407–418.

Osman LM, Douglas JG, Garden C, Reglitz K, Lyon J, Gordon S, Ayres JG. Indoor air quality in homes of patients with chronic obstructive pulmonary disease. Am J Respir Crit Care Med. 2007;176(5):465-72.

over Amazonia. Journal of Geophysical Research 1988; 93(D2): 1509-1527.

Painschab MS, Davila-Roman VG, Gilman RH, Vasquez-Villar AD, Pollard SL, Wise RA et al. Chronic exposure to biomass fuel is associated with increased carotid artery

intima-media thickness and a higher prevalence of atherosclerotic plaque. Heart 2013; 99:984-991.

Pakistan Medical Research Council. National Health Survey of Pakistan. Health Profile of the People of Pakistan 1990–94. Islamabad: Network Publication Service, 1998.

Pekkanen J, Linn S, Heiss G, Suchindran CM, Leon A, Rifkind BM, Tyroler HA. Ten-year mortality from cardiovascular disease in relation to cholesterol level among men with and without preexisting cardiovascular disease. N Engl J Med. 1990;322(24):1700-7.

Perez-Padilla R, Perez-Guzman C, Baez-Saldana R, Torres-Cruz A. Cooking with biomass stoves and tuberculosis: A case-control study. Int J Tuberc Lung Dis. 2001; 5:441-447.

Peters SA, Huxley RR, Woodward M. Diabetes as risk factor for incident coronary heart disease in women compared with men: a systematic review and meta-analysis of 64 cohorts including 858,507 individuals and 28,203 coronary events. Diabetologia. 2014; 57(8):1542-51.

Pokhrel AK, Bates MN, Verma SC, Joshi HS, Sreeramareddy CT, Smith KR. Tuberculosis and indoor biomass and kerosene use in Nepal: A case-control study. Environmental health perspectives (Online). 2010; 118:558.

Pokhrel AK, Smith KR, Khalakdina A, Deuja A, Bates MN. Case-control study of indoor cooking smoke exposure and cataract in Nepal and India. Int J Epidemiol. 2005;34(3):702-8.

Pollard SL, Williams DL, Breysse PN, Baron PA, Grajeda LM, Gilman RH, Miranda JJ, Checkley W[1]; CRONICAS Cohort Study Group. A cross-sectional study of determinants of indoor environmental exposures in households with and without chronic exposure to biomass fuel smoke. Environ Health. 2014 Mar 24;13(1):21. doi: 10.1186/1476-069X-13-21.

Pope CA, Thun MJ, Namboodiri MM, Dockery DW, Evans JS, Speizer FE, Heath CW Jr. Particulate air pollution as a predictor of mortality in a prospective study of US adults. Am J Respir Crit Care Med 1995; 151: 669–674.

Pope CA, Thun MJ, Namboodiri MM, Dockery DW, Evans JS, Speizer FE et al. Particulate air pollution as a predictor of mortality in a prospective study of US adults. Am J Respir Crit Care Med 1995; 151:669-74.

Population Division of the Department of Economic and Social Affairs of the United Nations Secretariat (UNDESA). World Population Prospects: The 2006 Revision and World Urbanization Prospects: The 2007 Revision. New York, United Nations, 26 February 2008 (http://esa.un.org/unup).

Pratali L, Cogo A. Exposure to indoor air pollution induces endothelial dysfunction in Nepalese high altitude dwellers. High Altitude Medicine and Biology 2014;15: A241-A242.

Prineas RJ, Crow RS, Zhang Z-h. The Minnesota code manual of electrocardiographic findings. 2nd Edition. London. Springer London; 2010.

Prospective Studies Collaboration. Age-specific relevance of usual blood pressure to vascular mortality: a meta-analysis of individual data for one million adults in 61 prospective studies. Lancet. 2002;360: 1903-13.

Rao SV, Kaul P, Newby LK, Lincoff AM, Hochman J, Harrington RA, Mark DB, Peterson ED. Poverty, process of care, and outcome in acute coronary syndromes. J Am Coll Cardiol. 2003 Jun 4;41(11):1948-54.

RAE systems, Honeywell. TN-114: Sensor specifications and cross-sensitivities. http://www.raesystems.com/customer-care/resource-center/tn-114-sensor-specifications-and-cross-sensitivities (accessed on 29th July, 2017).

Ray MR, Mukherjee S, Roychoudhury S, Bhattacharya P, Banerjee M, Siddique S et al. Platelet activation, upregulation of CD11b/CD18 expression on leukocytes and increase in circulating leukocyte-platelet aggregates in Indian women chronically exposed to biomass smoke. Hum Exp Toxicol 2006;25:627-35.

Rehm J, Sempos CT, Trevisan M. Alcohol and cardiovascular disease-more than one paradox to consider. Average volume of alcohol consumption, patterns of drinking and risk of coronary heart disease-a review. J Cardiovasc Risk. 2003 Feb;10(1):15-20.

Report of the Joint International Society and Federation of Cardiology/ World Health Organization task force on standardization of clinical nomenclature. Nomenclature and criteria for ischemic heart disease. Circulation 1979; 59:607-9.

Research Triangle Institute (RTI). https://www.rti.org/sites/default/files/brochures/rti_micropem.pdf [accessed on 29th July, 2017].

Richardson S, Shaffer JA, Falzon L, Krupka D, Davidson KW, Edmondson D. Meta-analysis of perceived stress and its association with incident coronary heart disease. Am J Cardiol. 2012 Dec 15;110(12):1711-6.

Romero-Corral A, Montori VM, Somers VK, Korinek J, Thomas RJ, Allison TG, Mookadam F, Lopez-Jimenez F. Association of bodyweight with total mortality and with cardiovascular events in coronary artery disease: a systematic review of cohort studies. Lancet. 2006;368(9536):666-78.

Ronksley PE, Brien SE, Turner BJ, Mukamal KJ, Ghali WA. Association of alcohol consumption with selected cardiovascular disease outcomes: a systematic review and meta-analysis. BMJ. 2011 Feb 22;342:d671.

Saha A, Kulkarni PK, Shah A, Patel M, Saiyed HN. Ocular morbidity and fuel use: an experience from India. Occup Environ Med. 2005;62(1):66-9.

Sathiakumar N. Indoor air pollution due to biomass fuel use and acute coronary syndrome among Sri Lankan women. Epidemiology 2012;23: S224.

Schunkert H, König IR, Kathiresan S, Reilly MP, Assimes TL, Holm H, Preuss M, Stewart AF, Barbalic M, Gieger C, Absher D, Aherrahrou Z, Allayee H, Altshuler D, Anand SS, Andersen K, Anderson JL, Ardissino D, Ball SG, Balmforth AJ, Barnes TA, Becker DM, Becker LC, Berger K, Bis JC, Boekholdt SM, Boerwinkle E, Braund PS, Brown MJ, Burnett MS, Buysschaert I; Cardiogenics, Carlquist JF, Chen L, Cichon S, Codd V, Davies RW, Dedoussis G, Dehghan A, Demissie S, Devaney JM, Diemert P, Do R, Doering A, Eifert S, Mokhtari NE, Ellis SG, Elosua R, Engert JC, Epstein SE, de Faire U, Fischer M, Folsom AR, Freyer J, Gigante B, Girelli D, Gretarsdottir S, Gudnason V, Gulcher JR, Halperin E, Hammond N, Hazen SL, Hofman A, Horne BD, Illig T, Iribarren C, Jones GT, Jukema JW, Kaiser MA, Kaplan LM, Kastelein JJ, Khaw KT, Knowles JW, Kolovou G, Kong A, Laaksonen R, Lambrechts D, Leander K, Lettre G, Li M, Lieb W, Loley C, Lotery AJ, Mannucci PM, Maouche S, Martinelli N, McKeown PP, Meisinger C, Meitinger T, Melander O, Merlini PA, Mooser V, Morgan T, Mühleisen TW, Muhlestein JB, Münzel T,

Musunuru K, Nahrstaedt J, Nelson CP, Nöthen MM, Olivieri O, Patel RS, Patterson CC, Peters A, Peyvandi F, Qu L, Quyyumi AA, Rader DJ, Rallidis LS, Rice C, Rosendaal FR, Rubin D, Salomaa V, Sampietro ML, Sandhu MS, Schadt E, Schäfer A, Schillert A, Schreiber S, Schrezenmeir J, Schwartz SM, Siscovick DS, Sivananthan M, Sivapalaratnam S, Smith A, Smith TB, Snoep JD, Soranzo N, Spertus JA, Stark K, Stirrups K, Stoll M, Tang WH, Tennstedt S, Thorgeirsson G, Thorleifsson G, Tomaszewski M, Uitterlinden AG, van Rij AM, Voight BF, Wareham NJ, Wells GA, Wichmann HE, Wild PS, Willenborg C, Witteman JC, Wright BJ, Ye S, Zeller T, Ziegler A, Cambien F, Goodall AH, Cupples LA, Quertermous T, März W, Hengstenberg C, Blankenberg S, Ouwehand WH, Hall AS, Deloukas P, Thompson JR, Stefansson K, Roberts R, Thorsteinsdottir U, O'Donnell CJ, McPherson R, Erdmann J; CARDIoGRAM Consortium, Samani NJ. Large-scale association analysis identifies 13 new susceptibility loci for coronary artery disease. Nat Genet. 2011 Mar 6;43(4):333-8.

Sesso HD, Lee IM, Gaziano JM, Rexrode KM, Glynn RJ, Buring JE. Maternal and paternal history of myocardial infarction and risk of cardiovascular disease in men and women. Circulation. 2001; 104:393–398.

Siddiqui AR, Lee K, Bennett D, Yang X, Brown KH, Bhutta ZA, Gold EB. Indoor carbon monoxide and PM2.5 concentrations by cooking fuels in Pakistan. Indoor Air. 2009 Feb;19(1):75-82.

Singh RB, Niaz MA. Coronary heart disease in Indians, Pakistanis, and Bangladeshis: aetiology and possible prevention. Br Heart J. 1993 Jun;69(6):572.

Singh RB. Coronary artery disease risk factors in south Asian and American premenopausal women. Am J Clin Nutr. 1999 Dec;70(6):1112-3.

Smith KR, Apte MG, Yuqing M, Wongsekiarttirat W, Kulkarni A. Air pollution and the energy ladder in Asian cities. Energy 1994; 19 (5):587-600.

Smith KR, Mehta S, Maeusezahl-Feuz M. Indoor air pollution from household use of solid fuels: comparative quantification of health risks. In: Ezzati MLA, Rodgers A, Murray CJL, editors. Global and regional burden of disease attributable to selected major risk factors. Geneva, Switzerland: World Health Organization; 2004. pp. 1435–1493.

Smith KR, Samet JM, Romieu I, Bruce N. Indoor air pollution in developing countries and acute lower respiratory infections in children. Thorax. 2000 Jun;55(6):518-32.

Smith KR, McCracken JP, Thompson L, Edwards R, Shields KN, Canuz E, Bruce N. Personal child and mother carbon monoxide exposures and kitchen levels: methods and results from a randomized trial of woodfired chimney cookstoves in Guatemala (RESPIRE). J Expo Sci Environ Epidemiol. 2010;20(5):406-16.

Sobue T. Association of indoor air pollution and lifestyle with lung cancer in Osaka, Japan. Int. J. Epidemiol. 1990; 19: S62–6.

Sook Lee E, Park SS, Kim E, Sook Yoon Y, Ahn HY, Park CY, Ho Yun Y, Woo Oh S. Association between adiponectin levels and coronary heart disease and mortality: a systematic review and meta-analysis. Int J Epidemiol. 2013;42(4):1029-39.

Teo KK, Ounpuu S, Hawken S, Pandey MR, Valentin V, Hunt D et al. Tobacco use and risk of myocardial infarction in 52 countries in the INTERHEART study: a case-control study. Lancet 2006;368:647-58.

Teo KK, Ounpuu S, Hawken S, Pandey MR, Valentin V, Hunt D, Diaz R, Rashed W, Freeman R, Jiang L, Zhang X, Yusuf S; INTERHEART Study Investigators. Tobacco use and risk of myocardial infarction in 52 countries in the INTERHEART study: a case-control study. Lancet. 2006 Aug 19;368(9536):647-58.

The CARDIoGRAMplusC4D Consortium. Large-scale association analysis identifies new risk loci for coronary artery disease. Nat Genet. 2013 January; 45(1): 25–33.

The Global Alliance for Clean Cookstoves. [http://cleancookstoves.org/].

The World Health Report 2002: reducing risks, promoting healthy life. Geneva, World Health Organization, 2002.

Thygesen K, Alpert JS, Jaffe AS, Simoons ML, Chaitman BR, White HD: The Writing Group on Third Universal definition of myocardial infarction. European Heart Journal, 2007; 28 (20), Pages 2525–2538 [https://doi.org/10.1093/eurheartj/ehm355].

Todd Miller M, Lavie CJ, White CJ. Impact of obesity on the pathogenesis and prognosis of coronary heart disease. J Cardiometab Syndrome 2008; 3:162–7.

Torres-Duque C, Maldonado D, Pérez-Padilla R, Ezzati M, Viegi G; Forum of International Respiratory Studies (FIRS) Task Force on Health Effects of Biomass Exposure. Biomass fuels and respiratory diseases: a review of the evidence. Proc Am Thorac Soc. 2008 Jul 15;5(5):577-90.

Toshima, S., Hasegawa, A., Kurabayashi, M., *et al*. Circulating oxidized low density lipoprotein levels: a biochemical risk marker for coronary heart disease. Arterioscler Thromb Vasc Biol. 2000; **20**: 2243–2247.

Tunstall-Pedoe H (ed), prepared by Tunstall-Pedoe H, Kuulasmaa K, Tolonen H, Davidson M, Mendis S, for the WHO MONICA Project. MONICA Monograph and Multimedia Source Book. The World's Largest Study of Heart Disease, Stroke, Risk Factors and Population Trends (1979-2002). World Health Organization, Geneva, 2003.

Tunstall-Pedoe H, Kuulasmaa K, Amouyel P, Arveiler D, Rajakangas AM, Pajak A. for the World Health Organization MONICA Project. Myocardial infarction and coronary deaths in the World Health Organization MONICA Project: registration procedures, event rates, and case fatality rates in 38 populations from 21 countries in four continents. Circulation 1994; 90:583-12.

Wang DZ, Jiang GH, Zhang H, Song GD, Zhang Y. Effect of air pollution on coronary heart disease mortality in Tianjin, 2001-2009: a time-series study. Zhonghua Liu Xing Bing Xue Za Zhi. 2013 May;34(5):478-83. Chinese.

Warrell D, Cox TM, Firth JD, Weatherall D, Benz E, editors. Oxford Textbook of Medicine (Three Volume Set). 5th Edition. Oxford, Cambridge and Boston: Oxford University Press; 2010.

Wells AJ. Heart disease from passive smoking in the workplace. J Am Coll Cardiol 1998, 31:1-9.

Wendel-Vos GC, Schuit AJ, Feskens EJ, Boshuizen HC, Verschuren WM, Saris WH, Kromhout D. Physical activity and stroke: A meta-analysis of observational data. International Journal of Epidemiology, 2004, 33(4):787–798.

Wilcosky T, Harris R, Weissfeld L. The prevalence and correlates of Rose questionnaire angina among women and men in the Lipid Research Clinics Program Prevalence Study. Am J Epidemiol. 1987;125 (3):400-409.

Wolff GT, Groblicki PJ, Cadle SH, Countess RJ. Particulate Carbon at Various Locations in the United States. In: Wolff GT, Klimisch RL, editors. Particulate Carbon: Atmospheric Life Cycle. Boston, MA: Springer US; 1982. p. 297-315.

World Health Organization (WHO/MNC/82, Rev. 1). Proposal for the Multinational Monitoring of Trends and Determinants in Cardiovascular Disease and Protocol (MONICA Project). Geneva: WHO, 1983.

World Health Organization. Global estimate of the burden of disease from second-hand smoke. Geneva, WHO, 2010.

World Health Organization. Global recommendations on physical activity for health. Geneva, WHO, 2010.

World Health Organization. Global status report on non-communicable diseases 2010. Geneva, WHO, 2010.

World Health Organization. Myocardial Infarction Community Registers. Public Health in Europe, Paper No. 5, Regional Office for Europe. Copenhagen: WHO, 1976.

World Health Organization. Prevention of cardiovascular disease: Guidelines for assessment and management of cardiovascular risk. Geneva, WHO, 2007.

World Health Organization. WHO report on the global tobacco epidemic: The MPOWER Package. Geneva, WHO, 2008.

Xu X, Niu T, Christiani DC, Weiss ST, Chen C, Zhou Y, Fang Z, Jiang Z, Liang W, Zhang F. Occupational and Environmental Risk Factors for Asthma in Rural Communities in China. Int J Occup Environ Health. 1996 Jul;2(3):172-176.

Yamamoto SS, Phalkey R, Malik AA. A systematic review of air pollution as a risk factor for cardiovascular disease in South Asia: limited evidence from India and Pakistan. Int J Hyg Environ Health 2014; 217:133-44.

Yusuf S, Hawken S, Ounpuu S, Bautista L, Franzosi MG, Commerford P, Lang CC, Rumboldt Z, Onen CL, Lisheng L, Tanomsup S, Wangai P Jr, Razak F, Sharma AM, Anand SS; INTERHEART Study Investigators. Obesity and the risk of myocardial infarction in 27,000 participants from 52 countries: a case-control study. Lancet 2005;366(9497):1640-9.

Yusuf S, Hawken S, Ounpuu S, Dans T, Avezum A, Lanas F et al. on behalf of the INTERHEART study investigators. Effect of potentially modifiable risk factors associated with myocardial infarction in 52 countries (the INTERHEART study): case-control study. Lancet 2004; 364:937-52.