A study of the association of prenatal inflammatory diet and adverse infant birth outcomes in a birth cohort in Uganda

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Dedication

I would like to dedicate this to my late mother Nedi Ndlovu, my father Danny Ndlovu, my wife Phomello, my children Boikarabello, Lwandile and Cebolenkosi, my family and friends. Thank you for your encouragement, love and support.

Declaration

I, DAVIES NDLOVU (NDLDAV007) hereby declare that the work on which this dissertation is based on is my original work (except where acknowledgements indicate otherwise) and that neither the whole work nor any part of it has been, is being or is to be submitted for another degree in this University of Cape Town (UCT) or any other university. I empower UCT to reproduce for the purpose of research, either the whole or any portion of the contents, in any manner whatsoever.

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ABSTRACT

Background: Low birth weight (LBW) and low infant lung capacity are some of the risk factors for childhood and adulthood chronic respiratory diseases such as chronic obstructive pulmonary disease (COPD) and asthma. These respiratory diseases are among the leading causes of death and disability worldwide. The aetiology of these respiratory diseases and other inflammatory conditions has recently been linked to maternal diet during pregnancy. As such it has been important to study the role of maternal diet during pregnancy to find any association with maternal and infant outcomes. Highly diverse diets have been thought to be a proxy to maternal nutrient adequacy as well as healthy diet. Diverse diets may offer protection from inflammatory airway diseases and other inflammatory diseases by evening out inflammatory and anti-inflammatory food components. The global burden of chronic respiratory diseases has increased over the past decade leading to increased burden on the health systems as well as economic losses due to lack of productivity from the affected individuals. There is no cure for asthma and other chronic respiratory conditions, however with proper interventions they can be well managed and prevented.

In light of this, the aim of this mini-dissertation is to investigate the effect of Dietary diversity (DD) and Dietary inflammatory index (DII), on infant birth outcomes particularly birth weight and lung function and to determine if there is any association. With knowledge of this appropriate interventions can be put in place to reduce the burden of chronic respiratory diseases.

This study was a secondary data analysis of a primary study called IMPALA, a birth cohort conducted in Kyamulibwa Health Demographic Surveillance Site in Kyamulibwa sub-county in rural district of Kalungu in Uganda. In the primary study 564 pregnant women were recruited as they attended their routine antenatal care at the health care facilities in this district. Their infants were recruited to the study as they were born and the outcome of interest, birth weight and lung capacity were measure at delivery and at presentation for postnatal care.

This mini-dissertation is divided into four parts:

Part A contains the protocol which was approved by University of Cape Town Faculty of Health Sciences Human Research Ethics Committee. The brief literature review in the protocol describes the burden of chronic respiratory diseases, the global distribution and the under-diagnosis of respiratory diseases in low income countries. It also links dietary factors to the pathogenesis of inflammatory diseases.

Part B of this mini dissertation contains the Manuscript. This part of the mini-dissertation will focus mostly on the results of the study, discussion and conclusions that can be made from this study. In summary, the study found no association between dietary inflammatory index, dietary diversity and the outcome variables of interest, infant birth weight and infant lung capacity. However interesting associations were found between maternal age and infant birth weight.

The mean Dietary Diversity score was 4.61 +/- 1.79 SD. A score less than 5 is classified as inadequate dietary diversity. 84.8% of the participating women had consumed tubers such as cassava, 57.1% reported consuming grains or cereal, 12.6% vegetables, 19.3% Fruits, 1.2% meat and 7.4% eggs. There were statistically significant differences in dietary practices of the women according to their level of education, with 81% of those who attained tertiary education having adequate dietary diversity.

Starches were the most consumed food group with an average of 16 servings per week while meat, processed starches (samosas etc), fruits and vegetables were consumed at less =<2 serving per week, with meat the least consumed at an average of less than 1 serving per week.

Although marginal, the diets of the participants were mostly anti-inflammatory with an average dietary inflammatory score of -1.2. Those with the lowest inflammatory score were associated with more servings of legumes, green leafy vegetables, fish and less servings of processed starches and animal oil.

Part C contains Appendices, which includes the literature review. As the burden of chronic respiratory diseases was dealt with extensively in the protocol, this literature review dwells more on dietary patterns and their influence on inflammatory diseases such as asthma and other chronic respiratory diseases. This literature review will show that dietary diversity is inversely related to dietary inflammatory index, with a highly diverse diet likely to be anti-inflammatory.

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List of abbreviations

BMI	Body mass index
COPD	Chronic obstructive pulmonary disease
DD	Dietary diversity
DD-W	Dietary diversity for women
DII	Dietary Inflammatory Index
FANC	Four-contact model for antenatal care
FFQ	Food frequency questionnaire
GINA	Global Initiative for Asthma Guidelines
HS-CRP	High-sensitivity C-reactive protein
IMPALA	
IL-6	Interleukin-6
LBW	Low birth weight
LMIC	Low and Middle income countries
LSTM REC	Liverpool School of Tropical Medicine Research Ethics Committee
MDD-W	Minimum dietary diversity for women
MUFAs	Monounsaturated fatty acids
OR	Odds ratio
PUFAs	Polyunsaturated fatty acids
SD	Standard deviation
SFA	Saturated fatty acids

TB	Tuberculosis
TFA	Trans-fatty acids
TN	Tumor necrotic factor
US	United States of America
WHO	World Health Organisation

Contents

Part A: Protocol

Protocol Synopsis

Lung function is a term that can in simple terms be used to describe how well the lungs works in helping a person breathe [1,2]. It can be measured as early as in the first days of life in infants or at any stage of life for both clinical and research purposes. When correctly performed during infancy, lung function tests can provide useful information on lung growth and development, disease status, and progression, and can aid the clinicians in decision making [2]. Lung function is however used more as a research tool than as a clinical too. Epidemiological studies have indicated reduced lung function at birth is a risk factor for asthma within the first 10 years of life [3]. Asthma is one of the leading chronic respiratory airway diseases, the other being chronic obstructive pulmonary disease [2, 3]. In 2016 the WHO estimated the global prevalence of asthma to be about 334 million people while that of chronic obstructive pulmonary disease at 174 million. It was also reported that the burden of asthma increased by 9.5% globally in 2015 [4, 5]. As such asthma is one of the most important non-communicable diseases and poorly controlled asthma leads to poor quality of life, mortality and an increased burden to the healthcare system as well as negative economic impact due to loss of employment [5].

This study seeks to identify if prenatal inflammatory diet is associated with poor lung function which is a risk factor for childhood and adulthood asthma. This is important as there is no cure for asthma and early life interventions may be important in reducing the burden of the disease. The objectives of this study are to describe the association between maternal inflammatory diet during pregnancy, measured by the Dietary Inflammatory Index, and infant lung capacity. The second objective is to determine the association between dietary diversity and infant lung capacity using the dietary diversity score. The dietary inflammatory index is a tool used to assess the overall inflammatory potential of a diet by categorising individual's dietary intake as either anti-inflammatory or pro-inflammatory [6]. Inflammation is an important aspect in the pathogenesis of asthma and studies have revealed that nutrition has the potential to increase the risk of diseases with an inflammatory etiology, hence the interest in pursuing this study.

This study is an analysis of secondary data that is already completed. No participants will be recruited or enrolled for this study. The parent study enrolled 564 pregnant women who gave consent, from antenatal care facilities that serve the Kalungu district of South Western Uganda. The infants of these women were also recruited.

At recruitment, baseline information and the pregnant mothers' diet were collected using the Food frequency questionnaire and Dietary Diversity for Women questionnaire. The mothers and their babies were assessed again six weeks after birth when they attended the routine vaccinations and infant and maternal lung capacity was measured using non-invasive procedures. Data was stored on a secure REDCap database (HREC:R042-2018) and an anonymized data extract will be used for this secondary data analysis.

There will be no direct benefits for participants in this study as no participants are recruited or enrolled. However, findings of this study may formulate guidelines on prenatal nutrition as an potential point of intervention to reduce the later risk of asthma. Similarly, there are no direct risks to any individuals as the study will use secondary data only. There are minor indirect risks due to the potential for loss of confidentiality and privacy which will managed by using only anonymous data and safe storage of data files on password protected computers.

1.Project Summary

1.1 Introduction

This study is part of a parent study conducted in Kalungu district of rural Uganda, whose main objective was to describe the maternal and household factors associated with lung function in infants. This was the first study to attempt to relate maternal diet to infant lung capacity. This study focuses more on the maternal factors associated with infant lung capacity with particular focus on the influence of pre-natal inflammatory diet on infant lung capacity. Studies have shown that reduced lung capacity at birth or early infancy is associated with childhood obstructive airway diseases such as asthma and there has been epidemiological evidence of a link between childhood lower respiratory illness and the development of chronic respiratory diseases in adults [3]. Epidemiological studies have also shown the influence of food in the pathogenesis of inflammatory diseases [7]. As such the role played by nutrition on asthma outcomes is of growing interest, however relevant data has not always been available as dietary habits of asthma patients are not commonly investigated in clinical practice [7]

1.2. Objectives

1.2.1 Overarching Aim

To determine the dietary patterns of pregnant women in Uganda, and its association with infant birth weight and infant lung function.

1.2.3 Specific objectives

- To describe the association between maternal inflammatory diet during pregnancy, measured by the Dietary Inflammatory Index, and infant birth weight and lung capacity.

- To determine the association between dietary diversity, infant birth weight and infant lung capacity using the dietary diversity score.

1.3 Methods

This was a birth cohort study conducted in Kyamulibwa Health Demographic Surveillance Site in Kyamulibwa sub-county in rural district of Kalungu in Uganda. Pregnant women were recruited as they attended their routine antenatal care at the health care facilities in this district. At recruitment, baseline information and the pregnant mothers' diet were collected using the Food frequency Questionnaire and a validated Dietary Diversity for Women Questionnaire. The mothers and their babies were assessed again six week after birth when they attended the routine vaccinations and the mothers' lung capacity was measured during this visit using a spirometer. The Dietary Inflammatory Index and Dietary Diversity were determined from the Food Frequency questionnaires and Dietary Diversity for Women questionnaire respectively.

2. Background Literature review and rational for study

2.1 Lung Function

Lung function is a term that can in simple terms be used to describe how well the lungs works in helping a person breathe [1,2]. It can be measured as early as in the first days of life in infants or at any stage of life for both clinical and research purposes. When correctly performed during infancy, lung function tests can provide useful information on lung growth and development, disease status, and progression, and can aid the clinicians in decision making [2]. Lung function in infants is measured by Tidal breath analysis. This method relies on natural undisturbed physiological breathing at a resting state without any intentional forceful effort [2]. In this method the infant is put in a resuscitation position, i.e supine position with neck and shoulders supported in midline. A face mask is then applied carefully to cover the mouth and nose then attached to a pneumotochograph which records the volume of each breath. Tidal breathing is then recorded for a total of 10 minutes [2,3.8].

Epidemiological studies have indicated that lung function in early life can be used to as a predictive measure of the presence or absence of respiratory disease in early childhood [3]. In one study, infants who had high airway resistance were associated with increased risk of childhood wheezing [3,8] . High airway resistance and reduced specific airway conductance shortly after birth was also associated with an increased risk of recurrent bronchial obstruction and doctor diagnosed asthma at 2 years of age [3]. As such it was found that reduced lung function at birth is a risk factor for asthma within the first 10 years of life [3].

2.1.1 Causes of reduced lung function at birth

Lung development in humans occurs during prenatal life and continues into infancy where it increases in size but not in structure [9]. Exposure to a sub-optimal in utero environment is a risk factor for reduced lung function and increases risk of respiratory disease in childhood and later in life [9,10]. Early lung development has been shown to be influenced by maternal undernutrition, preterm birth, low birth weight, tobacco smoking and both maternal and infant respiratory infections [9,10]. Maternal nutrition during pregnancy has been shown to influence lung development in infants, with nutrition deficient in micronutrients such as Vitamins A associated with reduced lung function [11, 12]. This is because these vitamins are important in the formation of elastin and are also influence the genes responsible for production of surfactant proteins which is important in maturation and repair of lung tissue [11, 12].

2.1.2 Measurement of lung function in infants and adults

Measuring lung function in infants and young children presents significant challenges [13]. Methods and interpretation of lung function tests in older children is similar to that of adults, however, infants and pre-school children require different methods which consider safety as the most important considerations [13].

2.2 Obstructive respiratory diseases

Having established that reduced infant lung function at birth is a risk factor for chronic respiratory diseases and asthma, it is therefore important to briefly look at the epidemiology of obstructive respiratory diseases with particular emphasis on asthma.

2.2.1 Epidemiology of respiratory diseases

Respiratory diseases are amongst the leading causes of death and disability worldwide, with chronic obstructive pulmonary disease affecting about 65 million people and killing more than 3 million people annually across the globe [5]. This makes respiratory diseases the third leading cause of death globally according to the WHO [14,15]. Asthma is one of the major non-communicable diseases. In 2016 it was estimated that asthma affected about 334 million people globally [5,14,15]. Asthma is also the most common childhood chronic health condition, affecting about 14% of all children globally with a global death rate of up to 0.7 per 100 000 children [5].

There are global differences in the prevalence of asthma [5,16]. While some European countries have seen a massive decline in the prevalence of paediatric asthma, some European, Asia, south American and African countries have seen an increase in the prevalence of asthma and the WHO predicts that numbers of affected people may increase to about 400 million by 2025 [5,15,16]. In recent studies,

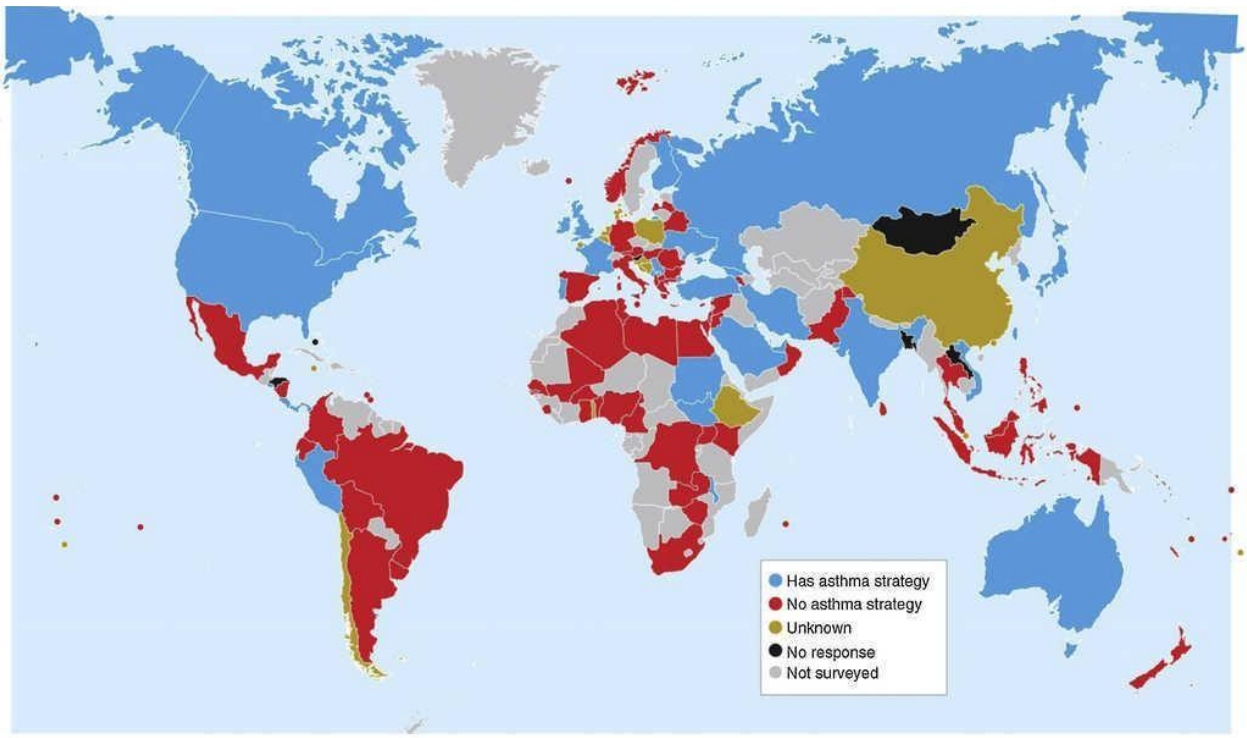
asthma appeared to be less documented in LMIC due to less awareness of the symptoms of asthma such as wheezing and underdiagnoses to poor health care systems [17].

2.2.2 Global economic impact of asthma

Asthma has an enormous direct and indirect economic burden on patients and healthcare systems across the world [18]. In 2013, the US estimated that asthma alone costs its economy around $81.9 billion, and it is projected that uncontrolled asthma in the US will lead to direct costs up to $300 billion in twenty years and indirect costs or economic burden of up to $900 billion [18,19].

2.2.3 Global response to asthma

Despite studies showing an increased prevalence of asthma globally and more so in Africa, most LMIC in Africa, Asia and South America surveyed in a study by the Global Asthma network, did not have a strategy to deal with asthma as shown in Fig 1 [20]. As a result of this regional and or national lack of strategy to deal with asthma, it is estimated that in 2013, 22 million disability adjusted life years were lost due to uncontrolled asthma [20,32].



Allergol Immunopathol (Madr). 2017;45:105–14

2.2.4 Etiology and pathogenesis of asthma

The cause and pathogenesis of asthma is not yet fully understood. However, early studies believed asthma developed as a result of interplay between genetic and environmental factors early in the life [21]. Sudden unexpected increase in number of asthma cases over the past 20 years prompted a lot of research looking into the adaptable environmental risk factors [21].

Recent studies show that childhood and adulthood asthma is influenced by the in utero environment which is in turn influenced by maternal smoking, nutrition, stress and use of antibiotic [21]. Maternal dietary intake during pregnancy in particular has been shown to have a big impact in offspring lung and airway development [21]. Poor maternal nutrition has been associated with poor offspring lung capacity through poor development of the immune system [21]. A number of studies have investigated the association of maternal diet with offspring asthma. Most of these studies have however, focused on individual foods instead of assessing the quality of whole diets as people do not eat foods in isolation. Limited studies have investigated the influence of maternal dietary quality on offspring asthma risk [21].

Inflammation is an important aspect in the pathogenesis of asthma and studies have revealed that nutrition has the potential to increase the risk of diseases with an inflammatory etiology [22]. The ever changing dietary and eating patterns have also seen an increase in prevalence of diseases with an inflammatory etiology such as asthma.[22,23]. There is increasing transition from diets high in anti-inflammatory compounds such as vegetables and fish to westernized types of diets composed mostly of processed foods and sweets, which have high inflammatory potential [23]. This therefore makes it of paramount importance to investigate the inflammatory nature of foods eaten by pregnant women and try to find its association with asthma as reducing overall dietary inflammatory potential could be an important intervention for lowering the risk of asthma. Studies to evaluate the association between maternal dietary inflammation and risk of infant asthma are limited [5].

2.3 Dietary patterns and food insecurity in Sub-Saharan Africa

The Ugandan diet is composed mainly of starchy roots such as cassava and sweet potatoes as well as cereals such as maize, millet and sorghum [24]. This diet is complemented by pulses, nuts and green leafy vegetables [25]. Overall, the diet is considered to meet the population's energy demands; however it is poor in protein, lipids and micronutrient-rich foods [24,25]. Food insecurity persists in some parts of the country as a result of poverty, climate change conditions and political instability [24,25]. There are limited food choices in Uganda due to lack of adequate outlets, poor food availability and poverty [24].

Despite steady economic growth recorded in Africa and sub-Saharan Africa since the dawn of the new millennium, Africa still faces major challenges such as socioeconomic inequality, youth unemployment, undernourishment, food insecurity, persistent drought and climate change [26]. Climate change in particular is projected to have the most profound direct impact on global food insecurity, with sub-Saharan Africa, which already has a high undernourished population, to be affected the most [26]. Food insecurity as a result of climate change is projected to increase undernutrition of women mostly in low resourced areas leading to poor infant health outcomes such as low birth weight, poor lung function and infant mortality [26]. In these low resource areas, women face great challenges to maintain good nutrition during pregnancy due to insufficient availability of food especially during the dry season [26].

The ongoing COVID-19 pandemic is expected to increase food insecurity in Sub Saharan Africa, especially amongst women who make up the majority of the poor and vulnerable [27,28]. This is a result of many African countries enforcing hard lockdown to curb the spread of the disease, leading to disruptions in food supply, particularly for the poor who depend on day to day purchases [27,28]. COVID-19 related lockdown regulations have seen an increased number of job losses and major losses of income throughout the African continent and it has been estimated that the number of hungry people will increase significantly in the next few years [28].

2.4 Dietary transition in Sub-Saharan Africa

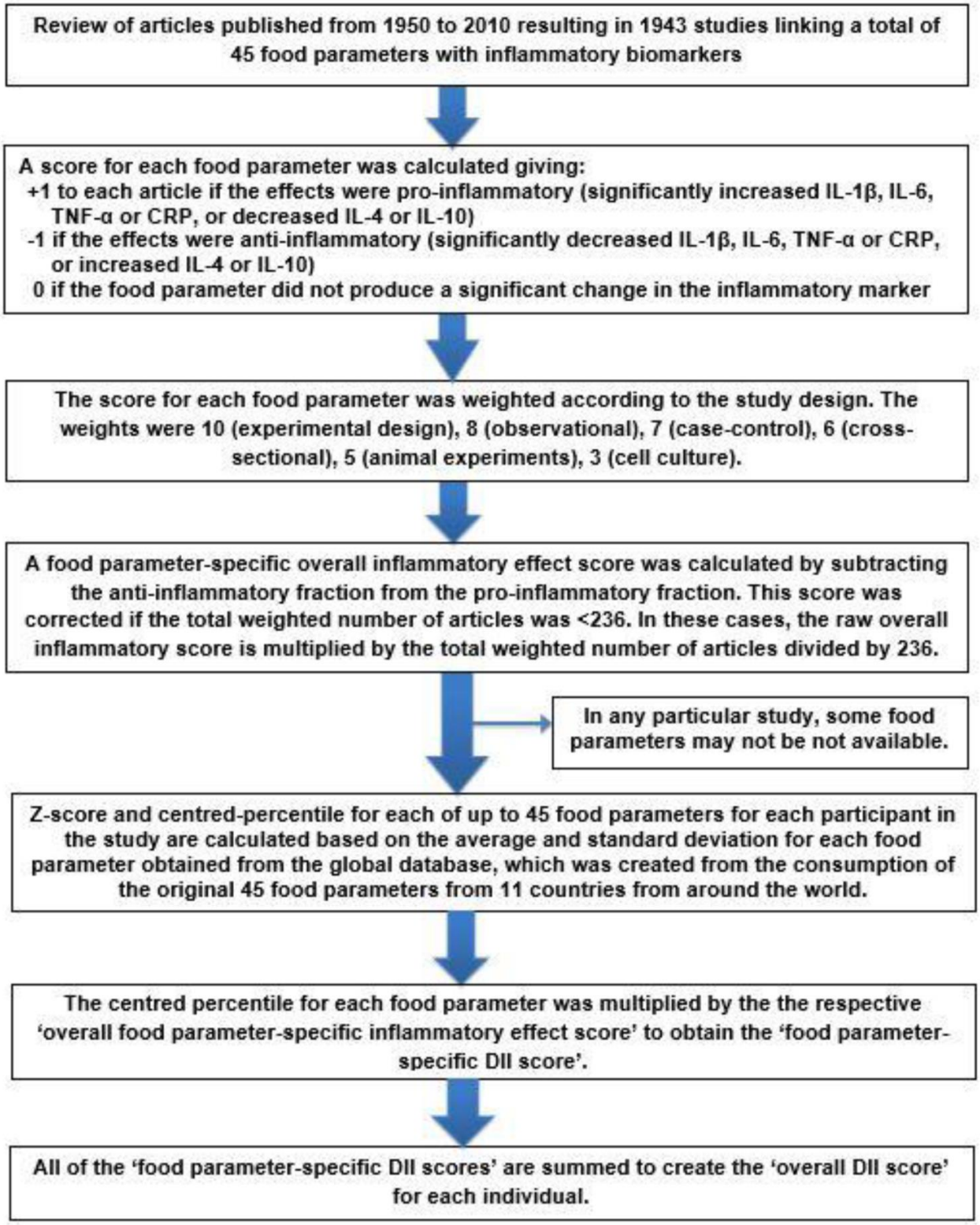
It is important to consider the inflammatory potential of food in the African context as well as the nutritional transition happening in sub-Saharan Africa. There has been an increase in the availability of affordable Western type diets in urban sub-Saharan Africa [29]. These western type diets include processed foods, high red meat, high-fat dairy products, refined grains, simple carbohydrates, convenient snacks and sugary beverages [25, 29]. These have been associated with higher levels of inflammatory mediators, making the western diet pro-inflammatory [29]. Most of the dietary transition in sub-Saharan Africa has occurred in urban areas, however, diets from urban areas are being adopted extensively in rural areas as their accessibility in rural areas continues to increase [25]. This has in turn affected rural health in some sub-Saharan countries [30, 31].

2.5 Dietary inflammatory index

The dietary inflammatory index was introduced in 2009 as an applicable tool to assess the overall inflammatory potential of a diet by categorising individual's dietary intake as either anti-inflammatory or pro-inflammatory [33]. It was based on literature from different study designs, from cell culture to observational and experimental studies in humans [34,35]. Fig 2 below is adapted from a study by

Shippava and outlines the steps followed to come up with the DII. In Summary The dietary inflammatory index was produced by reviewing articles published between 1950 and 2010 which linked nutrients to specific inflammatory markers. The relevant articles were weighted and classified as anti-inflammatory and pro-inflammatory [34]. Articles that found pro-inflammatory markers were assigned a +1 and those that found anti-inflammatory properties given a -1 and 0 to those that found no effect. [34,35].The individual food parameter-specific raw inflammatory effect scores were then calculated by using weighted values of the articles which were based on the type of study [34,35]. Finally the overall inflammatory effect score of each food parameter was calculated by dividing the weighted pro- and anti-inflammatory articles by the total weighted number of articles and then subtracting the anti-inflammatory fraction from the pro-inflammatory fraction [34,35].

DII was designed to be applicable to all human studies and has since been used in various studies to determine the association of inflammatory diet with various health conditions such as gastric cancer, sleep quality, insulin resistance and schizophrenia amongst other studies [34,35].


Review of articles published from 1950 to 2010 resulting in 1943 studies linking a total of 45 food parameters with inflammatory biomarkers
A score for each food parameter was calculated giving:
+1 to each article if the effects were pro-inflammatory (significantly increased IL-1β, IL-6, TNF-α or CRP, or decreased IL-4 or IL-10)
-1 if the effects were anti-inflammatory (significantly decreased IL-1β, IL-6, TNF-α or CRP, or increased IL-4 or IL-10)
0 if the food parameter did not produce a significant change in the inflammatory marker
The score for each food parameter was weighted according to the study design. The weights were 10 (experimental design), 8 (observational), 7 (case-control), 6 (cross-sectional), 5 (animal experiments), 3 (cell culture).
A food parameter-specific overall inflammatory effect score was calculated by subtracting the anti-inflammatory fraction from the pro-inflammatory fraction. This score was corrected if the total weighted number of articles was <236. In these cases, the raw overall inflammatory score is multiplied by the total weighted number of articles divided by 236.
In any particular study, some food parameters may not be not available.
Z-score and centred-percentile for each of up to 45 food parameters for each participant in the study are calculated based on the average and standard deviation for each food parameter obtained from the global database, which was created from the consumption of the original 45 food parameters from 11 countries from around the world.
The centred percentile for each food parameter was multiplied by the the respective 'overall food parameter-specific inflammatory effect score' to obtain the 'food parameter-specific DII score'.
All of the 'food parameter-specific DII scores' are summed to create the 'overall DII score' for each individual.

3. Study objectives

The objectives of the study are to determine association if any, between prenatal inflammatory diet and reduced lung function in infants. As reduced lung function is a risk factor for childhood asthma, this study will help to determine if prenatal inflammatory diet is a risk factor for childhood asthma.

4. Methodology

4.1 Study area

The parent study was a prospective study carried out in the General population Cohort, which is a Health and Demographics Surveillance Site in Kyamulibwa, in Kalungu district of South-Western Uganda. This study will use quantitative data collected in the parent study using quantitative data collection methods.

4.2 Study design

This will be a secondary analysis of data collected from IMPALA birth cohort, a prospective cohort study of pregnant women in rural Uganda, whose main aim was to describe the maternal and household factors associated with lung function in infants..

4.3 Study population

Pregnant women are required to present for antennal care four times before giving birth as recommended by the WHO [36].In this study pregnant women who attend antenatal care at one of four health facilities that serve the Kalungu district were recruited. The infants of these women were also recruited. A total of 560 pregnant women were recruited from the antenatal care facilities for this study.

4.4 Inclusion and exclusion criteria

Inclusion criteria

Only pregnant women 15 years and older who provided informed consent for the research were included.

The women were also included if they were willing to go for the second antenatal care visit and were also willing to allow home visits by the research team. Mothers had to give consent for their infants to be included in the study.

Exclusion criteria

Women who had intentions to relocate permanently out of the district were excluded and infants with congenital structural upper airways abnormalities at birth were also excluded.

4.5 Sampling

Convenience sampling technique was used to recruit pregnant women who presented for antenatal care at the three health facilities that offer maternity for this cohort study. Potential participants attending the antenatal clinics were provided with an information sheet in the local language to read whilst waiting to be seen. Where necessary the clinic staff read the information sheet and explained the study to the potential participants. Participants who express an interest in taking part were directed to the research team at the end of the clinic appointment and informed written consent was obtained from them. Those who requested more time to think about it were given 24 hours or returned on another day

4.6 Sample size

As this will be a secondary study, sample size will not be calculated. However, the primary study enrolled a minimum of 560 into the study. Since there had not been any studies that investigated maternal nutrition during pregnancy and lung function of their young infants in Africa, sample size calculation was based on air pollution as the main exposure, and was based on a birth cohort study on air pollution during pregnancy and lung function in infants in which air pollution levels were related with the lung function in infants aged 6-10 weeks, and reported a mean (SD) of 1401 (242) ml/l [37].

In recruiting 560 pregnant women, it was anticipated that infant lung function will be obtained on 360 infants, assuming an estimated 10% loss to follow up, 5% rate of miscarriages, still births, and neonatal deaths and that lung function measurements will be obtained on 75% of infants that attend.

This sample size estimation was based on the primary exposure (maternal diet) and association with infant lung function. The study was projected to have 80% power to detect an 8% difference in minute volume across the quintiles of maternal dietary intakes at the 5% level of significance. With

a minimum sample size of 360, the study was expected to have atleast 80% power to estimate effect sizes of an OR = 1.5 or larger.

4.7 Dietary inflammatory index and Dietary diversity score

The recruited mothers were required to complete a Food frequency questionnaire at 2 time points. We used the resulting dietary data to calculate DII scores for each participant. DII will be discussed in detail in next chapter.

5. Data collection and Measurements

The data was collected at four time points; first at recruitment during the antenatal clinic visit ; then during a home visit to the home of the pregnant woman; followed by collection at the postnatal clinic visit(6 weeks) and lastly at home visit during the postnatal period (5-6 weeks). Dietary information was collected from the recruited mothers through Food Frequency questionnaires as well as the Dietary diversity for women questionnaire. The FFQ DD-W questionnaires were given at recruitment at antenatal facilities.

5.1 Outcome Measures and other covariates

The outcomes of interest were doctor measured infant lung function measured at first inoculation. The Dietary inflammatory index will be divided into quartiles and will be used as our primary exposure of interest. Other covariates to be considered include Mothers age, education status, smoking status, alcohol consumption, BMI at enrolment, Maternal and paternal (biological father) asthma status at enrolment.

5.2 Data analysis and Descriptive statistics:

R version 3.5.3 will be used for statistical analysis. Exploratory data analysis will look at the distribution and summary statistics of each individual variables for both mother and infant. Categorical variables will be assessed using frequency tables. Continuous variables will be assessed using histograms as well as means and standard deviations for normally distributed data, and medians and interquartile ranges for data not normally distributed. Prevalence (95% confidence intervals) of key outcomes will be estimated. Baseline characteristics of women completing the study versus lost to follow up will also be described. Univariable and multivariable generalised linear models will be

used to determine the association between maternal diet and infant lung function parameters. The most suitable model will be selected for the outcome of interest (infant lung function). Exposures, important confounders and additional co-variates will be included in the multivariable models. Model appropriateness and fit will be assessed using standard model diagnostics. Associations with p-values <0.05 will be interpreted as statistically significant.

6. Ethical consideration and consent

This study uses secondary data from a primary study that got ethical approval from the Liverpool School of Tropical Medicine Research Ethics Committee (LSTM REC). This protocol and associated documents will be submitted for ethical approval to the Human Subjects Research Ethics Committee of the Faculty of Health Sciences at the University of Cape Town.

Informed consent

The primary study obtained informed consent of all participants before enrolment. This was through standardized script in participants home language (Luganda), delivered by trained study staff. The script detailed the purpose of the study, study procedures, and the risks and benefits to mothers and infants that participants may encounter during the study. It was emphasized that participation is voluntary and participants may exit the study at any time without compromising the quality of health care they received from the health care facilities.

Risks

In this specific protocol, there are no risks to any individuals as the study will use secondary data obtained from a primary study that considered all possible risk and was carried out under ethical approval.

7. Use of information or publication

The study findings will be collated and submitted as the mini-dissertation component of the author's Masters in Public Health degree.

8. Logistics

	June	July	August	Sept	October	November	Dec/Jan
Literature review							
Data analysis							
Results							
Write up							
Submission							

9. Budget

No funding will be required for this study as it will be using secondary data obtained from another study. All components of the data analysis will be done at the other's time with no expenses expected

10. Conflict of interest

No conflict of interests anticipated.

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PART B: MANUSCRIPT

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Abstract

Background: Infant lung capacity and low birth weight among others, are risk factors for childhood and adulthood chronic respiratory diseases such as chronic obstructive pulmonary disease (COPD) and asthma. These respiratory diseases are among the leading causes of death and disability worldwide. The aetiology of these respiratory diseases and other inflammatory conditions has recently been linked to maternal diet during pregnancy. As such it has been important to study the role of maternal diet during pregnancy to find any association with maternal and infant outcomes. Highly diverse diets have been thought to be a proxy to maternal nutrient adequacy as well as healthy diet. Diverse diets may offer protection from inflammatory airway diseases and other inflammatory diseases by evening out inflammatory and anti-inflammatory food components.

Purpose: To investigate the effect of Dietary diversity (DD) and Dietary inflammatory index (DII), on infant birth outcomes particularly birth weight and lung function and to determine if there is any association.

Methods: In this study we analysed data obtained from 564 women who attended antenatal care facilities in Kalungu district of rural Uganda. These women were recruited by convenience sampling as they walked in to the facilities for antenatal care. Those who gave consent were given asked about their diets and socioeconomic statuses by means of questionnaires and home visits. Dietary scores were created as the number of unique food groups obtained from the data collected. The scores ranged from 0-14, with 14 representing those who consumed all 14 unique food groups identified in the study. Dietary inflammatory index was also calculated from the data obtained. The methods for calculating the DII will be explained in detail under methods. The data collection on Dietary diversity was based on 24hr recall.

Results: The mean tidal volume was higher in female infants at 7.63ml/kg (SD=1.57), than in male infants at 7,35ml/kg (SD=1.53). This difference in tidal volume was however not statistically significant.The mean Dietary Diversity score was 4.61 +/- 1.79 SD. In the previous 24 h, 84.8% of the participating women had consumed tubers such as cassava, 57.1% reported consuming grains or

cereal, 12.6% vegetables, 19.3% Fruits, 1.2% meat and 7.4% eggs. There were statistically significant differences in dietary practices of the women according to their level of education, with 81% of those who attained tertiary education having adequate dietary diversity.

Starches were the most consumed food group with an average of 16 servings per week while meat, processed starches (samosas etc), fruits and vegetables were consumed at less =<2 serving per week, with meat the least consumed at an average of less than 1 serving per week.

Although marginal, the diets of the participants were mostly anti-inflammatory with an average dietary inflammatory score of -1.2. Those with the lowest inflammatory score were associated with more servings of legumes, green leafy vegetables, fish and less servings of processed starches and animal oil.

There was no association observed between dietary diversity and infant birth outcomes, birth weight and lung function. No association was also observed between Dietary inflammatory scores and infant lung function.

Conclusion: This study shows that in rural areas or in low income countries, dietary diversity is low and uniform across the population. There was high of consumption of starches and legumes with low consumption of fruits, vegetables and meat products. There were no significant differences in consumption of different food groups across different occupations, age groups, marital status and to some extent level of education. Interventions aimed at improving food diversity may be required.

Introduction

Lung function, a term used to describe how well the lungs work in helping a person breathe, has been used in epidemiological studies as a predictive measure for the presence or absence of respiratory disease in early childhood as well as later in adulthood [1]. Studies indicated that there was an increased risk of early childhood wheezing in children reported to have increased airway resistance in the first few weeks of life [1,2]. High airway resistance and reduced specific airway conductance shortly after birth was also associated with an increased risk of recurrent bronchial obstruction and doctor diagnosed asthma at 2 years of age [1]. As such it was found that reduced lung function at birth is a risk factor for asthma within the first 10 years of life [1]. Lung function has also been shown to have associated with infant birth weight, with low birth weight associated with reduced lung capacity [2,3]. As such factors that influence infant lung function will influence development of childhood and adulthood chronic respiratory diseases such as asthma [2,3]. Some of these factors include prenatal maternal diet.

Recent studies have associated prenatal maternal diet with adverse infant outcomes such as low birth weight and reduced lung function amongst others [8,12]. Furthermore, dietary factors have been found to play a role in the pathogenesis of inflammatory diseases such as asthma [8,12]. Certain types of foods have been shown to have nutrients that promote inflammatory diseases by stimulating increased production of certain inflammatory mediators in the body. [8]. These types of food are called pro-inflammatory foods. Conversely, some food items contain nutrients or antioxidants that result in reduction of inflammatory mediators thereby playing a protective role against inflammatory diseases [8,12]. The inflammatory potential of diets has been measured using a recently developed tool called the Dietary inflammatory index [18]. A negative DII score means the diet is anti-inflammatory while a positive score means the diet is inflammatory [8]. Dietary diversity, which is defined as the different number of unique food groups consumed at a specified time period, has been universally regarded as a proxy for healthy diets which contain a balance of all essential nutrients [8,11]. Highly diverse diets have been shown to be protective against inflammatory diseases such as asthma [8].

With the increasing global burden of asthma, it is vital to explore all possible risk factors so as to provide adequate interventions to reduce the burden of the disease. Studies as early as the 1980s by Professor David Barker suggested that chronic diseases (such as asthma and COPD) which often manifest in adulthood are programmed during pregnancy and during the early stages of growth and development [13]. As such this study aims to find association if any between pre-natal maternal diet and infant adverse outcomes with particular attention on low birth weight and reduced lung capacity.

Methods

Study design and study population

The original study was a prospective cohorts study where pregnant women accessing antenatal healthcare facilities in Kyamulibwa in Kalungu district of rural Western Uganda were enrolled as they presented for antenatal care at the Health and Demographics Surveillance site. This surveillance site comprises of 25 rural villages and a small township of Kyamulibwa Town Council and has a total population 22,000 people. A door to door census is conducted every year to update the population demographics. There are five health care facilities that provide basic medical care and antenatal and postnatal care to the population. The majority of people in this low income area made a living from farming and selling bananas, coffee, vegetables, potatoes and other root plants. The education levels were low with only one third of the population having attained secondary education. A total of 564 pregnant women who gave consent were recruited from this HDSS.

Inclusion and exclusion criteria

Only pregnant women of 15 years and older, who provided informed consent for the research were included in the study. Women were also included if they were willing to attend the second antenatal care visit and also willing to allow home visits by the research team. Both parents of the infants had to give consent for their infants to be included in the study. Women who had intentions of permanently relocating out of the district were excluded from the study. Infants with congenital structural upper airways abnormalities at birth were also excluded. The lung function of infants found to be severe sick or with current respiratory illness was deferred to three weeks after recovery.

Sample size calculation

Sample size calculation was based on air pollution as the main exposure, and was based on a birth cohort study on air pollution during pregnancy and lung function in infants in which air pollution levels were related with the lung function in infants aged 6-10 weeks, and reported a mean (SD) of 1401 (242) ml/l [9]. In recruiting 564 pregnant women, it was anticipated that infant lung function will be obtained on 360 infants, assuming an estimated 10% loss to follow up, 5% rate of miscarriages, still births, and neonatal deaths and that lung function measurements will be obtained on 75% of infants that attend.

The study was projected to have 80% power to detect an 8% difference in minute volume across the quartiles of maternal dietary intakes at the 5% level of significance. With a minimum sample size of 360, the study was expected to have at least 80% power to estimate effect sizes of an OR = 1.5 or larger.

Data collection and Measurements

Data was collected from the women at recruitment during their antenatal clinic visit. Here maternal sociodemographic characteristics were taken as well as dietary information through a FFQ and DD-W questionnaire. Infant lung function data was collected at post-natal presentation. Dietary diversity score was calculated from the data obtained from the DD-W questionnaire. The DD-W 14 food group were used the calculate the DDS, these included, cereals, roots and tubers, fruits, meat (organ, poultry and offal), Eggs and dairy, fish, legumes, green leafy vegetables, orange vegetables, sugars, oils/fats, non-alcoholic beverages. Each food group was then assigned a score of either 0 or 1 for not consumed and consumed respectively. The DDS was then measured by the sum of all the food items consumed. The DDS was then dived into two groups, inadequate and adequate. Participants who reported consuming less than 5 food groups were categorised under inadequate dietary diversity while those who consumed more than 5 food groups were grouped under adequate dietary diversity. The DDS was used as the primary exposure of interest.

The data from the FFQ was used to calculate the dietary inflammatory index score. This was done by dividing the weekly food frequency by 7 to obtain the daily food frequency. The daily food frequency was then multiplied by estimated portion sizes (Supplementary Figure 1) to get the food consumption in grams for each food parameter. Each food parameter was z-scored by subtracting the mean then dividing by the standard deviation obtained from the global database. This was followed by centering the z-scores by subtracting 1. The result was then divided by 100 to get a percentile. Each food parameter percentile was multiplied by the food specific inflammatory effect score (Supplementary Figure 2) to obtain the food parameter specific DII score. The overall dietary inflammatory score for each individual was obtained by summing up all the food parameter specific DII scores. The overall DII scores were. The Dietary inflammatory index was divided into quartiles and used as the primary exposure of interest.

Outcome Measures and other covariates

The outcomes of interest were infant birth weight which is defined as the first weight of the infant measured by the health care professionals at birth and doctor measured infant lung function measured at first inoculation (6 weeks). Infant lung function was measured by Tidal breath analysis and presented as Tidal volume (ml/kg). Minute ventilation(ml/kg/min) was calculated by multiplying respiratory rate by tidal volume and also used as a measure of infant lung function. Other covariates that were considered include Mother's age, educational status, smoking status, alcohol consumption, BMI at enrolment, Maternal and paternal (biological father) asthma status at enrolment.

Data analysis Descriptive statistics:

Exploratory data analysis looked at the distribution and summary statistics of the relevant variables for both mother and infant. Continuous variables were assessed using histograms as well as means

and standard deviations for normally distributed data, and medians and interquartile ranges for data not normally distributed. Prevalence (95% confidence intervals) of key outcomes were estimated. Baseline characteristics of women completing the study were described. Univariable and multivariable generalised linear models were used to determine the association between maternal diet and infant lung function parameters. Exposures, important confounders and additional co-variates were included in the multivariable models. Associations with p-values <0.05 were interpreted as statistically significant.

Ethical consideration and consent

Informed consent was obtained from all participants at recruitment through standardized script in participants home language (Luganda). The scripts were delivered by trained study staff and detailed the purpose of the study, the procedures, and the risks and benefits to mothers and infants.
This study used secondary data from a primary study that received ethical approval from the Liverpool School of Tropical Medicine Research Ethics Committee (LSTM REC). The protocol for this study was submitted to the Human Subjects Research Ethics Committee of the Faculty of Health Sciences at the University of Cape Town and was granted ethical approval.

Results

A total of 564 pregnant women were enrolled in the study and 384 infants were considered in the data analysis. The majority of participants were black Africans (99.6%) with only n=2 Caucasians. The average age of the women who participated in the study was 26.6 years (SD=6.5), with the youngest being 15 and the oldest woman recruited being 46 years of age. Most of the women (n=318) in the study were between 20 and 29 years of age which is 56.4% of the study population. Women over 40 years old (n=18), made up 3,2% of the study population. Of the women who participated in the study, over 90% had only attained primary education and worked as subsistence farmers (71.3%). 8.9% of them were unemployed (n=50), with 48 being housewives and 2 students.

The majority (n=550) of the women who participated in the study were married, with 79.3% (n=447) married monogamously and 18.3% (n=103) in polygamous marriages. Only 12 participants (2.1%) were not married, with 9 of them never married, 2 divorced and 1 widowed. 50.2% of the participants had healthy weight and history of comorbidities was low at the time of the interview, with only 1.6% reporting history of asthma, hypertension and 0.9% for TB. Most of the study participants had no history of smoking or alcohol consumption. Only 1.1% reported a history of smoking and 6.7% for alcohol consumption.

Participant baseline characteristics and the differences between those who had low infant birth weight and those who had normal infant birth weight are shown in Table 1.There were notable differences in distribution of maternal age in each birth weight category, with an average age of 24.3 for those whose infants had low birth weight compared to 26.6 for normal birth weight. . Bivariate analysis showed a statistically significant association between birth weight and maternal age with a p-value <0.05.

Occupation, level of education, alcohol consumption, maternal BMI, history of asthma, TB, diabetes and smoking, were not associated with infant birth weight with p-values >0.05.

Table 1. Maternal characteristics by infant birth weight categories

	Low birth weight (N=46)	Norma birth weight (N=335)	P-value
Maternal Age			0.009
Mean (SD)	24.3 (6.62)	26.6 (6.45)	
Median [Min, Max]	22.0 [15.0, 41.0]	26.0 [16.0, 46.0]	
Age category			0.04
14- 19 years	12 (26.1%)	40 (11.9%)	
20-29 years	25 (54.3%)	192 (57.3%	
30-39 years	7 (15.2%)	91 (27.2%)	
>=40 years	2 (4.3%)	12 (3.6%)	
Level of Education			0.82
None	2 (4.3%)	16 (4.8%)	
Primary	27 (58.7%)	189 (56.4%)	
Secondary	16 (34.8%)	114 (34.0%)	
Tertiary	1 (2.2%)	14 (4.2%)	
History of Smoking			0.88
No	46 (100)	329 (98.2%)	
Yes	0 (0%)	5 (1.5%)	
History of TB			0.88
No	46 (100%)	330 (98.5%	
Yes	0 (0%)	5 (1.5%)	
History of Asthma			0.32
No	46 (100%)	328 (97.9%)	
Yes	0 (0%)	7 (2.1%)	
History of Alcohol use			0.28
No	45 (97.8%)	308 (91.9%	
Yes	1 (2.2%)	26 (7.8%)	
Weight			0.18
Mean (SD)	58.1 (11.5%)	61.3 (10.1)	
Median [Min, Max]	56.5 [35.0, 92.0]	60.0 [40.0, 97.5]	
BMI Category			0.31
Underweight	2 (4.3%)	12 (3.6%)	
Healthy weight	28 (60.9%)	169 (50.4%)	
Overweight	7 (15.2%)	83 (24.8%)	
Obese	5 (10.9%)		

Starches were the most frequently consumed food items amongst women who had low birth weight infants at an average of 16.4 servings per week., followed by fruits at an average of 13.4 servings per week as shown in Supplementary table 1. Meat and non-alcoholic beverages were the least frequently consumed at1.15 and 0.54 serving per week respectively. Mothers who gave birth to infants with normal birth weight showed similar food frequency patterns with starch being the most frequently consumed food item at 16.4 serving per week, while non-alcoholic beverages and meat were the least consumed at 0.54 and 0.99 servings per week respectively. There was no association between maternal frequency of consumption of all these food items and infant birth weight, with bivariate analysis giving a p-value >0.05.

Table 2 shows the infant summary statistics by gender. There was an even distribution of boys and girls with 182 females' babies and 202 male babies. The average weight of all infants was 3.28kg with a standard deviation (SD) of 1.62kg. The weight of the infants was not normally distributed with a p-value < 2.2e-16 from the Shapiro-Wilk normality. Female infants were slightly heavier than male infants with average weight of 3.37kg among female infants and 3.22kg amongst males. This difference in means was not statistically significant with a p-value of 0.2904 from Wilcoxon rank sum test. There were slightly more female infants who were underweight than male infants. There were no statistically significant differences in the mean tidal volume per body weight by gender with a p-value >0.05. The prevalence of low birth weight in this study was 12,1%.

Table 2. Infant characteristic by gender

	Overall (N=384)	
	Female(N=182)	**Male (N=202)**
Birth Weight (Kg)		
Mean (SD)	3.37 (2.55)	3.22 (0.555)
Median [Min, Max]	3.10 [1.60, 33.0]	3.20 [1.30, 4.90]
Missing	38 (20.9%)	29 (14.4%)
Birth Weight Category		
Low birth weight	18 (9.9%)	18 (8.9%)
Normal birth weight	126 (69.2%)	155 (76.7%)
Tidal volume per body weight (ml/kg)		
Mean (SD)	7.63 (1.57)	7.35 (1.53)
Median [Min, Max]	7.47 [3.74, 13.2]	7.13 [2.05, 12.8]
Minute ventilation per body weight (ml/min/kg)		
Mean (SD)	333 (60.7)	323 (61.7)
Median [Min, Max]	331 [175, 611]	316 [51.5, 472]

Table 3 below shows the number of meals consumed a day by maternal characteristics. The participating women reported eating an average of 2.7 meals per day, with a minimum of one meal per day and a maximum of 5 meals per day. No one (n=0) reporting not having any meal a day while 95.9% (n=541) of the participants reported having 2-3 meals a day. Only 2.48% (n=14) reported having 4-5 meals per day. As shown in table 3 below, those who reported to having 3 meals per day were aged between 20-29 years (55.3%) n=197, attained primary education (54.5%) n=194, were married monogamously (79.5%) n=283 and were subsistence farmers (66%) n=235.

There was no statistically significant difference in the number of meals per day by age category (p-value = 0.8782, Chi-squared test. Similarly, there was also no statistically significant difference in meals per day among different levels of education and marital status with a p-values of 0.3871 and 0.9198 respectively.

Table 3: No of meals per day by maternal characteristics make this table 3

	Overal (N=564)				
	1(N=2)	2 (N=185)	3 (N=356)	4 (N=13)	5 (N=1)
Age Category					
14- 19 years	0 (0%)	34 (18.4%)	55 (15.4%)	0 (0%)	0 (0%)
20-29 years	1 (50.0%)	102 (55.1%)	197 (55.3%)	10 (76.9%)	1 (100%)
30-39 years	1 (50.0%)	42 (22.7%)	92 (25.8%)	3 (23.1%)	0 (0%)
>=40 years	0 (0%)	7 (3.8%)	11 (3.1)	0 (0%)	0(02%)
Level of Education					
Primary	2 (100%)	113 (61.1%)	194 (54.5%)	6 (46.2%)	1 (100%)
None	0 (0%)		10 (5.4%)	15 (4.2%)	0 (0%)
Secondary	0 (0%)	54 (29.2%)	132 (37.1%)	5 (38.5%)	0 (0%)
Tertiary	0 (0%)	4 (2.2%)	15 (4.2%)	2 (15.4%)	0(0%)
Occupation					
Farmer	1 (50.0%)	153 (82.7%)	235 (66.0%)	8 (61.5%)	1 (100%)
Business	0 (0%)	7 (3.8%)	23 (6.5%)	1 (7.7%)	0 (0%)
Housewife	0 (0%)	9 (4.9%)	38 (10.7%)	1 (7.7%)	0 (0%)
Teacher	0 (0%)	7 (3.8%)	15 (4.2%)	1 (7.7%)	0 (0%)
Student	0 (0%)	0 (0%)	2 (0.6%)	0 (0%)	0 (0%)
Marital Status					
Married Mono	2(100%)	148 (80%)	283 (79.5%)	8 (61.5%)	1 (100%)
Married Poly	0 (0%)	31 (16.8%)	66 (18.5%)	4 (30.8%)	0 (0%)
Divorced	0 (0%)	0 (0%)	2 (0.6%)	0 (0%)	0 (0%)

Only 5.7% (n=32) of the women reported ever being short of food as shown in Supplementary table 2. Most of the food shortage occurred in April, with 32 women reporting food shortage in this month, followed by 12 women in August. No participants reported food shortages in December. There were differences in food shortage incidence among the different marital statuses, with 33.3% (n=3) of those who were never married reporting food shortage, while only 5.1% (n=23) of those married monogamously and 4.9% (n=5) of those married polygamously, reported food shortage. These differences were statistically significant with a p-value of 5.5e-06 from the Pearson's Chi-squared test.

Table 4 below was obtained derived from data obtained from FFQ. It shows the frequency of consumption of the individual food items. Starches were the most consumed food items with no one reporting to have not consumed starch at all on any given day. The majority of the participants

(85.3%) consumed starch 6 times and more a day. The weekly consumption of starch followed a similar trend with 97% consuming it 7 times and more. Legumes were also highly consumed with about 50% of participant consuming them 2-3 times a day. 92.38% of the participants reported not consuming animal oil at all. While 94.5% did not consume orange vegetables at all. Meat, non-alcoholic beverages, green leafy vegetables, and processed starched were also amongst the least consumed food items. Supplementary table 4 shows the average weekly servings of the food items and its shows that starches were the most consumed food group, with an average 16.3 servings per week. Amongst the starches, tubers were the most consumed, with 84.8% (n=478) of participants reporting to have consumed them followed by grains at 57.1% (n=322) as shown in Table 5. Meat organ (rich in iron) was the least consumed food items as shown in Table5, with only 1.2% (n=7) of participants reporting to have consumed it. Amongst those who reported to consuming meat, average weekly consumption was very low at 0.94 servings per week as shown in Supplementary table 3.

Table 4: Results of food frequency of individual food items keep

Food	Never	Once a day	2-3 x/d	4-5 x/d	>=6 x/day	Once/week	2-4 x/week
Meat	203(35.99)	141(25)	171(30.32)	37(6.56)	12(2.13)		108(19.15)
Starch	0	0	9(1.60)	74(13.12)	481(85.28)	0	2(0.35)
Fish	65(11.52)	93(16.49)	336(59.57)	55(9.75)	5(0.86)	15(2.66)	109(19.33)
Legumes	17(3.01)	60(10.64)	280(49.65)	185(32.80)	22(3.9)	9(1.60)	217(38.48)
Non-alcoholic	422(74.82)	93(16.49)	47(8.33)	2(0.35)	0	15(2.66)	60(10.64)
Dairy and egg	268(47.52)	186(32.98)	108(19.15)	2(0.35)	0	22(3.9)	140(24.82)
Fruit	19(3.37)	25(4.43)	103(18.26)	158(28.01)	257(45.57)	3(0.53)	48(8.51)
Green leafy vegetables	181(32.09)	152(26.95)	127(22.52)	50(8.87)	14(2.48)	38(6.74)	224(39.72)
Insects	518(91.84)	45(7.98)	1(0.18)	0	0	14(2.48)	10(1.11)
Oil-animal	521(92.38)	32(5.67)	11(1.95)	0	0	5(0.89)	25(4.43)
Oil-veg	14(2.48)	318(56.38)	220(39.01)	10(1.77)	2(0.35)	7(1.24)	296(52.48)
Orange vegetables	533(94.50)	25(4.43)	5(0.89)	0	1(0.18)	10(1.77)	12(2.13)
Other vegetables	117(20.74)	187(33.16)	252(44.68)	7(1.24)	1(0.18)	23(4.08)	180(31.91)
Processed Starch	259(45.92)	128(22.70)	121(21.45)	37(6.56)	19(3.37)	43(7.62)	131(23.23)
Sugars	58(10.28)	316(56.03)	186(32.98)	4(0.71)	0	12(2.13)	123(21.81)
Meals	0	2(0.35)	541(95.92)	14(2.48)			

Table 5 below also shows that vegetable intake amongst the participants was low with only 14.4% (n=81) participants reporting that they consumed green leafy vegetables, 12.6% (n=71) orange vegetables and 15.6% (n=88) for other vegetables. Among those who reported to consume green leafy vegetables, their weekly consumption was poor at an average of 2.09 servings per week as shown in Table 2.4. 53.4% (n=301) consumed legumes such as beans at an average weakly serving of 5.

Dairy products and eggs were poorly consumed with an average of 1.79 servings per week and only 7.4% (n=42) of the participants reported to consuming them.

It is also worth noting that processed starches were also minimally consumed with average consumption of 1.74 servings per week and only 7.4% (n=42) participants reported consuming fried snacks or process starches. Vegetable oil products were far commonly consumed than animal derived fats with an average weekly serving of 4.49 compared to 0.152.

Table 5: Summary table of food items consumed from food Dietary diversity instrument

	Overall N=564)	
	No	**Yes**
Grain	242 (42.9%)	322 (57.1%)
Orange Vegetables	493 (87.4%)	71 (12.6%)
Tubers	85 (15.1%)	478 (84.8%)
Green Vegetables	480 (85.1%)	81 (14.4%)
Orange Fruits	451 (80.0%)	109 (19.3%)
Other Fruits	441 (78.2%)	119 (21.1%)
Other Vegetables	476 (84.4%)	88 (15.6%)
Meat Organ	552 (97.9%)	7 (1.2%)
Eggs	520 (92.2%)	42 (7.4%)
Fish	385 (68.3%)	179 (31.7%)
Beans	263 (46.6%)	301 (53.4%)
Fried Snacks	518 (91.8)	42 (7.4%)

The dietary diversity scores measured by the DD-W questionnaire ranged from 1 to 14 food groups. Only 1.6% (n=9) consumed only one of the 14 food groups and 0.35% (n=2) reported consuming all 14 food groups in the previous 24hrs. The average DDS was 4.61 (+/-1.79SD).

Table 6 below shows that 49.1% (n=277) of the participants had adequate dietary diversity score (>=5 food groups), while 47,2% (n=266) had inadequate dietary diversity (<5 food groups). There was an even distribution of dietary scores across the different age categories with the major differences in dietary score occurring in the 30-39 age group. An association was found between dietary diversity and maternal age with a p-value <0.05. 81.8% (n=18) of those who attained tertiary education had adequate dietary diversity and there was an association between dietary diversity and level of education with a p-value of 0.04. 63.2% (n=24) of those who reported a history of alcohol use, had adequate dietary scores. There was an association between history of alcohol use and history of TB, with a p-value<0.05.

History of smoking, hypertension, and diabetes, as well as occupation, BMI and ethnicity, had no association with dietary diversity practices of participants with a p-value >0.05. Infant gender, weight and respiratory outcomes (Tidal volume and Minute ventilation) were also not associated with dietary diversity practices with a p-value >0.05.

Table 6: Maternal and infant characteristics by dietary diversity categories

	Adequate Diversity (N=277)	Inadequate Diversity (N=266)	P-value
Maternal Age			0.009
Mean (SD)	27.8 (20.9)	25.2 (6.10)	
Median [Min, Max]	26.0 [16.0, 35]	24.0 [15.0, 46.0]	
Level of Education			0.11
None	10 (3.6%)	12 (4.5%)	
Primary	152 (54.9%)	151 (56.8%)	
Secondary	97 (35.0%)	95 (35.7%)	
Tertiary	18 (6.5%)	4 (1.5%)	
History of Smoking			0.61
No	275 (99.3%)	263 (98.9%)	
Yes	2 (0.7%)	2 (0.8%)	
History of TB			0.02
No	277 (100%)	263 (98.9%)	
Yes	0(0%)	3 (1.1%)	
History of Asthma			0.9
No	273 (98.6%)	263 (98.9%)	
Yes	4 (1.4%)	3 (1.1%)	
History of Alcohol use			0.25
No	253 (91.3%)	253 (95.1%)	
Yes	24 (8.7%)	12 (4.5%)	
Weight			0.84
Mean (SD)	61.0 (10.9)	61.2 (9.6)	
Median [Min, Max]	59.1 [40.0, 97.5]	60.0 [35.0, 94.0]	
BMI Category			0.1483
Underweight	13 (4.7%)	3 (1.1%)	
Healthy weight	139 (50.2%)	134 (50.4%)	
Overweight	64 (23.1%)	69 (25.9%)	
Obese	27 (9.7%)	24 (9.0%)	
Infant Gender			0.37
Female	90 (32.5%)	82 (30.8%)	
Male	105(37.9%)	93 (35.0%)	
Infant Weight			
Mean (SD)	5.99 (1.73)	6.12 (1.81)	0.51
Median [Min, Max]	5.4 [3.5, 12.5]	5.50 [2.70, 12.8]	
Tidal Volume (ml/kg)			0.5734
Mean (SD)	7.41 (1.52)	7.55 (1.61)	
Median [Min, Max]	7.23 [2.05, 12.8]	7.33 [3.72, 13.2]	
Minute ventilation ml/kg/min			0.68
Mean (SD)	330 (63.5)	324 (59.1)	
Median [Min, Max]	329 [51.5, 611]	320 [132, 492]	

The average overall dietary inflammatory score was -1.20, with a minimum of -4.56 and a maximum of 0.14. Table 7 below shows the weekly consumption frequency of various food groups by DII

quartiles. The quartiles were as follows: Q1 -4.56 – (-1.52), Q2 -1.53 – (-1.15), Q3 -1.16 – (-0.79), Q4 -0.8 – (0.14). Intake of starch, legumes, fruit, green vegetables, fish and dairy products was observed to be higher in the more anti-inflammatory quartiles of DII than in the lesser anti-inflammatory quartiles. Bivariate analysis showed that there was a statistically significant association between Dietary inflammatory score and the frequency of consumption of legumes, starch, vegetables, fish and fruit, with p-values <0.05.

There was an even distribution of the maternal characteristics across the different dietary inflammatory index quartiles as shown in Supplementary table 4. The average age of participants in Q1 was 25.8 years while that of Q4 was 25.9 years. The average weight of the participants in Q1 was 60.9 while that of participants in Q4 was 60.5. There was no association between dietary inflammatory index quartiles and any of the maternal characteristics, with all giving a p-value>0.05 on various bivariate statistical tests.

Table 7: Food frequency by Dietary inflammatory quartile obtained from FFQ

	DII Q1 (N=142)	DII Q2 (N=143)	DII Q3 (N=139)	DII Q4 (N=140)	P Value
Starch per week					<0.0001
Mean (SD)	19.6 (9.78)	16.1 (7.03)	14.6 (5.58)	14.5 (6.43)	
Median [Min, Max]	18.0 [5.00, 66.0]	15.0 [5.00, 43.0]	14.0 [4.00, 34.0]	13.0 [4.00, 36.0]	
Legumes per week					<0.0001
Mean (SD)	8.25 (2.32)	5.49 (0.626)	4.04 (0.711)	2.18 (1.10)	
Median [Min, Max]	7.50 [6.00, 20.0]	5.00 [4.00, 7.00]	4.00 [3.00, 5.00]	2.00 [0, 4.00]	
Green leafy vegetables per week					0.07
Mean (SD)	2.51 (2.97)	1.76 (2.46)	2.04 (2.43)	1.89 (2.37)	
Median [Min, Max]	2.00 [0, 18.0]	1.00 [0, 15.0]	2.00 [0, 12.0]	1.50 [0, 11.0]	
Meat per week					0.81
Mean (SD)	1.27 (2.55)	0.839 (1.39)	0.748 (1.37)	0.900 (1.60)	
Median [Min, Max]	0 [0, 16.0]	0 [0, 7.00]	0 [0, 7.00]	0 [0, 7.00]	
Fish per week					0.00
Mean (SD)	4.00 (2.56)	3.35 (1.79)	3.14 (1.89)	2.88 (2.13)	
Median [Min, Max]	4.00 [0, 11.0]	3.00 [0, 9.00]	3.00 [0, 9.00]	3.00 [0, 9.00]	
Other vegetables per week					0.01
Mean (SD)	4.18 (2.96)	3.49 (2.78)	3.29 (2.94)	3.10 (2.81)	
Median [Min, Max]	4.00 [0, 12.0]	3.00 [0, 9.00]	3.00 [0, 13.0]	3.00 [0, 9.00]	
Dairy & egg per week					0.15
Mean (SD)	2.30 (2.95)	1.78 (2.80)	1.45 (2.09)	1.64 (2.47)	
Median [Min, Max]	0 [0, 11.0]	0 [0, 14.0]	0 [0, 11.0]	0 [0, 10.0]	
Insects per week					0.95
Mean (SD)	0.0563 (0.310)	0.0699 (0.349)	0.0576 (0.336)	0.0714 (0.332)	
Median [Min, Max]	0 [0, 3.00]	0 [0, 2.00]	0 [0, 3.00]	0 [0, 2.00]	
Vegetable Oil per week					0.15
Mean (SD)	4.81 (2.23)	4.29 (1.85)	4.30 (2.01)	4.54 (1.71)	
Median [Min, Max]	4.00 [0, 17.0]	4.00 [0, 14.0]	4.00 [0, 14.0]	4.00 [0, 9.00]	
Animal Oil per week					0.27
Mean (SD)	0.204 (0.749)	0.196 (0.906)	0.0935 (0.550)	0.114 (0.481)	
Median [Min, Max]	0 [0, 4.00]	0 [0, 7.00]	0 [0, 4.00]	0 [0, 3.00]	
Fruit per week					0.00
Mean (SD)	15.3 (11.7)	11.5 (6.66)	11.2 (7.09)	10.8 (7.62)	
Median [Min, Max]	12.0 [0, 64.0]	10.0 [0, 42.0]	10.0 [0, 53.0]	9.00 [0, 47.0]	

Table 8: below shows the infant characteristics and outcomes by DII quartiles. There is also an even distribution of birth weight, tidal volume and minute ventilation per body weight across the different

DII quartiles. There were no statistically significant association between DII quartiles and infant birth weight, Tidal volume and minute ventilation per body weight with p-values >0.05.

Table8: Infant characteristics by DII quartiles

	DII Q1 (N=98)	DII Q2 (N=102)	DII Q3 (N=95)	DII Q4 (N=89)	P Value
Birth Weight (Kg)					0.74
Mean (SD)	3.20 (0.534)	3.21 (0.514)	3.53 (3.09)	3.17 (0.564)	
Median [Min, Max]	3.20 [1.30, 4.20]	3.15 [2.00, 4.90]	3.20 [2.00, 33.0]	3.10 [2.00, 4.60]	
Birth Weight Category					0.68
Low birth weight	10 (7.0%)	10 (7.0%)	12 (8.6%)	14 (10.0%)	
Normal birth weight86 (60.6%)	88 (61.5%)	84 (60.4%)	77 (55.0%)	335 (59.4%)	
Tidal volume per body weight (ml/kg)					0.73
Mean (SD)	7.29 (1.36)	7.61 (1.68)	7.45 (1.59)	7.58 (1.57)	
Median [Min, Max]	7.21 [3.74, 11.7]	7.41 [3.72, 12.8]	7.23 [2.05, 13.2]	7.30 [4.28, 12.2]	
Minute ventilation per body weight (ml/min/kg)					0.17
Mean (SD)	328 (61.1)	321 (54.6)	323 (64.4)	339 (64.8)	
Median [Min, Max]	330 [175, 472]	317 [132, 65]	317 [51.5,569]	330 [167, 11]	

In both unadjusted and adjusted analyses, DII scores as quartiles during pregnancy showed no associations with infant tidal volume.

Discussion

In this study we found a lack of evidence for an association between maternal diet during pregnancy and either infant birth weight or infant lung function. Although there were indications of low dietary diversity, the reported diets were also low in inflammatory foods. Specifically, we looked at dietary diversity, dietary inflammation index and food frequency instruments to describe the diets of pregnant women in the rural Ugandan context, and to evaluate evidence for the association between diet and infant lung function.

This study re-confirmed the association of maternal age and infant birth weight, finding younger women (15-19 age group) had lower birth weight infants on average. This was consistent with studies that show a non-linear relationship between maternal age and birth weight with optimum weight attained at age 34 [5].

Similarly, differences in dietary practices according by level of education attainment were observed, with more years of education associated with adequate dietary diversity, but not with dietary inflammatory index score. This may be due to increased knowledge about nutritional demands during pregnancy amongst women who attained a higher level of education [11].

Although the study investigated association between maternal diet and infant birth weight and lung capacity, the findings of this study are similar to findings from studies that investigated association between maternal diet and childhood asthma. These studies found no association between diet quality and childhood asthma. A study by Nguyen et al, which was a prospective cohort from fetal life onwards in the Netherlands, found no association between maternal diet quality and ever asthma until age of 10 years [12]. However, associations have been found between higher DII scores and occurrence of asthma in older populations [12].

Despite finding no evidence of association between dietary diversity infant lung function, the study findings were consistent with literature regarding dietary patterns of low-income rural communities. There was higher consumption of starchy staples such as cassava and grains, with low intake of vegetables, which even when farmed are often sold, animal products and fruits. On investigating

dietary patterns in pregnant women, we found no evidence of association between dietary diversity during pregnancy and infant birth weight and lung function. There was inadequate dietary diversity in the study population and food consumption patterns showed a very low consumption of fruits, cereal, fish and vegetables, and especially low in items making up the "Mediterranean diet", which, during pregnancy, has been shown to be associated with decreased infant respiratory signs such as wheezing and atopy [4].

Similar to other studies, findings here suggest that rural women may have limited dietary intake and increased micronutrient deficiencies due to limited income, poor availability of nutritious foods and seasonality [6,7].

This study had several limitations which include reliance on self-reported measures of diet, potentially leading to recall bias. The study was also limited by inherent issues in the use of Food Frequency Questionnaires as methodology for dietary intake. The FFQ is heavily dependent on participant memory and literacy and numerical skills [6], and can lead to large recall bias. Using a single 24hr dietary recall for the FFQ may have introduced random error which would affect both the dietary inflammatory index hem towards the null [8]. The study participants were recruited at different gestational stages and some measures such as weight and BMI might have been influenced by the stage of pregnancy. No data was available pre-pregnancy. There might also have been a narrow exposure range and perhaps a shorter exposure time to see harmful effects.

There was also low diversity in income and socioeconomic status in the study population. This had an impact on the dietary patterns of the participants. As such the findings of this study may not be generalised to a more advantaged or diverse populations. Rural areas with a high proportion of low income residents may limit available food choices to starchy staples and grains. The pressure to sell fruit and vegetable for income similarly may limit dietary diversity. As with all observational studies, unmeasured confounding may also limit inference. Finally, women were enrolled into the study at a variety of gestational ages, and gestational age at time of interview may impact results as eating patterns change during pregnancy.

Conclusion

Maternal dietary diversity is low in Uganda due to lack of availability of diverse food items and poverty. These factors are important in determining the overall nutritional state of the pregnant mother. A single snapshot of self-reported diet may not adequately capture the true or total exposure to harmful (inflammatory) foods or even the full diversity of the diet. However, the overall maternal diet appears poor, and interventions aimed at improving dietary diversity and quality may be necessary.

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Supplement to:

A study of the association of prenatal inflammatory diet and adverse infant birth outcomes in a birth cohort in Uganda

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Supplementary table 1: Food frequency by birth weight category

	Low birth weight (N=46)	Normal birth weight (N=335)	Overall (N=381)
Starch per week			
Mean (SD)	16.4 (9.54)	16.4 (7.78)	16.3 (7.65)
Median [Min, Max]	14.0 [4.00, 50.0]	15.0 [5.00, 66.0]	15.0 [4.00, 66.0]
Meat per week			
Mean (SD)	1.15 (2.23)	0.994 (1.94)	0.940 (1.80)
Median [Min, Max]	0 [0, 11.0]	0 [0, 16.0]	0 [0, 16.0]
Fish per week			
Mean (SD)	3.80 (2.65)	3.28 (2.00)	3.35 (2.15)
Median [Min, Max]	3.50 [0, 11.0]	3.00 [0, 11.0]	3.00 [0, 11.0]
Legumes per week			
Mean (SD)	4.61 (2.41)	5.13 (2.71)	5.01 (2.61)
Median [Min, Max]	4.00 [0, 13.0]	5.00 [0, 20.0]	5.00 [0, 20.0]
Non-alcoholic beverages per week			
Mean (SD)	0.543 (1.38)	0.540 (1.40)	0.509 (1.36)
Median [Min, Max]	0 [0, 5.00]	0 [0, 9.00]	0 [0, 9.00]
Processed starch per week			
Mean (SD)	2.39 (3.95)	1.79 (2.94)	1.74 (2.88)
Median [Min, Max]	0.500 [0, 22.0]	0 [0, 18.0]	0 [0, 22.0]
Vegetable Oil per week			
Mean (SD)	3.89 (1.73)	4.64 (2.08)	4.49 (1.97)
Median [Min, Max]	3.50 [0, 8.00]	4.00 [0, 17.0]	4.00 [0, 17.0]
Fruit per week			
Mean (SD)	13.4 (8.93)	12.4 (9.11)	12.2 (8.69)
Median [Min, Max]	10.5 [0, 43.0]	11.0 [0, 64.0]	10.0 [0, 64.0]

Supplementary table 2: Maternal characteristics by food shortage, with No meaning no food shortage reported and yes meaning food shortage was reported.

	no (N=530)	yes (N=32)	Overall (N=564)
Age Category			
14- 19 years	84 (15.8%)	4 (12.5%)	89 (15.8%)
20-29 years	300 (56.6%)	17 (53.1%)	318 (56.4%)
30-39 years	127 (24.0%)	11 (34.4%)	138 (24.5%)
>=40 years	18 (3.4%)	0 (0%)	18 (3.2%)
Missing	1 (0.2%)	0 (0%)	1 (0.2%)
Level of Education			
none	23 (4.3%)	2 (6.3%)	25 (4.4%)
primary	293 (55.3%)	23 (71.9%)	318 (56.4%)
secondary	188 (35.5%)	7 (21.9%)	195 (34.6%)
tertiary	22 (4.2%)	0 (0%)	22 (3.9%)
Missing	4 (0.8%)	0 (0%)	4 (0.7%)
DS$marital.status			
divorced/separated	2 (0.4%)	0 (0%)	2 (0.4%)
married monogomously	422 (79.6%)	23 (71.9%)	447 (79.3%)
married polygamously	98 (18.5%)	5 (15.6%)	103 (18.3%)
never married	6 (1.1%)	3 (9.4%)	9 (1.6%)
widowed	0 (0%)	1 (3.1%)	1 (0.2%)
Missing	2 (0.4%)	0 (0%)	2 (0.4%)

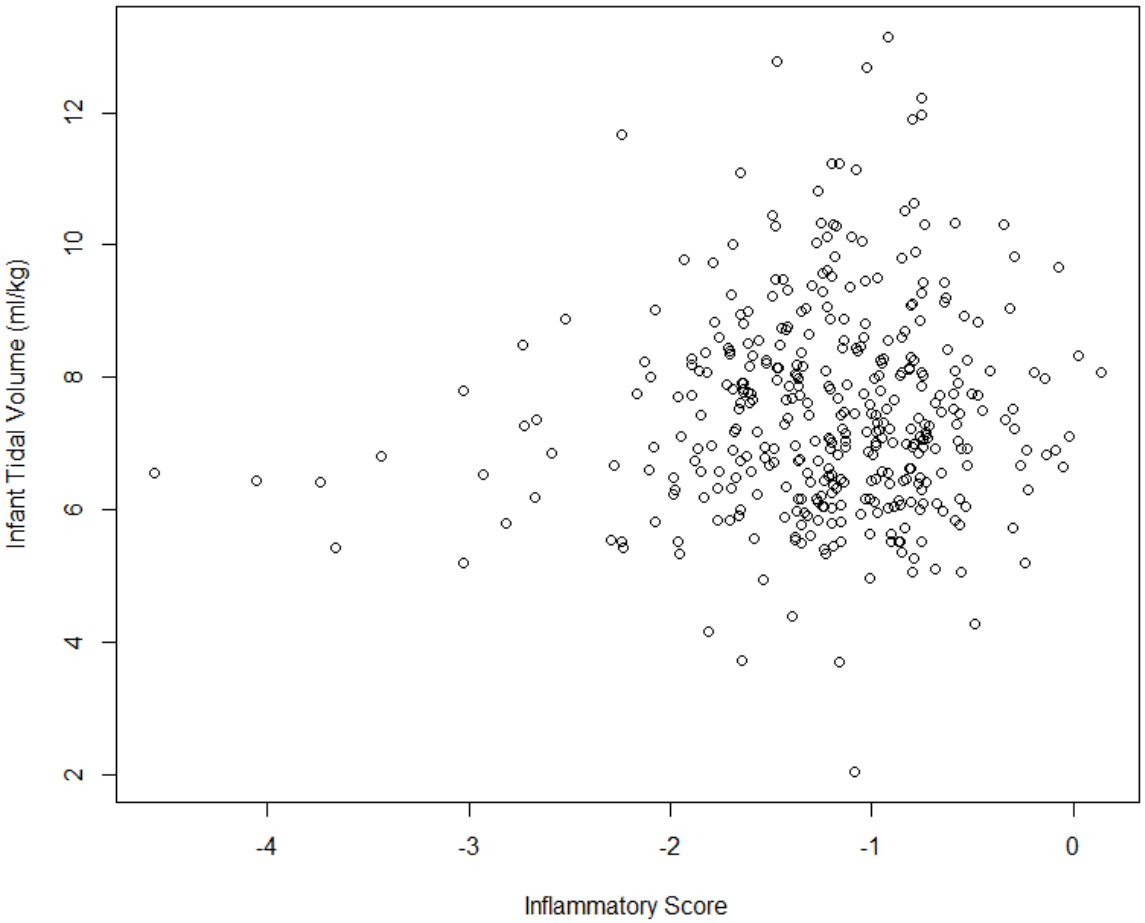
Supplementary table 3: Weekly food frequency

	Overall (N=564)
Starch per week	
Mean (SD)	16.3 (7.65)
Median [Min, Max]	15.0 [4.00, 66.0]
Meat per week	
Mean (SD)	0.940 (1.80)
Median [Min, Max]	0 [0, 16.0]
Fish per week	
Mean (SD)	3.35 (2.15)
Median [Min, Max]	3.00 [0, 11.0]
Legumes per week	
Mean (SD)	5.01 (2.61)
Median [Min, Max]	5.00 [0, 20.0]
Non-alcoholic beverages per week	
Mean (SD)	0.509 (1.36)
Median [Min, Max]	0 [0, 9.00]
Processed starch per week	
Mean (SD)	1.74 (2.88)
Median [Min, Max]	0 [0, 22.0]
Vegetable Oil per week	
Mean (SD)	4.49 (1.97)
Median [Min, Max]	4.00 [0, 17.0]
Fruit per week	
Mean (SD)	12.2 (8.69)
Median [Min, Max]	10.0 [0, 64.0]
Green leafy vegetables per week	
Mean (SD)	2.05 (2.58)
Median [Min, Max]	2.00 [0, 18.0]
Dairy & egg per week	
Mean (SD)	1.79 (2.61)
Median [Min, Max]	0 [0, 14.0]
Sugars per Week	
Mean (SD)	5.13 (2.45)
Median [Min, Max]	7.00 [0, 10.0]

Supplementary table 4: Maternal characteristics by DII quartiles

	DII Q1 (N=142)	DII Q2 (N=143)	DII Q3 (N=139)	DII Q4 (N=140)	Overall (N=564)
Maternal Age					
Mean (SD)	25.8 (6.22)	26.4 (6.61)	28.2 (28.7)	25.9 (7.22)	26.6 (15.4)
Median [Min, Max]	25.0 [16.0, 43.0]	26.0 [15.0, 43.0]	25.0 [16.0, 356]	24.0 [15.0, 46.0]	25.0 [15.0, 356]
Level of Education					
none	11 (7.7%)	4 (2.8%)	5 (3.6%)	5 (3.6%)	25 (4.4%)
primary	78 (54.9%)	84 (58.7%)	79 (56.8%)	77 (55.0%)	318 (56.4%)
secondary	41 (28.9%)	49 (34.3%)	52 (37.4%)	53 (37.9%)	195 (34.6%)
tertiary	10 (7.0%)	4 (2.8%)	3 (2.2%)	5 (3.6%)	22 (3.9%)
Missing	2 (1.4%)	2 (1.4%)	0 (0%)	0 (0%)	4 (0.7%)
History of Smoking					
no	138 (97.2%)	143 (100%)	138 (99.3%)	138 (98.6%)	557 (98.8%)
yes	4 (2.8%)	0 (0%)	1 (0.7%)	1 (0.7%)	6 (1.1%)
Missing	0 (0%)	0 (0%)	0 (0%)	1 (0.7%)	1 (0.2%)
History of TB					
no	139 (97.9%)	143 (100%)	138 (99.3%)	139 (99.3%)	559 (99.1%)
yes	3 (2.1%)	0 (0%)	1 (0.7%)	1 (0.7%)	5 (0.9%)
History of Asthma					
no	138 (97.2%)	142 (99.3%)	138 (99.3%)	137 (97.9%)	555 (98.4%)
yes	4 (2.8%)	1 (0.7%)	1 (0.7%)	3 (2.1%)	9 (1.6%)
History of Alcohol Use					
no	133 (93.7%)	130 (90.9%)	129 (92.8%)	133 (95.0%)	525 (93.1%)
yes	9 (6.3%)	12 (8.4%)	10 (7.2%)	7 (5.0%)	38 (6.7%)
Missing	0 (0%)	1 (0.7%)	0 (0%)	0 (0%)	1 (0.2%)
Weight					
Mean (SD)	60.9 (9.78)	60.8 (10.4)	62.3 (11.4)	60.5 (9.32)	61.1 (10.3)
Median [Min, Max]	60.0 [42.0, 94.0]	59.0 [35.0, 92.0]	59.5 [42.1, 97.5]	60.0 [41.6, 90.8]	60.0 [35.0, 97.5]
Missing	7 (4.9%)	12 (8.4%)	8 (5.8%)	10 (7.1%)	37 (6.6%)
BMI Category					
Underweight	3 (2.1%)	2 (1.4%)	7 (5.0%)	4 (2.9%)	16 (2.8%)
Healthy weight	75 (52.8%)	71 (49.7%)	67 (48.2%)	70 (50.0%)	283 (50.2%)
Overweight	39 (27.5%)	36 (25.2%)	25 (18.0%)	38 (27.1%)	138 (24.5%)
Obese	15 (10.6%)	11 (7.7%)	15 (10.8%)	10 (7.1%)	51 (9.0%)
Missing	10 (7.0%)	23 (16.1%)	25 (18.0%)	18 (12.9%)	76 (13.5%)

Supplementary Fig 1: Plot of Tidal volume by inflammatory score



PART C: APPENDICES

LITERATURE REVIEW

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1. Objectives

This dissertation investigates the influence of maternal diet on infant birth weight and lung capacity.

The objectives of the literature review are:

- To explore the dietary patterns in pregnant women of Sub-Saharan Africa
- To explore the incidence of food shortages in pregnant women of Sub-Saharan Africa
- To explore dietary diversity in rural areas

To explore dietary insufficiency in pregnant women

To determine risk factors for dietary insufficiency in pregnant women

To link dietary diversity with inflammatory diet

To explore incidence of childhood pulmonary diseases

To link childhood and adulthood pulmonary diseases with maternal prenatal diet

2. Literature search strategy

Google scholar and Pubmed were searched for existence of any studies or literature related to asthma, inflammatory diseases, chronic obstructive pulmonary diseases and maternal diet. Search terms such as, dietary diversity, maternal prenatal diet, inflammatory dietary index, pulmonary function, lung capacity, low birth weight. Titles and abstracts of relevant published journals were reviewed and some of their references were also reviewed.

3. Literature review

3.1. Background

Many interventions have been focused on improving the health of pregnant women in Sub-Saharan Africa, targeting antenatal care such as the World Health Organization's recommendations of the four-contact model for antenatal care (FANC) as well as the "first thousand days" in infant care. In spite of these inventions, pregnant women of this region are still at risk of poor nutritional status and adverse outcomes of their infants [1, 2]. Adverse outcomes associated with poor maternal nutrition include low birth weight and poor infant lung capacity among others [1, 2, 3]. Infant lung capacity may have a role to play in later development of asthma, which is a lifelong chronic condition that can has a high burden of morbidity and mortality, which is particularly high in sub-Saharan Africa, where access to early diagnosis and treatment can be limited. This review focus' on poor maternal diet as a risk factor for low birth weight infants and reduced infant lung capacity. Studies also suggest that poor diets often modulate inflammatory pathways and predispose to chronic inflammatory diseases [28]. As such, part of this review will focus on diet and inflammation.

Pregnant women have an increased nutritional demand and as such require nutritional adjustments that meet the nutritional demands for a healthy outcome [2, 3]. It has been established through studies that women who have a poor nutritional status at conception are at higher risk of disease and death and their infants are predisposed to poor health outcomes such as low birth weight, premature birth and death [3, 4].

Dietary recommendations for pregnant women have been made by the WHO, with 6-11 daily serving of bread and grain recommended. Two to four daily servings of fruit, four or more servings of vegetables, four servings of dairy products, and three servings of protein sources are recommended [5,6]. However, these recommendations are often not met in Sub-Saharan Africa and other low income countries where there is high consumption of starchy staples and low consumption of fruits, vegetables and animal products due to poor food availability, poverty and ecological factors [7, 8].

Adequacy and diversity of diet can be difficult to measure, but a number of individual recall instruments have been developed. A commonly applied instrument for measuring dietary quality and dietary adequacy in low resourced areas is to measure Dietary Diversity [8].

3.2 Dietary Diversity

Dietary diversity is defined as "the number of different foods or food groups consumed over a given reference period" [8]. A highly diverse diet consists of enough variety of food groups leading to sufficient intake of nutrients for good health [8, 9]. Intake of a variety of food items increases probability of ensuring adequate intake of vital nutrients [8, 9]. While diverse diets can still lack macronutrients and balance, i.e. adequate proportions of fats, proteins and carbohydrates, diverse diets are still associated with better micronutrient density than diets with inadequate diversity [27].

Dietary Diversity has been generally recognised as a proxy to healthy eating and can give an indication of nutritional adequacy [8]. As such, several recommendations have been made for pregnant women to achieve nutritional adequacy during pregnancy, such as the Minimum Dietary Diversity for women (MDD-W) [6,8]. As a proxy for dietary quality, MDD-W can be used in poorly resourced communities to monitor and evaluate programs aimed at improving diet quality [8,10]. Studies have shown that dietary diversity decreases chances of airway inflammation in children [11,12].

3.3. Diet and inflammatory diseases

Systemic inflammation is hypothesised to play a role in many chronic conditions, and measures to assess the inflammatory index of diet have been developed [11].

Specific inflammatory markers, such as high-sensitivity C-reactive protein (HS- CRP), interleukin-6 (IL-6), and tumor necrosis factor alpha (TNF-α) have been investigated in association with diet through epidemiological studies [12]. These studies have linked inflammation to the pathophysiology of many chronic diseases such as cardiovascular diseases, diabetes, Alzheimer's disease and asthma among others [11, 12]. In turn, certain nutrients in food have been associated with increased inflammatory markers in the body [8,12].Diets high in foods likely to result in increased levels of inflammatory markers are called inflammatory diets. Equally, certain nutrients from foods are associated with anti-inflammatory factors, anti-oxidants, anti-allergic or decreases in inflammatory mediators thereby providing protective effects from inflammatory diseases [12]. Evidence from available studies suggest that consumption of food rich in Magnesium, fiber, omega-3 and 6 fatty acids, polyunsaturated fatty acids (PUFAs), monounsaturated fatty acids (MUFAs), flavonoids and carotenoids is associated with decreased levels of inflammatory markers [24]. However, foods rich in saturated fatty acids (SFA), trans-fatty acids (TFA), and high-glycemic index carbohydrates are associated with increased levels of inflammation [24].

3.4 Asthma and inflammatory diet

Asthma is a chronic respiratory disorder of significant global importance [13]. It is associated with airway inflammation as a result of genetic susceptibility and environmental factors such as inhaled allergens, exposure to smoke, indoor and outdoor air pollution [13]. Recent studies have shown that diet plays a critical role in asthma pathophysiology. There is however limited data on maternal prenatal diet on pathogenesis of childhood asthma [14].

Studies in the past decade have recognised the role of food in chronic diseases such as asthma, cardiovascular disease, type 2 diabetes and metabolic syndrome [4]. As such dietary guidelines have

been added to the prevention and management of chronic diseases guidelines, such as the Global Initiative for Asthma Guidelines (GINA) [25]. Gina has since recommended increased consumption of fruits and vegetables as a means of controlling and preventing asthma [25].

Dietary factors have been shown to be directly involved in the pathogenesis asthma [14]. Mediterranean diets which are high in fruit and vegetable intake have been observed to reduce hazard of asthma due to its anti-inflammatory properties [14].

Studies done in the 1980s suggested that chronic diseases which often manifest in adulthood are programmed during pregnancy and during the early stages of growth and development [12]. These studies further suggested that diet and lifestyle are important in making up a woman's body composition. The body's composition before conception and during pregnancy has significant effects on the health of her offspring and generations that follow [12]. Although results have been conflicting, epidemiologic studies that followed have suggested that there is a relationship between maternal nutrition during pregnancy and the occurrence of asthma during childhood [12].

Some studies have found empirical evidence that maternal diet influences fetal immune system by transferring essential nutrients from mother to fetus through the placenta leading to stimulation of inflammatory mediators that exert influence in the fetus [15]. These studies led to suggestions that maternal prenatal diet influences fetal immune responses thereby predisposing the infant to allergies that may cause asthma in childhood [16, 17].

The Inflammatory potential of diet can be measured through novel dietary index and empirical dietary inflammatory index.

3.5 Dietary inflammatory index

The Dietary Inflammatory Index (DII) is a tool that was developed to provide a quantitative means for assessing the role of diet in relation to health outcomes ranging from blood concentrations of inflammatory cytokines to chronic diseases [18]. The DII is based on literature from a variety of different study designs ranging from cell culture to observational and experimental studies in humans and it was designed to be universally applicable across all human nutritional studies [18]. A high DII score reflects pro-inflammatory potential of the diet, whereas a low DII score reflects the anti-inflammatory potential of the diet [18].

3.5.1 Development of Dietary Inflammatory Index

The dietary inflammatory index was produced by reviewing articles in PubmedR and OvidR, published between 1950 and 2010. Articles that assessed the effect of nutrients on specific inflammatory markers were included [18,19]. The food items that were found to increase inflammatory mediators were classified as inflammatory, while those that were found to decrease inflammatory mediators and possessed antioxidant properties were classified as anti-inflammatory [18,19.20]

The raw inflammatory effect scores for each food item were calculated by using weighted values of the articles which were based on the type of study i.e. Prospective cohort, Case–control, Cross-sectional, Human, Animal Experimental and Cell culture Experimental [19, 20].

The overall inflammatory effect score of individual food parameters was then calculated by dividing the weighted pro- and anti-inflammatory articles by the total weighted number of articles then subtracting the anti-inflammatory fraction from the pro-inflammatory fraction [19, 20]. Fig 1 below shows the resulting inflammatory effect scores for the various food items as well as the global daily mean intake and standard deviation which are all required to calculate individual dietary inflammatory score will be covered under methods.

Fig 1: Food parameters included in dietary inflammatory index, adapted from a study by Shivappa.

Food parameter	Weighted number of articles	Raw inflammatory effect score*	Overall inflammatory effect score†	Global daily mean intake‡ (units/d)	SD‡
Alcohol (g)	417	−0·278	−0·278	13·98	3·72
Vitamin B_{12} (μg)	122	0·205	0·106	5·15	2·70
Vitamin B_6 (mg)	227	−0·379	−0·365	1·47	0·74
β-Carotene (μg)	401	−0·584	−0·584	3718	1720
Caffeine (g)	209	−0·124	−0·110	8·05	6·67
Carbohydrate (g)	211	0·109	0·097	272·2	40·0
Cholesterol (mg)	75	0·347	0·110	279·4	51·2
Energy (kcal)	245	0·180	0·180	2056	338
Eugenol (mg)	38	−0·868	−0·140	0·01	0·08
Total fat (g)	443	0·298	0·298	71·4	19·4
Fibre (g)	261	−0·663	−0·663	18·8	4·9
Folic acid (μg)	217	−0·207	−0·190	273·0	70·7
Garlic (g)	277	−0·412	−0·412	4·35	2·90
Ginger (g)	182	−0·588	−0·453	59·0	63·2
Fe (mg)	619	0·032	0·032	13·35	3·71
Mg (mg)	351	−0·484	−0·484	310·1	139·4
MUFA (g)	106	−0·019	−0·009	27·0	6·1
Niacin (mg)	58	−1·000	−0·246	25·90	11·77
n-3 Fatty acids (g)	2588	−0·436	−0·436	1·06	1·06
n-6 Fatty acids (g)	924	−0·159	−0·159	10·80	7·50
Onion (g)	145	−0·490	−0·301	35·9	18·4
Protein (g)	102	0·049	0·021	79·4	13·9
PUFA (g)	4002	−0·337	−0·337	13·88	3·76
Riboflavin (mg)	22	−0·727	−0·068	1·70	0·79
Saffron (g)	33	−1·000	−0·140	0·37	1·78
Saturated fat (g)	205	0·429	0·373	28·6	8·0
Se (μg)	372	−0·191	−0·191	67·0	25·1
Thiamin (mg)	65	−0·354	−0·098	1·70	0·66
Trans fat (g)	125	0·432	0·229	3·15	3·75
Turmeric (mg)	814	−0·785	−0·785	533·6	754·3
Vitamin A (RE)	663	−0·401	−0·401	983·9	518·6
Vitamin C (mg)	733	−0·424	−0·424	118·2	43·46
Vitamin D (μg)	996	−0·446	−0·446	6·26	2·21
Vitamin E (mg)	1495	−0·419	−0·419	8·73	1·49
Zn (mg)	1036	−0·313	−0·313	9·84	2·19
Green/black tea (g)	735	−0·536	−0·536	1·69	1·53
Flavan-3-ol (mg)	521	−0·415	−0·415	95·8	85·9
Flavones (mg)	318	−0·616	−0·616	1·55	0·07
Flavonols (mg)	887	−0·467	−0·467	17·70	6·79
Flavonones (mg)	65	−0·908	−0·250	11·70	3·82
Anthocyanidins (mg)	69	−0·449	−0·131	18·05	21·14
Isoflavones (mg)	484	−0·593	−0·593	1·20	0·20
Pepper (g)	78	−0·397	−0·131	10·00	7·07
Thyme/oregano (mg)	24	−1·000	−0·102	0·33	0·99
Rosemary (mg)	9	−0·333	−0·013	1·00	15·00
Onion (g)	145	−0·490	−0·301	35·9	18·4
Protein (g)	102	0·049	0·021	79·4	13·9

3.5.2 Limitations of dietary inflammatory index

The indexes are calculated using daily amounts of food or nutrient consumption, which is difficult to calculate in daily clinical practice and depends on estimates.

The other limitation of the dietary inflammatory index is that it considers individual nutrients, however food or nutrients are not eaten in isolation and there are interactions that exist with common nutrients in foods [21].

4. Conclusion

Diet is an important aspect of disease manifestation or prevention. The literature review above has established the importance of inflammation in the pathophysiology of non-communicable diseases. It is also established that certain nutrients in food promote inflammatory diseases through increasing the level of certain inflammatory mediators. There are also certain food times that decrease inflammatory mediators and also have anti-oxidant and anti-allergic properties thereby providing protection against inflammatory diseases such as asthma. Dietary diversity is a proxy for healthy eating as-well as nutritional adequacy. A more diverse diet has been thought to provide anti-inflammatory properties that are essential in protecting against asthma. Inflammation is therefore an important aspect of many non-communicable diseases and it is thus important to study the inflammatory potential of maternal diets so as to prevent non-communicable disease in infants and throughout the life of the offspring [26].

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Appendix 1: Ethics Approval from UCT HREC

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HREC REF: 662/2021

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Student: davlesmthimkhulu@yahoo.com

Dear Prof Lesosky

PROJECT TITLE: A STUDY OF THE ASSOCIATION OF PRENATAL INFLAMMATORY DIET AND ADVERSE INFANT LUNG CAPACITY OUTCOMES IN A BIRTH COHORT IN UGANDA-MASTERS CANDIDATE-MR DAVIES NDLOVU-SUB-STUDY LINKED TO 806/2018

Thank you for submitting your study to the Faculty of Health Sciences Human Research Ethics Committee (HREC) for review.

It is a pleasure to inform you that the HREC has **formally approved** the above-mentioned study.

This approval is subject to strict adherence to the HREC recommendations regarding research involving human participants during COVID -19, dated 17 March 2020; 06 July 2020 & 01 July 2021.

Approval is granted for one year until the 30 October 2022.

Please submit a progress form, using the standardised Annual Report Form if the study continues beyond the approval period. Please submit a Standard Closure form if the study is completed within the approval period.
(Forms can be found on our website: www.health.uct.ac.za/fhs/research/humanethics/forms)

The HREC acknowledge that the student: Mr Davies Ndlovu will also be involved in this study.

Please quote the HREC REF 662/2021 in all your correspondence.

Please note that the ongoing ethical conduct of the study remains the responsibility of the principal investigator.

Please note that for all studies approved by the HREC, the principal investigator **must** obtain appropriate institutional approval, where necessary, before the research may occur.

Yours sincerely

PROFESSOR M BLOCKMAN
CHAIRPERSON, FACULTY OF HEALTH SCIENCES HUMAN RESEARCH ETHICS COMMITTEE
Federal Wide Assurance Number: FWA00001637.
Institutional Review Board (IRB) number: IRB00001938
NHREC-registration number: REC-210208-007

This serves to confirm that the University of Cape Town Human Research Ethics Committee complies to the Ethics Standards for Clinical Research with a new drug in patients, based on the Medical Research Council (MRC-SA), Food and Drug Administration (FDA-USA), International Council for Harmonisation of Technical Requirements for Pharmaceuticals for Human Use: Good Clinical Practice (ICH GCP), South African Good Clinical Practice Guidelines (DoH 2006), based on the Association of the British Pharmaceutical Industry Guidelines (ABPI), and Declaration of Helsinki (2013) guidelines. The Human Research Ethics Committee granting this approval is in compliance with the ICH Harmonised Tripartite Guidelines E6: Note for Guidance on Good Clinical Practice (CPMP/ICH/135/95) and FDA Code Federal Regulation Part 50, 56 and 312.

HREC/REF 662/2021sa

Appendix 2: Screening form from primary study

APPENDICES

APPENDIX 1: SCREENING FORM

Title of study: Maternal and Socioeconomic determinants of lung function among young infants in Uganda: a birth cohort study

Initials |__|__|__| Clinic ID |__|__|__|

Screening date |__|__|/|__|__|/|__|__|__|__|

dd / mm / yyyy

Age: |___|___| years

Contact telephone number: _____

Description of patient's address

_____

_____

_____

Does the person have any of the following features (Circle all that apply)?

a. Pregnant and resident of Kyamulibwa HDSS

If YES to any of the above, proceed to the next question

Is the person willing to participate in the study?

If YES, enrol person into the study.

Screened by:

Name_____ Signature_____

Date_____

Appendix 3: Participant information leaflet from original study

APPENDIX 2: PARTICIPANT INFORMATION LEAFLET

A study of looking into effects of diet and air quality on lung function among young infants in Uganda

My name is .....and I work at the Makerere University Lung Institute. We would like to invite you to take part in our study. In this study, we are trying to find out if the lung function of an infant can be affected by the mother's diet, the impurities in the air she breathes when she is pregnant and her socioeconomic status/livelihood.

- Before you decide whether you would like to take part, it is important for you to understand why the research is being done and what it will involve.
- Please take time to read the following information carefully and discuss it with others if you wish.
- Ask us if there is anything that is not clear or if you would like more information.
- Take time to decide whether you wish to take part. If you are interested in taking part, please let us know. You can also contact us on the telephone number provided at the end.
- Thank you for reading this.

For those who may not be able to read;

I will go through the information sheet with you and answer any questions you have. This should take about 10 minutes. Please feel free to ask me if there is anything that is not clear.

Purpose of this study

As you may or may not know, lung diseases such as asthma are major problems in Africa. These conditions are very common, they cause much suffering and cost a lot to treat. We are part of a group who are trying to work out ways to prevent people developing these diseases in the first place.

Research in Europe and the United States has shown that a woman's diet during pregnancy and exposure to air pollution affect the way a baby's lungs develop before it is born and can influence the risk of the baby developing lung disease as a child. We would like to see for the first time if this is happening in Africa. We are also interested in the factors that influence what you eat and the fuels you use and the effects they have on your family finances. Lastly, we would like to understand how the foods that you eat and the finances of your family may influence the health of the lungs of your baby.

Why have you been invited?

We are approaching you because we understand that you are pregnant/expecting. We are approaching women who are pregnant and residents of Kyamulibwa Health Demographic Surveillance Site (HDSS).
We are aiming to recruit 560 pregnant women. In order to get 560 pregnant women, the study is taking place in two other health centres within Kyamulibwa HDSS.

Do I have to take part?
No. Participation in this study is entirely voluntary. If you agree to take part, we will then ask you to sign a consent form. Should you choose to withdraw from the study anytime for any reason, you are free to do so without giving any reason and this will not affect your medical care or future participation in research in any way.

What will happen to me if I take part?

If you decide to take part in this study;

You and your baby will have the usual antenatal care

We will ask you to sign a form saying that you are willing to take part in the study. Then we shall conduct three visits as described below.

First visit: This will be during your routine antenatal care visit and will take 30-45 minutes.

- We shall ask you some questions regarding your health, your diet, what you use for cooking and lighting at your home.
- We shall measure your weight, height and arm circumference
- We shall also take off some blood (about 3ml- half a teaspoon) to check if you have enough blood and iron in your body. Using the same blood, we shall check if you have enough nutrients such as vitamins and minerals in your body.
- We will ask your consumption of food and beverages over 7 days.

During your subsequent antenatal visits, your weight, height and arm circumference will be measured and recorded.

Second visit: This will be conducted at your home a week or two later and will take about 1 (one) hour.

We shall measure the impurities in the air you breath at home using 2 small machines; one will be placed somewhere in your house for seven days and one of the research team members will visit your home every day to replace the battery and take information from the machine. Another machine will be worn on your clothing like a pen. Below are pictures of the machines.

Air quality monitor in the house

Personal air quality monitor

We shall also ask questions related to your livelihood activities, household consumption and expenditure, mothers and children's food consumption, weight and heights of under five children in your household, sources and uses of energy and household assets.

Third visit: This will involve measurements of baby's weight, length, physical check-up and lung function tests. It will be conducted during the routine vaccination visit at 6 weeks and will take about 1hour and 30 minutes.

When your baby is 6 weeks old, we shall measure his/her breathing. This is a simple process which involves resting a simple mask gently over the mouth and nose when your baby is asleep. The mask is connected to a simple machine which will read your baby's breathing, as shown in the picture below. This is a safe process and has been used before in studies in babies in other countries including South Africa. This measurement of infant lung function will be related to the information on diet and air quality collected when you are pregnant. The lung function measurement is a research tool, it is not possible yet to say if an individual baby's lung function is good or bad.

We shall also check if your lungs are functioning normally. This is a simple procedure which basically involves taking a deep breath, and blowing into a tube that will be connected to a machine. We shall demonstrate and coach you on how to do this on that day. This test is safe and is used in regular health care.

Fourth visit: 5-6 weeks after the birth of your baby, we will visit you at home to collect data on your household's food consumption, expenditure, socio-demographic data, energy use and sources, children's food consumption and anthropometric data.

Compensation

You will be compensated £4 (20,000 Uganda shillings) for each time we shall be working with you. The money you will use to travel to the health facility at 6 weeks after birth to measure yours and your baby's lungs will be refunded. The amount will be according to public transport fares (bus or commuter taxis), but the minimum amount will be £4 (20,000 Uganda shillings).

What are the possible disadvantages and risks of taking part?

There is minimal risk in taking part in this study, similar to what happens in routine medical care. During lung function testing, you may feel a little dizzy or nauseous after the test but this is very brief, and we shall minimize this by making sure that you sit while doing the test. You will also feel little and brief pain during the process of taking off blood, there may be a small bruise that will go in a couple of days.

Your baby may feel a little discomfort when we place the mask onto his/her nose and mouth, but most babies are generally comfortable and sleeping quietly..

What are the possible benefits of taking part?

We cannot promise that the study will help you but the information we get from this study will help us to find out if a mother's diet and/or the air impurities she is exposed to during pregnancy have an effect on the lungs of her baby. And if so, then this information can help us to plan and improve the mother's diet and air quality so that they can have babies with health lungs, and reduce the risk of having diseases later.

What will happen if I don't want to carry on with the study?
You can withdraw from the study at any time, and you do not need provide a reason. This will not affect your medical care or future participation in research in any way. You will continue receiving the usual care.
If you withdraw from the study, we will destroy all your identifiable samples, but we will need to use the data collected up to your withdrawal.

Will my taking part in this study be kept confidential?
Yes. None of the personal information obtained in the course of the study will be released to anyone without your written permission. Your identity and that of your baby will not be revealed in any discussions, presentations or publications of this study. The information will only be used for research purposes. Paper and computer records will be kept under lock and key. The computers that we shall use will have password and only accessible to a few research team members.
The information that you will give us will be managed by a team of experts from Makerere University Lung Institute, University of Cape Town in South Africa and Liverpool School of Tropical Medicine, United Kingdom. These experts are part of our study team. To ensure that confidentiality is maintained, your identity will not be revealed. Only codes will be used on the information about you and this means that your identity cannot be revealed at all stages of managing the information you give us.

What will happen to any data or samples I give?
The blood sample that you will provide will be made unidentifiable/anonymous. The blood test results will not be available immediately but we shall give them to you at the earliest opportunity (which is likely to be during your next planned clinic visit).

What will happen to the results of the research study?
The results of this study will be presented to scientists including health workers and health care planners at the district, national and international level. They will also be published in international journals. We also plan to have a community feedback meeting at the end of the study. If we find that your weight and arm circumference are lower than expected, we shall counsel you on nutrition and if necessary, we shall refer you to Masaka regional referral hospital for further care. If the results of your lung function and/or blood test are abnormal, we shall provide the necessary care within our means and where necessary, you will be referred to Masaka regional referral hospital. If we find that your baby needs any health care, we shall refer you to the clinical care team for care.

Study Conduct

Liverpool School of Tropical Medicine (The Sponsor) is ultimately responsible for the safe conduct of the study and the well-being of participants. Any unforeseen circumstances will be reported to the Sponsor and dealt with appropriately.

Complaints

If you have a concern about any aspect of this study, you should ask to speak to the researchers who will do their best to answer your questions. Please call Dr. Rebecca Nantanda on 0777-723332. If you remain unhappy and wish to complain formally, you can do this by contacting Dr. Tom Lutalo, the chairperson on the Research and Ethics Committee at Uganda Virus Research Institute Entebbe on 0414321962.

Sponsorship and Funding

This researched is funded by National Institute for Health Research, United Kingdom and has been reviewed and been approved by Liverpool School of Tropical Medicine and Uganda Virus Research Institute Research Ethics Committees.

Contact details

1. Dr. Rebecca Nantanda
2. Lead investigator
   Makerere University Lung Institute
   Tel: 0777-723332

3. Dr Tom Lutalo
4. Chairperson Research Ethics Committee
   Uganda Virus Research Institute
   Tel: 0414321962.

Signature or thumbprint of respondent _____	Name _____	Date(DD/mm/YY) ___/___/___
Person Conducing Informed Consent Discussion _____	Name _____ _	Date(DD/mm/YY) ___/___/___

Appendix 4: Father consent forms from primary IMPALA study

APPENDIX 5: CONSENT FORM FOR SPOUSES (FATHERS)

Title of study: *Maternal* and Socioeconomic determinants of lung function among young infants in Uganda: a birth cohort study

INTRODUCTION

My name is _____. I am part of the research team from Makerere University Lung Institute that is conducting a study titled: ***"Maternal and Socioeconomic determinants of lung function among young infants in Uganda: a birth cohort study"***. The lead investigator for this study is **Dr. Rebecca Nantanda** from Makerere University Lung Institute, Makerere College of Health Sciences, Kampala Uganda.

PURPOSE

The study is conducted by Liverpool School of Tropical Medicine and Makerere University Lung Institute. The purpose of the study is to better understand how household level food insecurity and energy use, and pregnant mothers' diet can affect the growth and development of new-born bay's lung function. We also aim to understand the food consumption and nutritional status of children below five years of age, if there is one in your household. Findings from this research may help in making policies to reduce the risk of lung diseases in childhood and later during adulthood.. This will be helpful in reducing burden of lung diseases at household level and national level. You are being asked to participate in this study because your wife/spouse is among pregnant women in this communities selected for the present study.

PROCEDURE

We shall ask you some questions following a standardized questionnaire. The questionnaire is designed to collect information about you and your family, your economic status and activities. We will ask you questions about each person in your household, including age, sex, marital status, and education. We shall also ask you questions about your financial expenditure, the foods that are consumed and the fuel you use in your household. The height and weight for children under five years old will be measured. The process will take approximately 1.5 hours of your time to complete. Someone will visit your house again, 5 weeks after the new baby is born, to ask similar questions. This will take about 1.5 hours.

RISKS

You may feel uncomfortable answering some of the questions, which may gather information that is private. However, all your information will remain confidential.

BENEFITS

We hope to have a better understanding about how household food insecurity, mothers' diet, and energy use can affect the growth and development of new-born bay's lung function. This will help future government services designed to address burden of poor lung

function through your participation in the study. However, there may be no other direct personal benefits for you or you under five children from this research. However, the height and weight measurement results may provide information about your child's nutritional status.

CONFIDENTIALITY

Any information that is obtained in connection with this study about you and your household members will be kept confidential. You will be assigned a code/number which can be linked to your personal information only through a numeric code that will be kept secure and encrypted by the survey administrator. The study will focus on the average answer within your community and not on individual answers. The honesty of your answers is very important. The information that you will give us will be managed by a team of experts from Makerere University Lung Institute, University of Cape Town in South Africa and Liverpool School of Tropical Medicine, United Kingdom. To maintain confidentiality, only codes will be used while at all points of managing the information, and this ensures that your identity is not revealed.

QUESTIONS

If you have any questions, comments or concerns about the study now or at any time during the study, please contact Dr. Rebecca Nantanda (Tel: 0777-723332) or any of the members of the research team. If for any reason you want to contact people other than the research team members, you may contact the Chairperson of the Research Ethics Committee at Uganda Virus Research Institute (Tel: 0414321962 or the Uganda National Council of Sciences and Technology. Tel: (+256) 772-404970 or (+256)-41-250431.

SOURCE OF FUNDING

This research project is supported by the IMPALA Programme with funding from the National Institutes of Health Research, Global Health Research United Kingdom (Grant Number 16/136/35).

VOLUNTARY PARTICIPATION AND WITHDRAWAL

Your participation in this study is voluntary. You may decide not to participate, or you may leave the study at any time. Your decision will not result in any penalty or loss of benefits to to you or any member of your household.

CONSENT STATMENT

I willingly agree to participate in this study. I have been informed about the study. The purpose and procedure of the study, the benefits and risks have been explained to me. I have also been informed that the information given will be kept confidential and that my participation in this study is voluntary and that no consequences will result if I refuse to participate or withdraw from the study.

Appendix 5: Maternal consent form from primary IMPALA study

APPENDIX 3: CONSENT FORM -ENGLISH

Title of study: Maternal and Socioeconomic determinants of lung function among young infants in Uganda: a birth cohort study

Introduction

My name is _____. I am part of the research team from Makerere University Lung Institute that is conducting a study titled: ***"Maternal and Socioeconomic determinants of lung function among young infants in Uganda: a birth cohort study"***. The lead investigator for this study is **Dr. Rebecca Nantanda** from Makerere University Lung Institute, Makerere College of Health Sciences, Kampala Uganda.

Purpose of the study

The purpose of study is to help us understand the factors that occur to the mother during pregnancy and households and how they can affect the growth and development of newborn baby's lungs, sometimes leading to poor lung function by the time the baby is born. Such factors include the mother's diet, the pollutants in the air they breathe, the health of their lungs, as well as socioeconomic status of the family. In addition, we would like to find the proportion of babies whose lungs may not be functioning well by the time they are born.

Research done in other countries has shown that some babies have poor lung function by the time they are born, although they may be looking normal, without any breathing problems. Such babies usually have respiratory problems later in life including frequent respiratory tract infections, asthma and Chronic Pulmonary Obstructive Disease (COPD).

The information from this get a better understanding of the factors that may affect the growth and development of babies' lungs, and make plans may help in mitigating the problems identified and therefore ensure that babies are born with normal lungs thus reducing their risk of respiratory diseases in childhood and later during adulthood.

Procedure

You have been identified to participate in this study and this requires your consent. You are being requested to take part in this study by answering some of the questions about your health, your diet and some other questions related to the environment at home. We shall also examine you to check your weight, height, mid-upper arm circumference, as well as the abdomen to ascertain the age of the baby.

About 3-4 milliliters of blood will be taken off from you. We shall explain the meaning of the results when they become available, most likely during your next antenatal care visit. We will also ask your food and beverage consumption over the past 7 days.

In addition, we shall visit your home to collect following data;

a) To monitor the amount of particles / dust in the air at your home. We will leave a small machine in the same part of your house for 1 week which collects this information.
b) To monitor the amount of pollutants in the air that you breathe in. This will be done by asking you to wear a small machine shown below (a Lascar monitor) for 24 hours. You will be allowed to remove it when going to bath, and put it on again after bathing.

c) To collect household consumption and expenditure data, socioeconomic data and the energy sources and use in your household.
d) Collect under five children's consumption and anthropometric data.
e) We shall also make a few observations regarding the cooking area and record them.

At each of the subsequent antenatal care visits, we shall take your weight and record it. This information will help us to know how much weight you gain over time and how it relates to the lung function of your baby.

We encourage you to give birth at a health facility. When the baby is born, please remember to let us know within 24 hours. We shall give you our telephone numbers, on which you can 'flash' us and then we shall call back. We request you to ask the midwife/health worker who will conduct the birth of your baby to weigh the baby and record the weight on the card we shall give you. You will bring the card at the time when you will be bringing your baby for measurement of lung function.

When your baby is 6 weeks old, you will be asked to bring him/her to the health centre for a check -up as recommended by the Ministry of Health. We will then measure his/her lung function. This test involves putting a mask on the baby's mouth and nose when he/she is breathing quietly. The mask will be connected to a small machine which will be measuring the amount of air the baby will be breathing in and out, for about 10 minutes. During the same visit, we will test your lung function as well by asking you to blow quickly into a machine. During this follow-up, we also want to collect consumption data form you and your household.

The money you will use to travel to the health facility for the above tests will be refunded. The amount will be according to public transport fares (bus or commuter taxis), but the minimum amount will be 10,000=.

Benefits and risks

There are no direct benefits to you or your baby's participation in this study.

If we find problems, for example, that you have signs of malnutrition, we shall discuss with you on what can be done to treat it. In extreme cases, we shall refer you to a facility where you can be helped.

You will feel a little and brief pain during the process of taking off blood from you for the tests that I described above, but there are no serious risks expected.

During lung function testing, you may feel a little dizzy or nauseous after the test but this is very brief.

Your baby may be startled when we place the mask onto his/her nose and mouth, but this will be for a short time and he/she will settle quickly. There are no serious risks involved in this procedure.

Disposal of the biologic /human materials

The blood samples that will be obtained from you will be stored for future research. We shall request for your consent to store these samples using a separate form. The decision to allow us store the samples is purely voluntary and does not affect your participation in the current study. You are free to participate in this study even if you do not consent to the storage of your blood samples for future research. If you choose not to have your blood stored for future research, these remaining blood after conducting the tests will be disposed of, in accordance with the standard operating procedures for disposal of human samples by laboratories.

Confidentiality

None of your personal information obtained will be released to anyone without your written permission. Your identity and that of your baby will not be revealed in any discussions, presentations or publications of this study. The information will only be used for research purposes. Paper and computer records will be kept securely. The information that you will give us will be managed by a team of experts from Makerere University Lung Institute, University of Cape Town in South Africa and Liverpool School of Tropical Medicine, United Kingdom. To maintain confidentiality, only codes will be used while at all points of managing the information, and this ensures that your identity is not revealed.

Medical care for the participants

You and your baby will undergo a usual clinical assessment that will be performed by the study Nurse. For any other tests that will be deemed necessary we will refer you to the place where these are usually done. The medication that you or your baby may need after

the clinical assessment will be obtained through the dispensary at this facility. In case you or your baby requires medicine that is not available at this health facility at the time of the research, the project will endeavor to provide those medicines within the financial limits available. For those medicines that the project is unable to provide, you will receive a prescription so that you can obtain them from other providers.
The clinical findings and test results that will be relevant to you and your baby's care will be shared with the clinical team at this facility to help in management. All the necessary steps will be taken to ensure yours and your child's confidentiality.

Feedback to participants
You will be informed about the findings from the clinical assessment and investigations. The actions that will be taken by the research and/or clinical care team will also be explained to you.

Problems/questions
If you have any questions, comments or concerns about the study now or at any time during the study, please contact Dr Rebecca Nantanda (the lead investigator- Tel: 0777-723332) or any of the members of the research team. If for any reason you want to contact people other than the research team members, you may contact the IRB at Uganda Virus Research Institute (Tel: 0414321962 or the Uganda National Council of Sciences and Technology. Tel: (+256) 772-404970 or (+256)-41-250431

Rights of the participant
Entry into the study is entirely voluntary and no penalty will be given for non-participation. Should you choose to withdraw from the study anytime for any reason, you are free to do so and this will not affect your medical care or future participation in research in any way. In case you are not happy with any of the procedures done on you, do not hesitate to contact me or any of the study team members.
In the event that significant new findings about a mother's health in relation to the lung function in her baby are made during the course of the study by our research team or other scientists, and that these findings relate to the decision for you to continue participating in the study, you will be informed promptly.
This study has been approved by the Uganda Virus Research Institute Research and Ethics Committee, Entebbe. This committee is responsible for ensuring that research is conducted according to the current guidelines on research in human participants and that yours and your baby's rights are protected.
If you have any questions about your rights now or at any time during the study, you may contact the Chairperson -Uganda Virus Research Institute Research and Ethics Committee, Entebbe, Dr. Tom Lutalo , Tel: 0414321962.

Funding for the project

This research project is supported by the IMPALA Project with funding from the National Institutes of Health Research, Global Health Research United Kingdom (Grant Number 16/136/35). The Senior Investigator is Dr. Jamie Rylance from Liverpool School of Tropical Medicine.

Other co-investigators are affiliated to Makerere University College of Health Sciences, Liverpool School of Tropical Medicine, Liverpool UK, and Uganda Virus Research Institute Entebbe Uganda.

Consent statement

I have been informed about the study on the influence of mother's health on the lung function of her baby's lungs. The purpose and nature of the study, the benefits and risks have been explained to me. I have been made aware that blood tests, as well as lung function testing for me and my baby will be done. I have also been informed that the information given will be kept confidential and that my participation in this study is voluntary and that no consequences will result if I refuse to participate or withdraw from the study.

I have hereby voluntarily agree to participate in this study.

Signature or thumbprint of respondent	Name	Date

I have explained this study to the above participant and I have sought her informed consent.

Researcher's names ---------- Researcher's signature ----------

Date.....

Where an impartial witness is required;

Signature or thumbprint of witness	Name	Date

Appendix 6: Food consumed past 7 days

Household Consumption and Expenditure: adapted to Food Consumption Score (FCS) tools

Part A: Number of household members present

On average, how many people were present in the last 7 days? In this section children are defined as less than 18 years.

	Household Members				Visitors		
Male adults	Female adults	Male children	Male children	Male adults	Female adults	Male children	Male children

Part B: Food, Beverage, and Tobacco (During the Last 7 Days)

Item Description	Code	Did you consume [ITEM] 1= Yes 2= No	How many days was [ITEM] consumed out of the last 7 days?	Unit of Qty	Consumption out of Purchases				Consumption out of home produce		Received in-kind/Free		Market Price
					Household		Away from home		Quantity	Value	Quantity	Value	
					Quantity	Value	Quantity	Value					
1	2	3A	3B	3C	4	5	6	7	8	9	10	11	12
Main staples													
Matooke (Bunch)	101												
Matooke (Cluster)	102												
Matooke (Heap)	103												
Matooke (Others)	104												
Sweet Potatoes (Fresh)	105												
Sweet Potatoes (Dry)	106												
Cassava (Fresh)	107												
Cassava (Dry/ Flour)	108												
Irish Potatoes	109												
Rice	110												
Maize (grains)	111												
Maize (cobs)	112												
Maize (flour)	113												
Bread	114												
Millet	115												
Sorghum	116												
Meat and fish													
Beef	117												
Pork	118												
Goat Meat	119												
Other Meat	120												

Chicken	121												
Fresh Fish	122												
Dry/ Smoked fish	123												
Eggs	124												
Fresh Milk 125													
Infant Formula Foods	126												
Oil													
Cooking oil	127												
Ghee	128												
Margarine, Butter, etc	129												
Fruit													
Passion Fruits	130												
Sweet Bananas	131												
Mangos	132												
Oranges	133												
Other Fruits	134												
Vegetables													
Onions	135												
Tomatoes	136												
Cabbages	137												
Dodo	138												
Other vegetables	139												
Fruits													
Beans fresh)	140												
Beans (dry)	141												
Ground nuts (in shell)	142												
Ground nuts (shelled)	143												
Ground nuts (pounded)	144												
Peas	145												
Sim sim	146												
Sugar													
Sugar	147												
Coffee	148												
Condiments													
Tea	149												
Salt	150												
Soda DRINK	151												
Beer	152												
Other Alcoholic drinks	153												
Other drinks	154												
Cigarettes	155												

Appendix 7: Education history

Education (All Persons 5 Years and above) – EXPENDITURE

PERSON ID	What grade/class is [NAME] currently attending? Code in consultation with Ugandans	How much has this household spent during the past 12 months on [NAME]'s schooling? IF NOTHING WAS SPENT, WRITE 0. IF THE RESPONDENT CAN ONLY GIVE A TOTAL AMOUNT, WRITE '999' IN THE RELEVANT COLUMNS AND THE TOTAL AMOUNT IN COLUMN 15G.						
		School and registration fees (contribution to school development fund)	Uniforms and sport clothes	Books and school supplies	Costs to and from school	Boarding fees	Other expenses	Total expenses

Appendix 8: MDD-W Questionnaire

APPENDIX 8: MINIMUM DIETARY DIVERSITY FOR WOMEN (MDD-W) QUESTIONNAIRE

Demographic data about pregnant women

We would like to ask about you

Age	What is the highest grade (NAME) completed? (in years of school)	Marital status 1= Married monogamously 2= Married polygamous 3=Divorced /Separated 4= Widow/ Widower 5= Never Married	Number of children before the current pregnancy (alive, and all others)	When did (NAME) deliver her last child? **[mark '0', if first pregnancy]**	Distance from this clinic	Gestation Estimate	Your residence 1-Rural 2-Urban/township

Enumerator instructions: main MDD-W module

Begin by reading the introductory portion of the questionnaire slowly, emphasising that the question concerns what the woman drank or ate yesterday during both the day and night. Then ask about each of the food group categories and provide examples of foods belonging to them in the order that they appear in the questionnaire. Mark '1' for "yes" if any item in a category was consumed and '0' if the woman reports she did ''not'' consume items in the category.

The following script can be included on the questionnaire or on a job aid/guidance sheet to be carried by the enumerator.

To be read to the respondent: Now I'd like to ask you about foods and drinks that you ate or drank yesterday during the day or night, whether you ate it at home or anywhere else. I am interested in whether you had the food items I will mention even if they were combined with other foods. For example, if you had a soup made with carrots, potatoes and meat, you should reply "yes" for each of these ingredients when I read you the list. However, if you consumed only the broth of a soup, but not the meat or vegetable, do not say "yes" for the meat or vegetable.

As I ask you about foods and drinks, please think of foods and drinks you had as snacks or small meals as well as during any main meals. Please also remember foods you may have eaten while preparing meals or preparing food for others.

Please do not include any food used in a small amount for seasoning or condiments (like chilies, spices, herbs or fish powder). I will ask you about those foods separately.

Yesterday during the day or at night, did you eat or drink:

	Food categories	**Description/examples** *[These will be modified based on local context in consultation with local researchers and translators who is the culture and language. AND piloting]*	**Consumed** Yes = 1 No = 0
A	Any foods made from grains, like:	Porridge, bread, rice, pasta/noodles or other foods made from grains	___ yes (1) ___ no (0)
B	Any vegetables or roots that are orange coloured inside, like	Pumpkin, carrots, squash or sweet potatoes that are yellow or orange inside	___ yes (1) ___ no (0)
C	Any white roots and tubers or plantains, such as:	White potatoes, white yams, manioc/ cassava/yucca, cocoyam, taro or any other foods made from white-fleshed roots or tubers, or plantains	___ yes (1) ___ no (0)
D	Any dark green leafy vegetables, such as:	List examples of any medium-to-dark green leafy vegetables, including wild/foraged leaves	___ yes (1) ___ no (0)
E	Any fruits that are dark yellow or orange inside, like:	Ripe mango, ripe papaya	___ yes (1) ___ no (0)
F	Any other fruits	List examples of any other fruits	___ yes (1) ___ no (0)
	Food categories	**Description/examples** *[These will be modified based on local context in consultation with local researchers and translators who is the culture and language. AND piloting]*	**Consumed** Yes = 1 No = 0
G	Any other vegetables	List examples of any other vegetables	___ yes (1) ___ no (0)
H	Any meat made from animal organs, such as:	Liver, kidney, heart or other organ meats or blood-based foods, including from wild game	___ yes (1) ___ no (0)
I	Any other types of meat or poultry, like	Beef, pork, lamb, goat, rabbit, wild game meat, chicken, duck, other birds	___ yes (1) ___ no (0)
J	Any eggs	Eggs from poultry or any other bird	___ yes (1) ___ no (0)
K	Any fish or seafood, whether fresh or dried	Fresh or dried fish, shellfish or seafood	___ yes (1) ___ no (0)
L	Any beans or peas, such as:	Mature beans or peas (fresh or dried seed), lentils or bean/ pea products,	___ yes (1) ___ no (0)

		including hummus, tofu and tempeh	
M	Any nuts or seeds, like:	Any tree nut, groundnut/peanut, or certain seeds or nut/seed "butters" or pastes	___ yes (1) ___ no (0)
N	Any milk or milk products, such as:	Milk, cheese, yoghurt or other milk products, but **NOT** including butter, ice cream, cream or sour cream	___ yes (1) ___ no (0)
O	Any insects or other small protein foods, including:	Insects, insect larvae/grubs, insect eggs and land and sea snails	___ yes (1) ___ no (0)
P	Any red palm oil	Red palm oil	___ yes (1) ___ no (0)
Q	Any oils and fats	Oil, fats or butter added to food or used for cooking, including extracted oils from nuts, fruits and seeds, and all animal fat	___ yes (1) ___ no (0)
R	Any savoury and fried snacks, such as:	Crisps and chips, fried dough, other fried snacks	___ yes (1) ___ no (0)
S	Any sweets, such as:	Sugary foods, such as chocolates, candies, cookies/sweet biscuits and cakes, sweet pastries or ice cream	___ yes (1) ___ no (0)
T	Any sugar-sweetened beverages, like:	Sweetened fruit juices and "juice drinks", soft drinks/fizzy drinks, chocolate drinks, malt drinks, yoghurt drinks, sweet tea or coffee with sugar	___ yes (1) ___ no (0)
Others- required			
U	Any condiments and seasonings, such as:	Ingredients used in small quantities for flavour, such as chilies, spices, herbs, fish powder, tomato paste, flavour cubes or seeds	___ yes (1) ___ no (0)
V	Any other beverages and foods	Tea or coffee if not sweetened, clear broth, alcohol	___ yes (1) ___ no (0)
	Optionally: if not listed above		___ yes (1) ___ no (0)

Appendix 9: Food frequency questionnaire

APPENDIX 7: FOOD FREQUENCY QUESTIONNAIRE (FFQ)

Study title: Maternal and Socioeconomic determinants of lung function among young infants in Uganda: a birth cohort study

Study title: Title of study: Maternal and socioeconomic determinants of lung function among young infants in Uganda: a birth cohort study

Participant ID |_|_|_|_|_| Date |_|_|/|_|_|/|_|_|_|_|

Date of birth |_|_|/|_|_|/|_|_|_|_| Age (in years) |_|_|

No.	Item	Response
1	How many meals on average do you eat per day?	.....meals
2	Since this time last year, has there been a time when there was not enough food for the household to have its normal meals? *(fewer meals per day, and/or smaller meals, and/or less variety of foods)*	☐ Yes ☐ No
3	If YES, in which month(s) did this happen?	☐ January ☐ February ☐ March ☐ April ☐ May ☐ June ☐ July ☐ August ☐ September ☐ October ☐ November ☐ December

No	Item **This is about the food you eat, how many times did you eat/drink the following**	**Responses *(Record the actual number)***				
		No. of times per day	No. of times per week	No. of times last month	No. of times since you noticed that you are pregnant	**Conclusion** Never =1 Rarely =2 Sometimes =3 Most times =4
4	Maize (roasted, boiled, steamed, fried, porridge, posho)					
5	Millet (bread, porridge)					
6	Sorghum (bread, porridge)					
7	Cassava (roasted, boiled, steamed, fried, bread, mixture (katogo), porridge)					
8	Rice (boiled, steamed, fried, porridge)					
9	Sweet potatoes (boiled, steamed, fried)					
10	Irish potatoes (boiled, fried)					
11	Yam (cocoyam, balugu, ndaggu, etc)					
12	Plantain (boiled, steamed, fried, katogo)					
13	Pasta (Spaghetti, macaroni)					
	Red meat					
14	Beef					
15	Goat's meat					
16	Mutton					
17	Pork					
18	Offals					
19	Liver (cow, goat, lamb, chicken)					
20	Giblets (liver, heart, gizzard of chicken)					
	White meat					
21	Chicken					
22	Others (Turkey, Duck,					

	etc.-specify)					
	Fish					
23	Tilapia					
24	Nile perch					
25	Silver fish					
26	Others (cat fish, mud fish, etc.-specify)					
	Pulses					
27	Bean					
28	Peas					
29	Soya beans					
30	Nuts (raw, roasted, steamed, boiled/stew)					
31	Sesame (raw, roasted, stewed)					
	Vegetables					
32	Amaranthus (Doodo,bbugga)					
33	Nakati					
34	Cabbage					
35	Pumpkin					
36	Avo cado					
37	Eg plant					
38	Carrots					
39	Sukuma wiki					
40	Spinach					
41	Solanum gilo (Entula)					
42	Mushrooms					
43	Onions/garlic (raw)					
44	Others (specify)					
	Oils: Which of these types of oils have you used in your cooking? And how often?					
45	Bidco					
46	Sunseed					
47	Rafiki					
48	Mukwano					
49	Nile					
50	Roki					
51	Star					
52	Sunflower					
53	Tamu					

54	Kimbo					
55	Cowboy					
56	Cow ghee					
57	Blue band					
58	Prestige					
59	Others (specify)					
	How many times did you eat/drink the following?					
	Fast foods					
60	Chapati					
61	Mandazi					
62	Doughnut					
63	Samosa					
64	Pancakes (kabalagala)					
	Insects					
65	Grasshoppers					
66	White ants					
67	Red ants					
	Milk products					
68	Cow's milk, yoghurt					
69	Goat's milk					
70	Eggs (boiled, fried, raw)					
	Bread					
71	Bread (brown, white)					
	Fruits and juices					
72	Mangoes					
73	Pawpaw/papaya					
74	Oranges					
75	Tangerines					
76	Pineapple					
77	Apples					
78	Lemon					
79	Passion fruits					
80	Watermelon					
81	Small bananas					
82	Cavendish (Bogoya)					
83	Tomatoes					
84	Sugar cane					
85	Others (specify)					
86	Soda (Coke, Fanta, Mirinda, Pepsi, etc.)					
87	Fruit juices					

	(commercial, home-made)					
88	Locally-made non-alcoholic drinks (Obushera, Omunanaasi)					
89	Others					
90	**Honey**					

91. Do/are you use any food supplements? If YES, which ones? (Write down the brand names of the supplements)

.....

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.....

.....

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Appendix 10: Maternal health questionnaire

APPENDIX 6: MOTHERS HEALTH QUESTIONNAIRE

Title of study: Maternal and Socioeconomic determinants of lung function among young infants in Uganda: a birth cohort study

Participant ID |_|_|_|_|_| Date |_|_|/|_|_|/|_|_|_|_|

Demographics

Date of birth |_|_|/|_|_|/|_|_|_|_| Age (in years) |_|_|

Address Village.....

Parish.....

Sub-county.....

Telephone contact.....

Phone ownership Self

Other..... If 'other' relationship.....

Tribe.....

Gravida..... Para..... Abortions.....

Date of last birth |_|_|/|_|_|/|_|_|_|_|

Health

Ask the following questions about all members of the household

PERSON ID	During the past 30 days, did (NAME) suffer from any illness or injury? 1= Yes 2= No (>> NEXT PERSON)	For how many days did (NAME) suffer due to illness or injury during the past 30 days? IF NONE, WRITE '0' AND SKIP TO COL 5	For how many days did (NAME) have to stop doing (NAME)'s usual activities due to illness or injury during the past 30 days? VALUE SHOULD BE LESS THAN OR EQUAL TO COL 4	Can you describe the symptoms that (NAME) primarily suffered due to the major illness or injury during the past 30 days? RECORD UP TO 2 SYMPTOM CODES SEE CODES BELOW		Was anyone consulted (e.g. a doctor, nurse, pharmacist or traditional healer) for the major illness/injury during the past 30 days? 1= Yes (>> 8) 2= No	Why was no one consulted for the major illness? SEE CODES BELOW [>>NEXT PERSON]	Where did (NAME) go for the first consultation during the past 30 days? PUBLIC SECTOR 1= Government hospital 2= Government health centre 3= Outreach 4= Government Community Based Distributor PRIVATE SECTOR 5= Private hospital 6= Pharmacy/ drug shop 7= Private Doctor/ Nurse/Midwife/Clinic 8= Outreach 9= NGO Community Based Distributor OTHER SOURCE 10= Shop 11= Religious Institution 12= Friend/ Relative 13= Traditional Healer	Distance to the place where this treatment was sought for in km?	What was the cost of this consultation , including any medicine prescribed even if purchased elsewhere? (in SHILLINGS)
1	2	3	4	5a	5b	6	7	8	9	10
01										
02										
03										
04										
05										
06										
07										
08										
09										
1										

Appendix 11: Infant health questionnaire

APPENDIX 13: INFANT'S GENERAL HEALTH ASSESSMENT

Title of study: Maternal and Socioeconomic determinants of lung function among young infants in Uganda: a birth cohort study

Participant ID |_|_|_|_|_|_|_|_|_| Date |_|_|/|_|_|/|_|_|_|_|

Mother's ID |_|_|_|_|_|_|_|_|_|

Demographics

Date of birth |_|_|/|_|_|/|_|_|_|_| Age (weeks) |_|_|

Gender male Female

Birth weight .....kg.....gms Current weight

Length.....cm Head circumference.....cm

Where was the baby delivered? Home Health facility

Who delivered the baby Self Relative TBA HCW

Mode of delivery:	□ Normal SVD	□ Vaginal delivery, abnormal presentation, if yes specify
	□ Vacuum extraction	□ Caesarean section, if yes, specify indication

Breastfeeding initiated within one hour after birth? Yes No

Current feeding practices

- Exclusively breastfeeding
- Mixed feeding (specify foods.....)
- Replacement feeding (specify foods.....)

Any history of illnesses since birth? Yes No

Physical examination

43	General condition Active=1 Weak =2 Lethargic =3	__|
44	Physical abnormalities Yes=1 No=2 Describe	__|
45	Temperature (axillary)	__|__|
46	Pallor Mild=1 Moderate =2 Severe=3	__|
47	Jaundice: Mild=1 Moderate =2 Severe =3 None=0	__|
48	Cyanosis: Peripheral =1 Central =2 Both =3	__|
49	Dehydration Mild =1 Moderate =2 Severe =3	__|
50	Weight (kg)	__|__| kg __|__|gm
51	Head circumference (cm)	__|__|
52	Length(cm)	__|__|
Respiratory system		
59	Respiratory rate (breaths per minute)	
60	Check for features of distress a) Severe chest in-drawing	__|
61	b) Nasal flaring	__|
62	c) Grunting	__|
63	d) Head nodding	__|

Appendix 12: Respiratory questionnaire

APPENDIX 9: RESPIRATORY QUESTIONNAIRE

Study title: Maternal and Socioeconomic determinants of lung function among young infants in Uganda: a birth cohort study

Participant ID |_|_|_|_|_|_| Date |_|_|/|_|_|/|_|_|_|_|

Date of birth |_|_|/|_|_|/|_|_|_|_| Age (in years) |_|_|

No	Item: symptoms	Response Yes =1 No = 2 Don't know = 3
COPD		
	Cough	
	Do you usually cough when you don't have a cold?	
	Are there months in which you cough on most days?	
	Do you cough on most days for as much as three months each year?	
	For how many years have you had this cough?	
	Do you usually bring up phlegm from your chest, or do you usually have phlegm in your chest that is difficult to bring up when you don't have a cold?	
	Are there months in which you have this phlegm on most days?	
	Is this phlegm frequently wet?	
	Is the phlegm worse when you lie in certain positions (on one side or the other)?	
	Do you bring up this phlegm on most days for as much as three months each year?	
	For how many years have you had this phlegm?	
Wheeze and asthma		
	Have you had wheezing or whistling in the chest in the past 12 months?	
	How many attacks of wheezing have you had in the past 12 months?	Write number
	In the past 12 months, how many times has your sleep been disturbed due to wheezing?	
	In the past 12 months, has wheezing ever been severe enough to limit your speech to only one or two words at a time between breaths?	
Breathlessness: Before this pregnancy;		

	Were you unable to walk due to a condition other than shortness of breath?	
	Please describe the condition	
	Were you too short of breath to leave the house, or short of breath on dressing or undressing?	
	Did you ever have to stop for breath after walking about 100 metres (or after a few minutes) on level ground?	
	Did you ever have to stop for breath after walking at your own pace on level ground?	
	Did you have to walk slower than people of your age on level ground because of shortness of breath?	
	Were you troubled by shortness of breath when hurrying on the level or walking up a slight hill?	
	MRC dyspnoea score	
Lung health relating to tuberculosis **This section relates to your lungs and any previous history of tuberculosis**		
	Have you ever been diagnosed with tuberculosis?	
	How many times have you been treated for tuberculosis	
	When were you diagnosed as having TB for this episode?	
	What part of the body did the tuberculosis affect?	
	Were the doctors/clinic sure that you had tuberculosis?	
	Which tests showed that you had tuberculosis?	
	Did you ever stay in hospital for treatment of TB?	
	How long for were you in the hospital (sleeping in the hospital)?	
	Where did you get your pills or injections for TB (which clinic)?	
	How long (in months) did you take treatment for?	
	Did you finish the treatment?	
	Why did you not complete the treatment?	
	Did you feel partly or completely well again (better) after ending treatment?	
	Did the clinic doctor say you were cured?	
	Did you stop attending the clinic before the treatment was meant to stop?	
Screening for current TB disease		
	Have you been coughing for 2 or more weeks? Note: For HIV positive individuals, any cough requires	