

Can dietary mineral deficiencies in a rural Malawi population be improved through the consumption of maize flour enriched using micronutrient fertilizers?

Submission date 20/02/2019	Recruitment status No longer recruiting	<input checked="" type="checkbox"/> Prospectively registered <input checked="" type="checkbox"/> Protocol
Registration date 05/03/2019	Overall study status Completed	<input type="checkbox"/> Statistical analysis plan <input checked="" type="checkbox"/> Results
Last Edited 25/01/2022	Condition category Nutritional, Metabolic, Endocrine	<input type="checkbox"/> Individual participant data

Plain English summary of protocol

Background and study aims

Selenium deficiency is widespread in Malawi. Deficiency of selenium leads to sub-optimal thyroid function and has a range of consequences including impaired cognitive development in children. Biofortification may be a cost-effective strategy to reduce selenium deficiency. Biofortification is the production of crops with greater concentrations of nutrients in their edible portions. One way to achieve this is through application of micronutrient-containing fertilizers during crop production, a process known as 'agronomic biofortification'. Biofortification has the potential to reach poorer, marginalised populations who rely heavily on the staple food maize with little dietary diversity.

Agronomic biofortification to address selenium deficiency is a promising technology, and widespread selenium deficiency in Finland was addressed through mandatory incorporation of selenium in fertilizers since the mid-1980s. However, there is currently insufficient evidence to know whether agronomic biofortification is an effective approach in the context of Malawi. The AHHA trial aims to test the efficacy of improving human selenium status through consumption of maize flour enriched with selenium through agronomic biofortification.

Who can participate

The trial is based in Wimbe Traditional Authority, Kasungu District, Central Region, Malawi. The area is characterised by predominantly subsistence farming alongside smallholder and estate tobacco production. Participants will be selected from a predefined study area with a recruitment target of 180 non-pregnant women of reproductive age and 180 school-aged children.

What does the study involve?

Households in the study area will be provided with maize flour for a period of 12 weeks. Participants will be randomly allocated to one of two arms to receive flour enriched with

selenium or control flour that is not biofortified with selenium. Blood samples will be drawn from participating individuals before and after flour distribution. Selenium status will be measured in the laboratory and individuals in the different trial arms will be compared.

What are the possible benefits and risks of participating?

Participants will receive free maize flour for the duration of the 12-week flour distribution period. Enough maize flour will be provided to meet household needs. This will allow households to save their own maize reserves or money that would have been spent on purchasing maize. There are minimal risks to participating. During formative research, participants raised the potential concern of negative social stigma through receiving free maize flour. This will be addressed through a comprehensive community sensitisation process.

Where is the study run from?

The study will be run in the community. The trial is led by researchers from the London School of Hygiene & Tropical Medicine (UK), the Lilongwe University of Agriculture and Natural Resources (Malawi), the College of Medicine, University of Malawi, and the University of Nottingham (UK).

When is the study starting and how long is it expected to run for?

Preparations for the study started in July 2018 with a period of formative research. The flour distribution period will run from mid-July to mid-October 2019 with baseline and end-line surveys conducted immediately before and after. Sample and data analysis will be completed by March 2020.

Who is funding the study?

The study forms part of the GeoNutrition project (www.geonutrition.com) which is a 42-month project funded by the Bill & Melinda Gates Foundation (OPP1181048).

Who is the main contact?

Edward Joy
edward.joy@lshtm.ac.uk

Contact information

Type(s)

Scientific

Contact name

Dr Edward Joy

ORCID ID

<https://orcid.org/0000-0002-0106-866X>

Contact details

Faculty of Epidemiology and Public Health
London School of Hygiene & Tropical Medicine
Keppel Street
London
United Kingdom
WC1E 7HT
+442079272214
edward.joy@lshtm.ac.uk

Additional identifiers

Protocol serial number

2018-KEP-196

Study information

Scientific Title

Alleviating Hidden Hunger with Agronomy: a randomised, controlled trial in rural Malawi to test the efficacy of alleviating selenium deficiency through consumption of maize flour enriched with fertilizers

Acronym

AHHA

Study objectives

Current study hypothesis as of 21/06/2019:

The study team hypothesise that the selenium status of women of reproductive age and school-aged children in rural Malawi can be improved through consumption of maize flour that is enriched with selenium through agronomic biofortification, i.e. application of micronutrient-containing fertilizers.

Previous study hypothesis:

The study team hypothesise that the zinc or selenium status of women of reproductive age and school-aged children in rural Malawi can be improved through consumption of maize flour that is enriched with zinc or selenium through agronomic biofortification, i.e. application of micronutrient-containing fertilizers.

Ethics approval required

Old ethics approval format

Ethics approval(s)

1. Approved 11/01/2019, London School of Hygiene & Tropical Medicine Interventions Research Ethics Committee (UK) (Keppel Street, London, WC1E 7HT; +44 (0) 20 7636 8636; Ethics@lshtm.ac.uk), ref: 16181
2. Approved 28/01/2019, College of Medicine Research Ethics Committee (Malawi) (3rd Floor, John Chipangwi Learning Resource Centre, Private Bag 360, Chichiri, Blantyre 3, Malawi; +265 11 871 911; comrec@medcol.mw), ref P.11/18/2539

Study design

Two-arm double-blind randomised controlled trial

Primary study design

Interventional

Study type(s)

Prevention

Health condition(s) or problem(s) studied

Deficiency of selenium

Interventions

Current interventions as of 21/06/2019:

The study area was defined by selecting two neighbouring Enumeration Areas with sufficient population to meet the target sample size, based on existing demographic information. All households in the study area will be enumerated. Households containing at least one non-pregnant woman of reproductive age (20-45 years) and one school-aged child (5-10 years) will be eligible for the trial and randomised into one of two arms: 'Selenium arm' or 'Control arm' in a 1:1 ratio. Randomisation will be conducted centrally after the baseline survey using simple randomisation. Grain will be processed into 'Granmill' maize flour prior to bagging and distribution. 'Granmill' flour is made from the whole grain after removing the bran. Households will receive maize flour in multiples of 5 kg bags sufficient to meet requirements of all household members for the 90-day flour distribution period, with distributions at two-week time points. Household requirements will be calculated based on estimated consumption of 330 g/capita/day for all household members over the age of 1 year (equivalent to 10 kg/capita/month).

Selenium arm

Households (n=90) will receive maize flour enriched with selenium through application of selenium-containing fertilizers during the production of the maize. The target selenium concentration in the selenium-biofortified maize flour is >0.2 ppm.

Control arm

Households (n=90) will receive maize flour grown with conventional application of plant macronutrients, thus not enriched with selenium. The expected range of selenium concentration in the control flour is 0.02-0.04 ppm.

Previous interventions:

The study area was defined by selecting three neighbouring Enumeration Areas with sufficient population to meet the target sample size, based on existing demographic information. All households in the study area will be enumerated. Households containing at least one non-pregnant woman of reproductive age (20-45 years) and one school-aged child (5-10 years) will be eligible for the trial and randomised into one of three arms: 'Zinc arm', 'Selenium arm' or 'Control arm' in a 2:1:2 ratio. Randomisation will be conducted centrally after the baseline survey using simple block randomisation stratified by village. Grain will be processed into 'Granmill' maize flour prior to bagging and distribution. 'Granmill' flour is made from the whole grain after removing the bran. Households will receive maize flour in multiples of 5 kg bags sufficient to meet requirements of all household members for the 90-day flour distribution period, with distributions at two-week time points. Household requirements will be calculated based on estimated consumption of 330 g/capita/day for all household members over the age of 1 year (equivalent to 10 kg/capita/month).

Zinc arm

Households (n=120) will receive maize flour enriched with zinc through application of zinc-containing fertilizers and compost during the production of the maize. The target zinc concentration in the zinc-biofortified maize grain is >30 ppm.

Selenium arm

Households (n=60) will receive maize flour enriched with selenium through application of selenium-containing fertilizers during the production of the maize. The target selenium concentration in the selenium-biofortified maize flour is >0.2 ppm.

Control arm

Households (n=120) will receive maize flour grown with conventional application of plant macronutrients, thus not enriched with zinc or selenium. The expected range of concentrations in the control flour are 18-22 ppm for zinc and 0.02-0.04 ppm for selenium.

Intervention Type

Other

Primary outcome(s)

Current primary outcome measure as of 21/06/2019:

Serum selenium concentration

Serum selenium concentration will be determined by Inductively-Coupled Plasma Mass Spectrometry (ICP-MS). The unit of measure is $\mu\text{g Se/L}$ of serum. Serum Se concentrations will be compared against established thresholds for deficiency measured at baseline and 12-weeks.

Previous primary outcome measure:

1. Zinc arm: DNA fragmentation analysis

DNA fragmentation will be quantified using the Comet Assay method and Comet Assay IV Lite software (Perceptive Instruments, London, UK) will be used to measure tail moments. The unit of measure is mean ($\pm\text{SEM}$) comet tail moment, defined as the product of the tail length and the fraction of total DNA in the tail (Tail moment=tail length x % of DNA in the tail) measured at baseline and 12-weeks.

2. Selenium arm: Serum selenium concentration

Serum selenium concentration will be determined by Inductively-Coupled Plasma Mass Spectrometry (ICP-MS). The unit of measure is $\mu\text{g Se/L}$ of serum. Serum Se concentrations will be compared against established thresholds for deficiency measured at baseline and 12-weeks.

Key secondary outcome(s)

Current secondary outcome measures as of 21/06/2019:

1. Haematology

Haemoglobin concentrations will be measured using HemoCue and compared against standard thresholds to indicate anaemia status. Inflammatory markers (α 1-acid glycoprotein and C-reactive protein) will be measured using a sandwich ELISA. Measured at baseline and 12-weeks.

2. Morbidity

Diarrhoea incidence, severity and duration, incidence of vomiting and incidence of fever will be recorded. Prevalence of pneumonia will be measured among school-aged children, i.e. number of days of coughing and fast or difficult breathing (due to a problem in the chest) in the two weeks prior to the baseline and end-line surveys.

3. Dietary selenium supplies

Dietary data will be collected among participating women of reproductive age using 4-pass interactive 24-hour recall at baseline and end-line surveys. Dietary data will be collected across all days of the week (population level) to account for any day of the week effect. Dietary data will be combined with relevant food composition data (including specific data for intervention maize flour) to determine the intakes of energy and nutrients (including selenium). The percentage of women at risk of inadequate intakes of selenium will be estimated using the Estimated Average Requirement cut-point method after adjustment for intra-subject variability. The percentage of energy from food groups, sub-groups and specific foods will be estimated to examine changes in diet patterns.

Previous secondary outcome measures:

1. Serum zinc concentration

Serum zinc concentration will be determined by Inductively-Coupled Plasma Mass Spectrometry (ICP-MS). The unit of measure is mg Zn/L of serum. Serum zinc concentrations will be compared against established thresholds for deficiency, adjusted for inflammation. Measured at baseline and 12-weeks.

2. Serum zinc: copper molar ratio

Serum zinc and copper concentrations will be determined by Inductively-Coupled Plasma Mass Spectrometry (ICP-MS). The molar zinc:copper ratio will be calculated and compared between trial arms. Measured at baseline and 12-weeks.

3. Fatty acid ratio

The molar ratio of linoleic acid:dihomo- γ -linolenic acid will be determined in erythrocytes through gas chromatography and compared between trial arms. Measured at baseline and 12-weeks.

4. Haematology

Haemoglobin concentrations will be measured using HemoCue and compared against standard thresholds to indicate anaemia status. Inflammatory markers (α 1-acid glycoprotein and C-reactive protein) will be measured using a sandwich ELISA. Measured at baseline and 12-weeks.

5. Morbidity

Diarrhoea incidence, severity and duration will be recorded using a standard score card. Prevalence of pneumonia will be measured among school-aged children, i.e. number of days of coughing and fast or difficult breathing (due to a problem in the chest) in the two weeks prior to the baseline and end-line surveys.

6. Dietary Zn supplies

Dietary data will be collected among a subset of at least 60 participating women of reproductive age using 4-pass interactive 24-hour recall at baseline and end-line surveys. Dietary data will be collected across all days of the week (population level) to account for any day of the week effect. Dietary data will be combined with relevant food composition data (including specific data for intervention maize flour) to determine the intakes of energy and nutrients (including zinc and selenium). The percentage of women at risk of inadequate intakes of zinc and selenium will be estimated using the Estimated Average Requirement cut-point method after adjustment for intra-subject variability; and assuming low bioavailability for Zn. The percentage of energy from food groups, sub-groups and specific foods will be estimated to examine changes in diet patterns.

Completion date

01/02/2020

Eligibility

Key inclusion criteria

Current inclusion criteria as of 21/06/2019:

Household level:

1. Participating households should have at least one non-pregnant woman of reproductive age (WRA; 20-45 years) and at least one school-aged child (SAC; 5-10 years) in residence during July-October
2. Household typically prepares and consumes meals at home
3. Household head provides permission to receive and consume assigned flour in place of their own flour for 12-week flour distribution period

Individual level:

1. One WRA and one SAC will be randomly selected to participate from each eligible household. Pregnancy status will be self-reported
2. Participant is planning to be in residence during July-October
3. Participant WRA is willing and able to provide consent, and caretaker of participant SAC is willing and able to provide assent

Previous inclusion criteria:

1. Participating households should have at least one non-pregnant woman of reproductive age (WRA; 20-45 years) and at least one school-aged child (SAC; 5-10 years). Pregnancy status will be self-reported. One WRA and one SAC will be randomly selected to participate from each eligible household
2. Household typically prepares and consumes meals at home
3. Household are willing and able to receive and consume assigned flour in place of their own flour for 12-week flour distribution period
4. Individual participants are willing and able to give informed consent (for WRA) or assent (for SAC)

Participant type(s)

Healthy volunteer

Healthy volunteers allowed

No

Age group

Mixed

Sex

All

Total final enrolment

360

Key exclusion criteria

Does not meet inclusion criteria

Date of first enrolment

26/06/2019

Date of final enrolment

06/07/2019

Locations

Countries of recruitment

Malawi

Study participating centre

Lilongwe University of Agriculture and Natural Resources
Bunda Campus

Lilongwe
Malawi
PO Box 219

Sponsor information

Organisation

London School of Hygiene & Tropical Medicine

ROR

<https://ror.org/00a0jsq62>

Funder(s)

Funder type

Charity

Funder Name

Bill and Melinda Gates Foundation

Alternative Name(s)

Bill & Melinda Gates Foundation, Gates Foundation, Gates Learning Foundation, William H. Gates Foundation, BMGF, B&MGF, GF

Funding Body Type

Government organisation

Funding Body Subtype

Trusts, charities, foundations (both public and private)

Location

United States of America

Results and Publications

Individual participant data (IPD) sharing plan

The datasets generated during and/or analysed during the current study will be stored in a publically available repository

IPD sharing plan summary

Study outputs

Output type	Details	Date created	Date added	Peer reviewed?	Patient-facing?
Results article		06/01/2022	25/01/2022	Yes	No
Protocol article		30/12/2019	30/12/2021	Yes	No
Other publications	Participants' experiences	03/12/2021	30/12/2021	Yes	No