Evaluation of the Coverage and Benefit Incidences of Food Fortification in Mozambique

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RESEARCH TEAM

IPC-IG
Design and Analysis

Diana Oya Sawyer (principal investigator)
José H C Monteiro da Silva
Elísio Mazive
Mariana Hoffmann
Mario Gyoeri
Sofie Olsson
Tamara Vaz de Moraes Santo
Vinicius Vaz Nogueira
Wesley de Jesus Silva

INTERCAMPUS
Household Survey Coordinators and Managers

Andreas Kokott (coordinator)
Gisela Lourenço
Duelo Macia
Yolanda Chongo
Ilda Mungoi
Afonso Ilhazia
Gregório Langa
Fátima Barbosa

BIOANALYT
Micronutrients Analysis

Holly McKee
Katrin Bernhöft

MINISTRY OF INDUSTRY AND COMMERCE OF MOZAMBIQUE
Section 1.2 National Food Fortification Programme in Mozambique and feedback on nutritional analysis

Eduarda Zandamela Mungoi

WFP MOZAMBIQUE
Section 1.3 The World Food Programme's Intervention to Support Food Fortification in Mozambique and overall feedback

Berguete Mariquele

Designed by the IPC-IG Publications team: Roberto Astorino, Flávia Amaral, Rosa Maria Banuth and Manoel Salles

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EVALUATION OF THE COVERAGE AND BENEFIT INCIDENCES OF FOOD FORTIFICATION IN MOZAMBIQUE

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ACRONYMS

CA	Control Area
CONFAM	Comité Nacional de Fortificação de Alimentos (National Food Fortification Committee)
CSP	Country Strategic Plan
EA	Enumeration Area
EU	European Union
FACT	Fortification Assessment Coverage Tool
FIES	Food Insecurity Experience Scale
GAIN	Global Alliance for Improved Nutrition
GMP	Good Manufacturing Practices
GoM	Grade of Membership
HDDS	Household Dietary Diversity Score
ICC	Intracluster Correlation
INAE	Inspecção Nacional de Actividades Económicas (National Inspection of Economic Activities)
INE	Instituto Nacional de Estatística (National Institute of Statistics)
INNOQ	Instituto Nacional de Normalização e Qualidade (National Institute for Standardization and Quality)
IPC-IG	International Policy Centre for Inclusive Growth
MDG	Millennium Development Goals
MIC	Ministério da Indústria e Comércio (Ministry of Industry and Commerce)
MISAU	Ministério da Saúde (Ministry of Health)
MoU	Memorandum of Understanding
NFFP	National Food Fortification Programme
PAMRDC	Plano de Acção Multesectorial para a Redução de Desnutrição Crónica (Multisectoral Action Plan for the Reduction of Chronic Malnutrition)
PQG	Programa Quinquenal do Governo (Five-year Plan of the Government)
PPS	Probability Proportional to Size
PSU	Primary Sampling Unit
QC	Quality Control
RC	Results Component
RNI	Reference Nutrient Intake
SDG	Sustainable Development Goals
SRS	Simple Random Sampling
SSU	Secondary Sampling Unit
TSU	Tertiary Sampling Unit
UNDP	United Nations Development Programme
UTFA	Technical Unit for Food Fortification
WFP	World Food Programme
WHO	World Health Organisation
WRA	Women of Reproductive Age

GLOSSARY OR CONCEPTS, DEFINITIONS AND MEASUREMENTS

FOOD FORTIFICATION

Food fortification: Food fortification is the practice of adding one or more essential nutrients to improve the nutritional quality of the food supply.

Mass fortification: Mass fortification (or population-based fortification) aims at fortifying foods that are widely consumed by the general population, often staple foods such as grains, salt and other condiments, to provide the population with additional amounts of essential vitamins and minerals.

Targeted fortification: Aims groups in society such as infants or women of reproductive age.

Vehicle of micronutrients: Vehicles are foods (such as salt, flour, sugar, and oil) to which vitamins and minerals are added during the processing stage to increase the food's micronutrient content. The selection of a suitable food vehicle is one of the key processes in developing a fortification programme.

Premix: Premix is a commercially prepared blend of vitamins and minerals that is added to food vehicles during the processing stage in order to increase the content of micronutrients.

National Food Fortification Programme in Mozambique (NFFP): A Government of Mozambique mass fortification programme, focused on the fortification of staple foods. According to the Mandatory Food Fortification Decree of March 2016, the vehicles of micronutrients in the programme are:

- Wheat flour (for bread)—with iron, folic acid, complex B vitamins and Zinc
- Vegetable oil—with vitamin A
- Sugar—vitamins A and D
- Maize flour—iron, folic acid, complex B vitamins and zinc
- Salt iodisation has been included under this Decree, although it is already mandatory.

COVERAGE OF THE NATIONAL FOOD FORTIFICATION PROGRAMME

Coverage of the National Food Fortification Programme: Conceptually, the coverage of the National Food Fortification Programme is the interaction between the Food Fortification Programme and the target households for which it is designed. It measures the reach of the programme regarding the target households.

Coverage definition and measurement: In this study, coverages are defined as potential and actual coverage, in a four-stage model, following the five-stage Tanahashi (1978) framework to evaluate the health service coverage. The Fortification Assessment Coverage Toolkit (FACT) surveys inspired the framework and the measurement of coverage of this study, which made some adaptations to the definition of the stages. The coverage rate measurements used data from a specific household survey and the consumption rates are their proxies. The rates are defined, in each stage, as the number of households that consume respective vehicles out of the total households of the country. Specific coverage rates in each stage—for subgroups such as rural/urban residence and vulnerability groups—consider the numerator and denominator of the specific groups.

Coverage assessment framework: The framework for this study considered four stages of the programme divided into two groups: potential coverage and actual coverage, according to the consumption of the vehicles by the households.

Potential coverage refers to the households that consume vehicles independently of the fortification condition. The stages are defined according to households that consume:

1. Vehicles chosen for fortification, denominated here as **vehicles from any source**. It reflects the **availability coverage,** meaning the degree of consumption of the chosen vehicles by the households.

2. Vehicles chosen for fortification that are from **fortifiable** in large or median scale source. They refer to households that consume industrialised vehicles; it reflects the **accessibility coverage** to the vehicle. In terms of maize flour, both industrialised flours and home-grown grain that were ground at community mills are considered fortifiable vehicles par.

Actual coverage are households that consume fortified vehicles. The stages are defined according to household that consumes:

1. Fortified vehicles with nutrient concentration at any level. This reflects the **contact coverage** of the households, meaning the contact they have with the output of the programme—that is, fortified vehicles found in the market. Throughout the report the vehicles are denominated **fortified at any level.**

2. Fortified vehicles that meet the national standards of food fortification regarding the minimum concentration of micronutrients in the vehicles. This reflects the **effectiveness coverage** of the NFFP, meaning consumption of the Programme's output—that is, fully fortified vehicles—by the population. Throughout this report, the vehicles of this stage are considered **fortified**.

Coverage of specific groups:

Benefit incidence: As defined by WFP, benefit incidence represents the population groups that have had the benefit of consuming fortified vehicles. This is measured, for each stage of the coverage model, as the number of households in a specific group that consume fortified vehicles out of the total number of households in the specific group.

The benefit incidence of the NFFP was estimated from the point of view that the coverage should reach regions and segments of the population targeted by the programme or beyond that, as such coverage levels were measured for rural areas. It also attempts to show how vulnerable population groups with low capability to acquire and consume fortified foods are reached. In that context, the estimation relied on calculating the programme's coverage among different population groups classified by their degree of vulnerability, in order to show the groups that are being benefited from the programme.

Assessment of vulnerable groups: A multidimensional method was employed to assess vulnerable groups, using 13 variables. Nine of them refer to the capability of people to acquire fortified foods and four to the hindrances. The concept of vulnerability in this study relies on the basic assumption that the segments of the population that might benefit from the NFFP are associated with the: 1) **capability** of people to acquire, adequately handle and consume nutrient vehicles; and 2) **hindrances** to the adequate intake of micronutrients by requiring higher consumption or jeopardising the absorption of the micronutrients. The 'Grade of Membership' method of assessment allows for the classification of continuous levels and composition of vulnerability.

Grade of Membership (GoM): A model based on fuzzy sets where the elements of the sets have degrees of membership to multiple subsets. In this case, one household has grades of memberships to two extreme profiles (very high vulnerability and very low vulnerability) estimated by the model.

The combination of the grades of membership allows for a classification of the household in a continuum of vulnerability in a multidimensional approach between those two extreme profiles

MICRONUTRIENT INTAKE OF THE HOUSEHOLD

Micronutrient intake: Micronutrient intake is the intake of dietary components, often referred to as vitamins and minerals, which enable the body to produce enzymes, hormones and other substances essential for proper growth and development, disease prevention, and wellbeing. Micronutrients are not produced in the body and must be derived from the diet.

Recommended nutrient intake: Recommended nutrient intake (RNI) is the daily intake which meets the nutrient requirements of almost all (97.5 per cent) apparently healthy individuals in an age and sex-specific population group. Daily intake corresponds to the average over a period of time. This study used the RNI table by age, sex, lactating and postmenopausal women, from FAO/WHO (1978).

Adequacy of micronutrient intake at the households. The adequacy of the micronutrient intake of each household was determined by comparing the household daily intake of the micronutrient—the concentration of the micronutrient as determined by laboratory test multiplied by the daily amount of the vehicle consumed by the household—with the expected total recommended intake in a household that has similar characteristics of age, sex and presence of lactating and post-menopausal women to those in the RNI table.

The expected household recommended intake was calculated by multiplying, for each sex, the number of persons in the household in a specific age group and women in special conditions by the respective RNI and adding them together. This was considered the expected household intake.

The ratio of the actual daily intake was divided by the expected intake, assessing the proportion of the contribution that the NFFP has to the adequate nutrient intake, for each household.

METHODOLOGY TO DETERMINE NUTRIENTS CONCENTRATION IN FOOD SAMPLES

iCheck is a test kit for the quantitative determination of micronutrients. It consists of two units—a portable photometer or fluorometer (iCheck) and the disposable reagent vials in which the reaction is performed.

iCheck Chroma 3 was used for the determination of vitamin A in edible oil. The determination of vitamin A is based on a colour reaction in which the reagents in the vial turn a brilliant blue (Carr-Price reaction), the intensity of which is dependent on retinol concentration. The iCheck Chroma 3 device measures the absorption of the colour in the reagent vial at 3 different wavelengths, over the course of 30 seconds. The device then calculates the vitamin A content through a sophisticated algorithm and displays the result in mg retinol equivalents/kg of oil. The linear range of the device is 3–30mg retinol equivalents (RE)/kg of oil.

iCheck Fluoro was used for the measurement of vitamin A in sugar. iCheck Fluoro quantitatively determines the concentration of vitamin A in food based on the measurements of the auto-fluorescence of vitamin A (retinol). Results are displayed in the measuring device iCheck Fluoro in µg retinol equivalents/L. This method has been validated against the reference method—HPLC (4).

iCheck Iron is a single wavelength photometer that measures absorption of a solution at 525 nm. The iCheck Iron reagents vials contain chemicals that react with iron present in food and turn red. The chemical composition is bathophenantrolin in organic solvent, reducing and chelating agents. The intensity of red colour correlates with the concentration of iron in the sample. When the reaction is complete, the vial is placed in the iCheck photometer, the absorption is measured at 525nm and the concentration is displayed in mg (Fe)/L.

EXECUTIVE SUMMARY

The main objective of this study is to evaluate the coverage of the National Food Fortification Programme (NFFP) in Mozambique regarding iron-fortified wheat and maize flours and vitamin A-fortified sugar and vegetable oil, as well as the benefit reach across population groups. A population-based cross-sectional household survey and laboratory tests to determine nutrient intake in food samples collected at households are the main source for the analysis.

The following research questions were addressed:

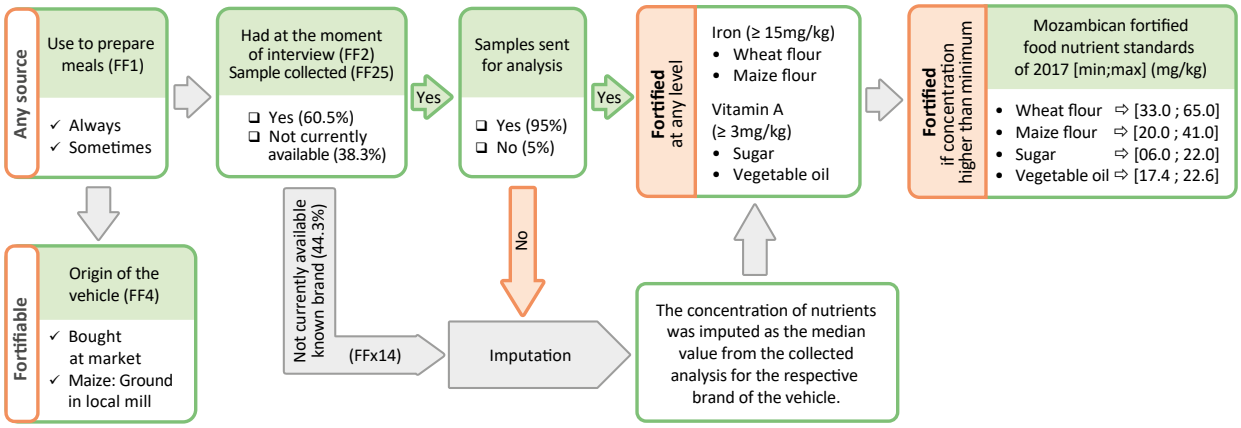
1. To what extent is the Mozambican population covered by fortifiable and fortified wheat flour, maize flour, vegetable oil, and sugar?

2. What is the benefit incidence of the NFFP, meaning the reach of the programme across vulnerable groups in the following dimensions: socioeconomic, rural-urban place of residence, health and nutritional status?

3. To what extent does the food fortification in Mozambique contribute to the recommended nutrient intake (RNI) of micronutrients through their respective vehicle?

A structured questionnaire was the instrument used to collect information regarding the consumption of the vehicles and other socioeconomic, nutritional and demographic information. The sample consisted of 1,500 households, randomly chosen in a three-stage design. In all the households, whenever available, samples were collected of 50gr of wheat flour, maize flour and sugar, and 50ml of vegetable oil. The 3,209 collected samples were analysed for the concentration of micronutrients. For maize and wheat flour, the iron content was determined by the iCheck Iron method; to test for vitamin A in sugar samples, iCheck Fluoro was used; and for vitamin A in vegetable oil, the method used was iCheck Chroma 3.

The classification of the vehicle in fortifiable and fortified followed the diagram



Note: (FFxx) refers to the questionnaire item.

In this study, coverages are defined as potential and actual coverage, in a four-stage model, following the five-stage Tanahashi (1978) framework to evaluate the health service coverage. The Fortification Assessment Coverage Toolkit (FACT) surveys inspired the framework and the measurement of coverage of this study, which made some adaptations to the definition of the stages. FACT was developed by the Global Alliance for Improved Nutrition (GAIN) and has been profusely employed in assessing the coverage of food fortification programmes (Aaron et al. 2017; NBS 2015).

The stages of the study framework are:

Potential coverage refers to the households that consume vehicles independently of the fortification condition. The stages are defined according to households that consume:

1. Vehicles chosen for fortification, denominated here as **vehicles from any source**, it reflects the **availability coverage,** meaning the degree of consumption of the chosen vehicles by the households.

2. Vehicles chosen for fortification that are from **fortifiable** in large or median scale source. They refer to households that consume industrialised vehicles; it reflects the **accessibility coverage** to the vehicle. For maize flour besides industrialised flours the household grown grains that were ground at community mills were also considered.

Actual coverage are households that consume fortified vehicles. The stages are defined according to households that consume:

1. Fortified vehicles with nutrient concentration at any level, it reflects the **contact coverage** of the households, meaning the contact they have with the output of the programme that is fortified vehicles in the market. Throughout the report the vehicles are denominated **fortified at any level**.

2. Fortified vehicles that meet the national standards of food fortification regarding the minimum concentration of micronutrients in the vehicles. This reflects the **effectiveness coverage** of the NFFP, meaning consumption of the Programme's output—that is, fully fortified vehicles—by the population. Throughout the report the vehicles of this stage are considered as **fortified**.

Coverage rates of vehicles from any source and those fortifiable and fortified at any level and fortified according to Mozambican standards for each of the vehicles, by urban and rural areas as well as households classified according to four profiles of vulnerability, have shown that the consumption of wheat flour was considerably lower than that of the other three vehicles. This fact reflects the design of the research, which focused on the household consumption of the wheat flour that was purchased, whereas most of the fortified flour consumption could be from derived products, such as pasta or bread. For maize flour, sugar and oil, the consumption of fortifiable foods was very high, meaning that there is good potential for an almost universal coverage of the NFFP, since the population is consuming vehicles from sources that allow large- and medium-scale fortification.

The effectiveness of the programme so far has been very low as per consumption of fortified foods classified in accordance with the 2017 Mozambican standards, if compared to the consumption of the respective fortifiable vehicle. The contact coverage as consumption of fortified foods regardless of the concentration (i.e. including fortified vehicles that do not meet the national standards) has been much closer to the consumption of fortifiable and has surpassed some of the population access goals set by WFP in their interventions to support the NFFP.

These patterns of consumption have shown that the access to fortified foods was not a problem. The problem lied in the fact that the population was ingesting nutrients at a significant level below Mozambican standards. Many questions have been raised:

- Why is it that even with high consumption of fortifiable foods and moderate consumption of foods fortifiable at any level in a mandatory NFFP, do the levels of nutrients consumed not meet the country's established nutritional standards?

- Where in the production chain (from factory to households) resides the problem?

- Are the imported products in accordance with the Mozambican standards?
- Is it too early to have total compliance from producers?

The main recommendation is to implement a system of continuous monitoring and evaluation of the components of the production chain. Other recommendations are to implement a surveillance system and a dissemination campaign regarding the importance of the fortified foods and the proper way to handle and store them.

A specific survey to assess the fortification coverage of wheat flour in derived products such as bread and pasta.

About 45 per cent of urban households reach at least 50 per cent of the RNI of vitamin A from vegetable oil or sugar and 23.92 per cent reach the same RNI threshold (50 per cent) of iron from wheat or maize flour. Rural settlements presented proportions of 25.43 per cent and of 20.36 per cent, respectively. As for results observed for vulnerability profiles, the share of households that reach half of the RNI for low vulnerable groups is about twice the share for the highly vulnerable groups for the intake of both vitamin A and iron.

However, considering that the NFFP has so far focused on the urban and peri-urban areas, the lower value for the rural areas and highly vulnerable groups should not be overlooked, because it represents a spread of the benefits of the programme, as well as a sign of the possibility of a universalisation of the benefits.

EVALUATION OF THE COVERAGE AND BENEFIT INCIDENCES OF FOOD FORTIFICATION IN MOZAMBIQUE

1. BACKGROUND

1.1 Nutritional context in Mozambique

Mozambique has about 28 million inhabitants, 70 per cent of whom live in rural areas (World Bank 2017). The population's access to health services, water, sanitation and education is still limited and income levels remain low. Moreover, the country has a large food deficit, and food and nutrition security remains a key challenge to human well-being and economic growth. According to MISAU and INE (2011), chronic and acute malnutrition rates in children aged 0-59 months are about 43 per cent and 6 per cent respectively, and malnutrition is responsible for about a third of deaths of children under five years.

In addition to chronic malnutrition, micronutrient deficiencies represent a largely invisible but devastating form of malnutrition that is particularly prevalent in Mozambique. It is considered a public health problem mainly affecting children and women of reproductive age. While there are regional variations in the prevalence of malnutrition, the main causes are a lack of available and affordable food, lack of a diverse diet, cultural and social traditions, and poverty. According to MISAU and INE (2011) about 69 per cent of children under five years and 14.3 per cent of pregnant women have vitamin A deficiency. The Demographic and Health Surveys (DHS) (*Inquérito Demográfico e de Saúde*) indicates that 44 per cent of women of reproductive age, 52.4 per cent of pregnant women and 69 per cent of children under five years are anaemic, and that 39 per cent of these children have moderate anaemia and 4 per cent severe anaemia. Although Mozambique has implemented universal salt iodisation since the late 90s, and the iodine deficiency in the population is considered moderate (WHO 2004), the coverage of iodised salt is only 25 per cent (Global Nutrition Report 2014), 68 per cent of the student population consumes an insufficient form of iodine, and only 46 per cent of households consume iodised salt at adppropriate levels (Ministry of Health 2004).

Micronutrient deficiencies affect the physical and mental growth of children, cause iron deficiency anaemia and blindness, and contribute to maternal mortality. They have costly repercussions in the long term for a country and its economic development, such as high social and public costs. According to Horton (2003), anaemia leads to 17 per cent lower productivity in heavy manual jobs, 5 per cent lower productivity in other manual jobs, and about 2.5 per cent lower income due to decreased cognitive abilities. PAMRDC (2010) and World Bank (2006) estimate that productivity losses in Mozambique represent 2-3 per cent of gross domestic product (GDP).

1.2 The National Food Fortification Programme in Mozambique

The Government of Mozambique has recognised chronic malnutrition and micronutrient deficiencies as major public health problems and has made a commitment to tackle them. Since the underlying causes of micronutrient deficiency are complex, the government, together with partners, has adopted a multi-intervention approach, one of which is the mandatory fortification of foods[1] through the NFFP. Programme design and the selection of food vehicles aim to increase the coverage of micronutrients at the national level in order to improve the nutritional status, population health and productivity of the country. It specifically aims to contribute to filling the gap of micronutrients in the daily diet of the population, caused partly by low ingestion of vitamins and minerals such as iron, folic acid, zinc, iodine, vitamin A, and vitamin B12.

1. There are other complementary interventions such as bio-fortification, supplementation with vitamins and minerals (vitamin A in children younger than 5 years old, iron in pregnant women), use of powdered micronutrients and nutritional education. However, out of all of the above strategies, food fortification is recognised as the most cost-effective and sustainable strategy to convey micronutrients to the population and consequently reduce micronutrient deficiency levels.

The NFFP is supported by the Multi-sectoral Action Plan for the Reduction of Chronic Malnutrition in Mozambique (PAMRDC 2011-2020) and the Five-year Government Programme (PQG 2015-2019) on Priority II (Development of Human and Social Capital). It envisages a reduction of chronic malnutrition from 43 per cent to 35 per cent (in 2019) by supporting actions that promote nutritional education and behaviour change programmes aimed at the use of fortified crops and foods with micronutrients. The programme's main objectives are to: i) shape the vision and strategies for fortification of staple foods in order to reduce micronutrient deficiencies in Mozambique; ii) increase the supply of high-quality fortified products at accessible prices; and iii) reduce the morbidity and mortality among the population, in particularly women of reproductive age and children, by raising awareness about and promoting the consumption of fortified products.

The programme is led and chaired by the Ministry of Industry and Trade (MIC) and co-chaired by the Ministry of Health (MISAU), coordinated by the National Food Fortification Committee of Mozambique (CONFAM) and implemented by the Technical Unit for Food Fortification (UTFA). This programme is a public-private partnership with a strong involvement by industries processing food vehicles used for food fortification, such as salt (iodine), maize flour and wheat flour (iron, zinc, folic acid, and vitamin B12), sugar and oil (vitamin A). Between 2013 and 2018, CONFAM has, together with the World Food Programme and other partners, developed several activities in its four areas of action, namely: production; legislation and national standards; communication and marketing; and monitoring and evaluation.

Within the area of **production**, Premix and microdosers were delivered to maize flour, wheat flour, vegetable oil, and sugar industries that participate in the programme. Moreover, stakeholders were trained on good manufacturing practices and quality control. Industries received training on matters related to the guarantee and quality control of fortified products and on techniques for the use of the logo of fortified products and their visualisation on the packaging. Other selected stakeholders were trained on the design of a monitoring and surveillance system for fortification. Furthermore, technical visits to countries that implement food fortification with Premix were carried out in 2016 and 2017, which among other things resulted in the signing of MoUs between MIC and Hexagon of India for the supply of Premix (vitamins A and D) to the oil, Milhouse Dalton supply (vitamin A) to the sugar industries, and the German company Muhlenchemie for the supply of Premix (zinc, iron, folic acid and vitamin B12) to wheat flour and maize flour industries.

In the area of **legislation and standards**, several guiding instruments were developed to support the implementation of the programme, including:

- The Regulation of Food Fortification with Industrially Processed Micronutrients—Decree No. 9/2016 of April 18;
- The National Food Fortification Strategy (2016-2021);
- The National Communication Strategy for the Food Fortification Programme (2016-2020);
- The manual on frequently asked questions about the food fortification regulation;
- The six manuals for internal and external monitoring (quality control and assurance) of fortified wheat flour, maize flour, and edible oil (approved and used during training and monitoring visits to the industries);
- The Positive List of Premix Suppliers for the fortification process (of the vehicles covered by the Regulation of Food Fortification with Industrially Processed Micronutrients—Decree No. 9/2016 of April 18). The list was approved by the Government of Mozambique to be used by the industries of Mozambique;
- Approval of the tariff exemption of Premix importation and equipment from the customs duties to benefit the industries involved in food fortification initiatives;
- Food fortification logo developed and disseminated to stakeholders and potential users; and

- The Mozambican standards for fortification of oil, wheat flour, maize flour, sugar, and salt approved by the INNOQ and disseminated to the programme stakeholders and general public.

In terms of **communication and marketing**, various seminars have been held with government officers, inspectors, industries involved in the food fortification programme, traders, consumers' associations, industrial associations, academy and civil society in all provinces; in particular where the programme is being implemented. The purpose has been to disseminate all the instruments, the National Food Fortification Strategy (2016-2021) and the communication strategy, monitor the implementation of standards, training for the use of the logo, and training the industries in good production practices (GMP and GHP) and quality control. Moreover, multiple outreach activities have been implemented to disseminate the logo of fortified foods to consumers and to monitor the display of promotional material in markets and supermarkets, as well as in schools and other places. This included activities such as radio spots in six local languages, video spots broadcast on TV, participation in local fairs, and presentations and lectures at schools, meetings, campaigns and events.

Monitoring and evaluation visits have been carried out at all the participating industries to assess the implementation of the fortification, such as the use of equipment and Premix, use of the fortification logo on the packaging, and business planning. Additionally, it has been verified that laboratories are following the established technical procedures.

Lastly, the programme has carried out assessment visits and mapping of 39 small-scale maize industries in rural areas with the purpose of expanding fortification coverage. This included identifying possible mills and factories, analysing the state of food safety at these, evaluating capacity, assessing the willingness and ability to fortify, and identifying the constraints and challenges of the small mills.

1.3 The World Food Programme's intervention to support food fortification in Mozambique

The World Food Programme (WFP) of the United Nations is the largest humanitarian organisation engaged in the global Zero Hunger initiative. WFP Mozambique has been supporting the development and implementation of the NFFP since its inception. Previously, it focused on voluntary fortification of staple foods, such as wheat and edible oil. In 2013, with European Union (EU)-approved financial support of a total of EUR67.3 million to support Mozambique's efforts to accelerate towards achieving the Millennium Development Goals (MDGs). The MDG-initiative, also referred to as the MDG1c programme, aims to reduce hunger and malnutrition in the country. This initiative included support to the NFFP, headed by the *Comitê Nacional de Fortificação de Alimentos* (CONFAM, Mozambique's Food Fortification Alliance) through MIC. WFP's role has been to complement the existing initiatives of the NFFP, to support MIC in strengthening the Technical Unit for Food Fortification to implement, supervise and monitor actions taken by the food industry with the aim of ensuring the production and provision of fortified products for the national market.

In alignment with WFP's Country Strategic Plan (CSP) 2017-2021 and the Sustainable Development Goals (mainly SDGs 2 and 17, ending hunger and contributing to revitalised global partnerships), WFP Mozambique supports the commitment of the national government to reduce malnutrition (WFP Strategic Result 2, SDG target 2.2). It is expected that targeted people in prioritised areas of Mozambique will have improved nutrition status in line with national targets by 2021 (outcome 4 of the CSP), which should be achieved through two outputs: (i) vulnerable people in Mozambique benefit from strengthened, evidence-based national capability to combat stunting and micronutrient deficiencies in order to improve their nutrition status; and (ii) vulnerable people in Mozambique benefit from improved knowledge in nutrition, care practices and healthy diets in order to improve their nutrition status. It was estimated that by the end of the project in 2018, 11.9 million people would have access to fortified wheat flour; 11.5 million people would have access to fortified vegetable oil; 13 million people would have access to fortified sugar; and 1.8 million people would have access to fortified maize flour.

The Food Fortification Result Component (called RC13) was created to ensure the success of the existing fortification of wheat flour and edible oil and expand fortification of other vehicles, such as maize flour and sugar. As large- and medium-scale manufacturers of these four foods are highly consolidated in Mozambique, it was possible to establish

mandatory fortification of these products by working with the regulators on fortification and supporting key producers of these commodities in the country. In addition, it aimed to strengthen the regulatory framework, monitoring systems and compliance mechanisms for food fortification, as well as quality control and assurance systems.

In order to achieve the proposed objectives, WFP provided technical and financial support to MIC to oversee the food fortification initiative in Mozambique and strengthen producers of wheat flour, maize flour, sugar, and edible vegetable oil through capability building, technical assistance and provision of equipment and micronutrient Premix. Quality control and assurance systems were also strengthened through support to laboratories and the inspection body, including equipment, training and technical assistance for the development of a monitoring and evaluation plan. In addition, the intervention created and launched a social marketing campaign on the importance of fortified foods to create awareness and increase demand; provided technical and financial assistance for the formulation of the legislation for mandatory food fortification, developed standards, guidelines, and the National Food Fortification Strategy (2016-2021), and finally measured if socioeconomic groups benefit from the fortification of wheat flour, maize flour, vegetable oil, and sugar (for more details, reference is made to the project implementation report). Key results obtained through this support include:

- 17 maize flour (small and medium scale), 9 wheat flour, 4 sugar, and 12 edible oil industries recruited to the programme;
- 32 microdosers for wheat flour, maize flour, edible oil and sugar purchased and installed;
- 22 MT, 43 MT, 6 MT and 86 MT of Premix for wheat flour, maize flour, edible oil and sugar respectively procured and donated to industries;
- Trainings provided to wheat flour, edible oil, maize flour, and sugar industries;
- 27 inspectors trained in monitoring and quality control of food fortification;
- 6 guidelines and manuals produced for industries and inspectors;
- Development of a communication strategy for the NFFP and the launch of a national social marketing campaign on the importance of fortified foods;
- Fortification legislation and fortification standards developed, approved and disseminated (national standards for fortified maize flour, wheat flour, edible oil, sugar, cassava flour, instant porridge);
- Food fortification roadmap improved through the development of an updated CONFAM strategy on food fortification for the 2016-2020 period;
- Capacities of government inspectors and other relevant staff (such as INAE, Customs, INNOQ) for monitoring and quality control of food fortification improved through the development of a fortification monitoring plan and trainings;
- Two laboratories (National Lab and Lurio University) supported with equipment (iChecks and respective vials)[2] and trainings.

As the programme is nearing completion, there is a need to assess how its outputs are met on two aspects: i) the coverage of the NFFP—translated as the Mozambican population who consume fortified foods, meaning

2. iCheck Chroma 3—vitamin A in oil; iCheck Iron—iron in flour; iCheck Fluoro—vitamin A in sugar; iCheck Iodine—iodine in salt.

that they have been reached by the programme; and ii) the extent of the NFFP benefits across the vulnerable groups (in terms of socioeconomic, territorial, nutritional and health factors)—translated as the population within these groups who consume fortified foods, meaning that they have been reached by the benefits of the programme.

1.4 Empirical evidence from previous food fortification interventions

Food fortification is the practice of adding one or more essential nutrients to improve the nutritional quality of the food supply (European Commission 2016). The practice of adding vitamins and micronutrients to foods has long existed in Europe and North America, and in the past decades has also become an increasingly common practice in countries of the global South (Moench-Pfanner et al. 2012). It is recognised as one of the most cost-effective and sustainable strategies to combat micronutrient deficiencies (Allen et al. 2006; Bhutta et al. 2013; Horton 2006; WHO 2016), in particular when fortification is implemented on a large, population-based[3] scale and focuses on foods that are broadly consumed (Moench-Pfanner et al. 2012). Moreover, as people's health improves, it indirectly increases productivity and economic progress (Forsman 2014).

Studies of previous food fortification interventions, including **empirical studies** (e.g. NBS 2015; Aaron et al. 2015; Aaron et al. 2016; Aaron et al. 2017; Knowles et al. 2017; Rohner et al. 2016; Martorell et al. 2014; Ogunmoyela et al 2013; Sandjaja et al 2015; Low et al 2007; Gibbs et al. 2015; Nkhoma 2017) **and systematic reviews** (see e.g. WHO 2016; Hurrell et al. 2010; Sablah et al. 2013; Liu et al. 2015; Neufeld et al. 2017; Nyumuah et al. 2012; Wirth et al. 2012), have shown mixed results, but overall agree that food fortification has large potential when done right.

The two key challenges identified in the studies are the following:

1. Low coverage of fortified foods, i.e. the intervention did not reach the population:
    a. The selected food was not widely consumed by the population (e.g. wheat flour in Tanzania, see NBS 2015);
    b. The selected food was not industrially processed (e.g. maize flour in Tanzania, see NBS 2015 and wheat flour in Rajasthan, see Aaron et al. 2016), thereby reducing the share of fortifiable produce and complicating the fortification process; or
    c. The coverage was inequitable (e.g. adequately fortified salt in Bangladesh, Ghana, India, Indonesia, the Philippines, Senegal, and Tanzania, where households in urban areas and/or with higher socioeconomic status had better coverage, see Knowles et al. 2017).
2. Inadequate quality of the fortified food, i.e. nutrient levels did not comply with recommendations or regulations. In some cases, the producer added an inefficient form of the nutrient and in others, the levels of added nutrients were too low to have any effect, as was the case in Ivory Coast (Rohner et al. 2016) and Nigeria (Ogunmoyela et al. 2013).

They conclude that coverage needs to be addressed already in the design, whereas improved quality requires capability development at the industry level as well as strengthening of regulations and monitoring systems.

3. Population-based (or mass) fortification aims at fortifying foods consumed by large segments of a country's population (often staple foods), whereas targeted fortification targets certain groups in society, such as infants or women of reproductive age. The literature also differentiates between voluntary and mandatory fortification; the latter usually with government involvement (see e.g. Allen et al. 2006; Friesen et al. 2017).

On the other hand, the majority of studies also reported successes with food fortification. Some countries indicated good potential impacts thanks to high coverage of fortifiable food vehicles, including oil and salt in Tanzania (NBS 2015) and oil and wheat flour in Senegal (Aaron et al. 2015). Furthermore, in Rajasthan, India (Aaron et al. 2016) and Uganda (Knowles et al. 2017), a large share of the consumed salt was both adequately fortified and had broad coverage. Lastly, some studies showed improvements in nutritional status thanks to fortification, such as in Abidjan, Ivory Coast (Rohner et al. 2016), where fortified salt and vegetable oil contributed significantly to the population's vitamin A intake; Indonesia (Sandjaja et al. 2015), where fortified oil improved vitamin A intake and serum retinol status in women and children; and Costa Rica, where fortified wheat flour, maize flour, and milk indicated improvements in iron deficiency and anaemia levels among women and children.

The following sections present the objectives, analytical strategy, procedures of household sampling and of data collection, results, discussion of results and recommendations of the study. Specific and detailed procedures of sampling, data collection and of methodology of analysis can be found in the respective Appendices.

2. INSTITUTIONS AND ETHICAL CLEARANCE

WFP Mozambique, through an agreement with the United Nations Development Programme (UNDP) of Brazil, financed the project and also contributed to the report by elaborating the background sections and reviewing the text. The International Policy Centre for Inclusive Growth (IPC-IG) was the implementer, coordinator and executor of all stages of the project. Intercampus, a specialised company located in Mozambique, carried out the data collection and field training, and wrote the sections and Appendix on data collection procedures. BioAnalyt, located in Teltow, Germany, performed the micronutrients analysis and wrote the section on Laboratory Analysis. Intercampus and BioAnalyt won international procurement processes. Eduarda Mungoi from MIC elaborated the section on the NFFP and provided overall feedback on nutrient analysis.

The project received ethical clearance by the *Comité Nacional de Bioética para Saúde de Moçambique* (the Mozambican National Bioethical Committee for Health), upon submission of all required documents:

- Cover Letter;
- Research Protocol (objectives, design, methods, expected outcomes, research information forms to provide to interviewees, interviewee informed consent form to participate, and questionnaire);
- Budget;
- Main Investigator CV and List of Publications of Senior Investigators;
- Main Investigator Acceptance of the Norms and Procedures of the Committee; and
- Declaration of conflicts of interest (if any).

3. OBJECTIVES AND RESEARCH QUESTIONS

This study is a population-based cross-sectional household survey. The main objective is to evaluate the coverage of iron-fortified wheat and maize flours and vitamin A-fortified sugar and vegetable oil in Mozambique, as well as the benefit reach across population groups. With the end of the EU-funded MDG1c initiative, the study expects to present, if necessary, recommendations in order to improve the reach of the fortified foods in terms of territory and population groups.

The following research questions were addressed:

1. To what extent is the Mozambican population covered by fortifiable and fortified wheat flour, maize flour, vegetable oil, and sugar?

2. What is the benefit incidence of the NFFP, meaning the reach of the programme across vulnerable groups in the following dimensions: socioeconomic situation, rural-urban place of residence, health and nutritional status?

3. To what extent does the food fortification in Mozambique contribute to the recommended nutrient intake (RNI) of micronutrients through their vehicle?

4. SAMPLING

The universe for the sampling is the set of all households living in all provinces of Mozambique, meaning that, in principle, all households in Mozambique had the same odds of participating in the research, as long as they met the requirement for inclusion in the survey (the presence of an adult of legal age who could act as a respondent and who would provide a written informed consent to participate).

4.1 The Master Sample

The sampling plan for the food fortification coverage study (See Appendix 1 for details of sample size calculation) was based on the master sample designed by INE (the National Institute of Statistics of Mozambique) in order to generate samples for the institution's household surveys. A brief explanation of the Master Sample, as well as the present project designs are presented below.

4.1.1 The sampling units in the Master Sample

The master sample has a stratified three-stage design, with sampling units as follows:

- Primary sampling units (PSU) are the Control Areas (CAs), which are sets of 3 to 5 contiguous enumeration areas (EAs).

- Secondary sampling units (SSU) are the EAs inside each PSU. Each EA is composed by a set of 120 to 150 households when located in an urban area, or 80 to 100 households when located in the rural area.

- Tertiary sampling units (TSU), represented by the households.

The master sample has 1,660 PSUs selected with probabilities proportional to size (PPS selection), of which 788 belong to the urban areas.

4.1.2 The stratification in the Master Sample

A stratification was performed in order to improve the master sample's efficiency. The procedure resulted in a set of 82 strata. The PSUs were selected independently in each stratum.

The first level of stratification corresponds to the 11 provinces, each divided into rural and urban areas (an exception is made to the province of "Maputo Cidade", composed of urban households only).

A second level of stratification was defined by a set of socioeconomic indicators taking into account average conditions of households inside each PSU. The indicators are:

- the composition of walls, roofs and floors;
- water source;
- sanitation condition;
- the existence of at least one person with a primary school education or more.

The PSUs were partitioned into 4 socioeconomic substrata, according to socioeconomic levels defined by the abovementioned indicators: i) low level, ii) medium-low level, iii) medium-high and iv) high level socioeconomic condition.

4.2 The project sampling

The strategy adopted for this project was the random selection of 100 PSUs from the master sample, 59 of them belonging to urban areas. This selection indirectly represents the stratifications of the master sample. The PSUs were selected with PPS in terms of the total number of households. Inside each PSU, one SSU was selected, also with PPS. In each of the SSUs, 15 households (TSU) were randomly selected.

A comparison of the rural/urban population composition between the census and our sample is shown in Table 4.1 and Table 4.2. The weighted sample population is the sample estimates expanded by the sampling weights, which are the inverse of the selection probability. It is noteworthy that, despite the fact that the number of rural EAs in the sample does not correspond to the distribution of the census data as shown in Table 4.1, the weighted estimates of proportion of rural population are quite close to the values observed in the census as in Table 4.2. The estimate is based on the total population in the selected EAs according to the 2007 Census Data.

Table 4.1

Number of Enumeration Areas (EA) and population by rural-urban residence. Mozambique, 2018

Area of residence	Number of EAs	Population	Population (%)
Urban	10,602	6,137,911	30.34
Rural	34,676	14,091,402	69.66

Source: INE Demographic Census (2007).

Table 4.2

Number of Enumeration Areas (EA) and unweighted and weighted population by rural-urban residence of the project sample. Mozambique, 2018

Area of residence	Number of Enumeration EAs	Unweighted		Weighted	
		Population	Population (%)	Population	Population (%)
Urban	59	42105	65.52	5621897	30.99
Rural	41	2216	34.48	12518422	69.01

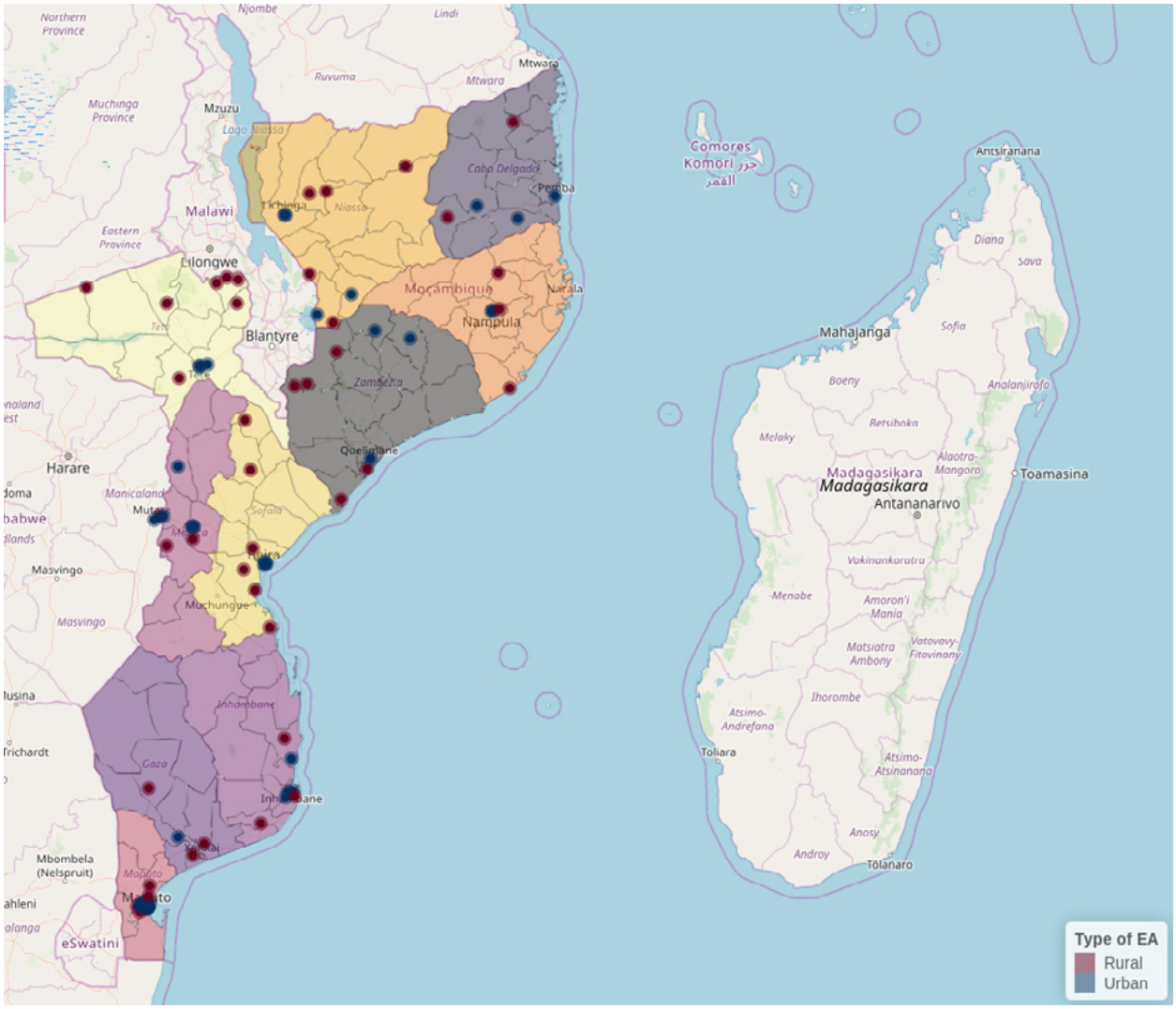
Source: Authors' elaboration.

In brief, the sample consists of 1,500 households drawn from the Master Sample in three stages: the first was the selection of 100 Control Areas (PSU), the second was the selection of one Enumeration Area (SSU) within each PSU and the third was the selection of 15 households (TSU) in each SSU.

Figure 4.1 shows the spatial distribution of the EAs in the Sample, which depicts the spread of the sample through the country. Appendix 1 provides a detailed description of the procedures to calculate the sample size and the sample weights.

Figure 4.1

Distribution of the Enumeration Areas in the sample



Source: Authors' elaboration.

5. DATA COLLECTION INSTRUMENTS

The following instruments have been used in the study:

- Geo-referencing system (GPS) to identify the households;

- Survey questionnaire (See Appendix 2 for the paper version of the questionnaire) to collect quantitative household data, covering the following:
    - Introductory questions regarding the family members' relation to the head of household, sex, age, civil status, religion, and language;
    - Questions regarding the family members' literacy and educational level;
    - Questions to women of reproductive age regarding infant mortality, pregnancy and breastfeeding habits;
    - Questions regarding the family members' self-rated health status and presence of symptoms related to vitamin A or iron deficiency;
    - Questions related to the socioeconomic characteristics of the household, including the geographical location, occupation/income sources, materials used for roofs, walls, and floors, number of bedrooms, electricity, drinking water source and treatment, sanitation facilities, durable goods, means of transportation, and access to road, market, and health centre;
    - Questions regarding the household's dietary diversity, consumption habits, and food security;
    - Questions related to the prevalence and consumption of the four foods in the household, including self-reported consumption of the foods, existence of the foods in the household at the moment of the interview, their storage conditions, origin (e.g. bought or produced by the family), brand, producer, and presence of fortification logo, as well as consumption patterns (quantity and frequency) of each food, familiarity with the fortification logo, and its influence on purchasing habits.
- Programmed tablets to record the data in the field;
- Smartphones equipped with the Geopaparazzi App to capture GPS coordinates;
- A recorded video with the purpose of food sample collection training: <https://bit.ly/2P2Sxmp>;
- Materials and tools to collect, handle, label, store, and ship the food samples: Hand sanitiser, disposable gloves, funnel, plastic spoons, large Styrofoam box, large Ziplock bag, small Ziplock bags (50gr capacity) with identification labels, transparent airtight bottle (50ml capability) with Identification label.

6. DATA COLLECTION

6.1 Survey

6.1.1 Training and data collection chronology

Intercampus organised three interviewer training sessions that took place in Maputo (for interviewers from Maputo Province, Maputo Cidade, Gaza and Inhambane), Chimoio (for interviewers from Manica, Tete and Zambézia) and Nampula (for interviewers from Nampula, Niassa and Cabo Delgado). Training in Maputo was held from 20–25 August 2018. Training in Chimoio and Nampula took place from 27–31 August 2018.

Figure 6.1

Training in Nampula, Chimoio and Maputo. Mozambique, 2018

On 25 August the field team conducted 22 pilot interviews in Maputo. In Chimoio, 17 pilots were conducted on 1 September and in Nampula, 18 pilot interviews were conducted on 4 September. During the pilot, interviewers were tested on their capability to find and define the respective enumeration area, using the digital map app, GPS capture, correct application of the questionnaire, synching of the completed interview, observation of the household's food storage, and correct food sample collection. Actual fieldwork started on 6 September and was concluded on 18 October 2018.

6.1.2 Data collection procedures

The data collection process was divided into the following phases:

- Upon arrival at an Enumeration Area (EA) the interviewer applied the Geopaparazzi App to define exactly the delimitation of each EA.
- He then presented himself to the community leader showing the bioethical authorisation and asked for a guide that would accompany him in the community.
- Together with the guide, he elaborated a numbered list of all households and names of the heads of households responsible inside the community.
- In each EA, 15 households were raffled, using systematic intervals. If, for example, an EA is constituted by 90 households, the systematic interval would be 6. The first interviewed household is also randomly raffled. So, if the first household would be number 5, then we would interview households number 5, 11,17,23,29, etc.
- In case of substitution (due to household refusal, household members travelling, etc.) the new household was raffled inside the preceding interval: if, for example, household 17 had to be substituted, then the new household was raffled between households 12 and 16.
- In all the selected households, the questionnaire in the Appendix 2 was applied.
- The average length of each interview was about 100 minutes. Before starting the interview, the respondents needed to sign a confirmed consent form.
- The data collection was done via computer-assisted personal interviewing (CAPI), using Android tablets. The questionnaire was scripted in the ASKIA data collection software.
- During the interview, the enumerators also observed the food storage inside the respective households.

- At the end of the interview, the enumerators collected, whenever available, the samples of the following foods: maize flour, wheat flour, vegetable oil, and sugar.

- As compensation, each household received one litre of vegetable oil.

Figure 6.2

Data collection in the field. Mozambique, 2018

Tables 6.1 to 6.4 present some basic information on numbers of: i) the sample distribution per province; ii) listed and selected households in the EAs; iii) visited households; and iv) outcomes for the interview and the ratio of interviews by interviewers. These represent a summary of the activities listed above.

Table 6.1

Number of EAs and completed interviews, by province. Mozambique, 2018

Province	Number of EAs	Completed interviews
Cabo Delgado	5	75
Gaza	4	60
Inhambane	7	105
Manica	9	135
Maputo Cidade	15	225
Maputo Província	18	270
Nampula	5	75
Niassa	9	135
Sofala	10	150
Tete	10	150
Zambezia	8	120
Total	**100**	**1,500**

Table 6.2

Number of listed households in the EAs, selected and replaced households. Mozambique, 2018

Households	Number
Listed households in EA	6,304
Selected households	1,500
Replaced households	24
Total selected households	**1,524**

Table 6.3

Visited households by outcome, completed interviews and replaced households. Mozambique, 2018

Condition of interview	Number
Completed interview	1,500
Replaced household: incomplete interview	2
Replaced household: responsible person absent	4
Replaced household: refusal	18
Total visited households	**1,524**

Table 6.4

Interviews and interviewers. Mozambique, 2018

Interviews by interviewers	Number
Total number of interviewers	35
Total number of interviews	1,500
Minimum number of interviews per interviewer	13
Average number of interviews per interviewer	43
Maximum number of interviews per interviewer	90

6.1.3 Quality control

In terms of quality control (QC), the QC team re-contacted a total of 781 households (52 per cent of the total sample), randomly chosen for a post-collection back-check of information.

QC was performed at two different levels:

- Face to face back-checks, where we revisited 121 interviewed households and applied a 10-minute-long questionnaire to compare to the previous selected data. The revisited households were randomly selected out of the respondents without a telephone number. They represent 8 per cent of the total sample.
- Telephonic back-checks, where we applied the same QC-questionnaire. As a norm, we randomly selected 20 per cent of each interviewer's work and concentrated more on interviewers whose data might have raised doubts (number of interviews per day, lengths of interview, data inconsistency). In this survey, we back-checked 660 interviews, representing 44 per cent of the total sample.

Out of those 781 back-checks, 766 interviews did not reveal any incoherence. In the remaining 15 interviews, there was no evidence of data collection fraud, but there was evidence of poor ethical behaviour, such as not delivering the consent form and/or the vegetable oil. All of these interviews were validated once the households had confirmed that the data was correct. The two concerned interviewers were removed from the study, and in the cases where vegetable oil had not been delivered as planned, the corresponding value was sent to the households.

6.2 Food sample collection

Simultaneously with the data collection, the enumerators collected, whenever available, and upon consent, 50gr of wheat flour, maize flour, sugar and 50ml of vegetable oil. In households where more than one source or brand of the same vehicle was used, the instruction was to collect samples of all of them, as well as to fill out the information of the respective brand in the questionnaire separately. As mentioned earlier, each household received as compensation one lt of vegetable oil.

6.2.1 Procedures

The procedures of food sample collection followed the instructions sent by the IPC-IG in a training video step-by-step:

- Prior to the fieldwork, the food sample recipients were labelled at the Intercampus office. The labels outlined the food type (in English and Portuguese), the enumeration area, the HS food code, and an empty space for the interviewer to fill in the household number during the visit.
- At the household, before collecting the samples, the interviewer asked for the respondent's permission to collect food samples.
- If such permission was given, the interviewer then observed the storage conditions of the food in the household (e.g. type of container and its location), as well as if the food sample was adequate to be collected (i.e. did not show signs of dirtiness or decomposition, as these aspects invalidate the sample).
- To avoid contamination, the interviewers washed their hands (whenever possible) and applied hand sanitiser. Some also opted for disposable gloves.
- Before collection, the food was homogenised (i.e. mixed) in the original recipient, using plastic spoons (or by shaking, in the case of oil). These spoons were then used to collect the respective dry sample and transfer them to Ziplock bags (bottle for oil).

- Lastly, the interviewer completed the identification label with the number of the household and placed the samples in the larger Ziplock bag and then in the protective Styrofoam box.

Figure 6.3

Food sample collection. Mozambique, 2018

6.2.2 The number of collected samples

Due to the difficult economic situation in most of the households, not all four vehicles were available at all times. Therefore, of 1,500 households, all four foods were collected in only 155 households and in 79 households none of the food categories were available. Thus, in 1,421 households at least one sample of food was collected, totalizing 3,209 samples, as shown in Table 6.5. There was a loss of 82 samples due to contamination and 3,127 samples were sent for analysis. Table 6.6 shows the number of samples collected and sent for analysis and the existence of the foods in the household at the moment of the interview by each type of food. Of the existing foods, 95 per cent were sampled and sent for analysis. The low number of wheat flour available at the household level calls for attention and might reflect a low level of consumption of this type of flour in the country.

Table 6.5

Number of households and samples collected by availability of food in the household. Mozambique, 2018

Number of available type of foods for collection	Number of households	Number of collected samples
4	155	620
3	423	1269
2	477	954
1	366	366
0	79	0
Total	**1,500**	**3,209**

Table 6.6

Number of households by existence of the food and samples collected, sent to laboratory and the type of food. Mozambique, 2018

Type of food	Food in the households (item number in the questionnaire)		Food Samples	
	Had at the moment of interview (FF2)	Had been shown (FF3)	Collected	Sent for analysis
Wheat flour	244	243	234	224
Maize flour	1,189	1,178	1,161	1,112
Sugar	826	821	800	788
Vegetable oil	1,037	1,032	1,014	1,003
Total	**3,296**	**3,274**	**3,209**	**3,127**

6.2.3 The shipment

In each province, Intercampus had one collaborator collecting the samples from the enumerators in the respective districts and sending them via DHL to the central office in Maputo, where inventory was taken and customs clearance was obtained, and international express shipment was then made to the laboratory BioAnalyt.

Figure 6.4

Shipping of food samples. Mozambique, 2018

7. LABORATORY ANALYSIS

7.1 Introduction

The IPC-IG collected samples of staple foods from households in Mozambique from September to November 2018. These samples were collected at the request of WFP in order to assess the national coverage of fortified foods and the levels of micronutrients in these foods. The samples of oil (50ml), sugar (50g), wheat and maize flour (50g) were sent to BioAnalyt for the measurement of vitamin A and iron levels. The samples were analysed for added or total micronutrient content using the iCheck technology.

7.2 Technology

iCheck is a test kit for the quantitative determination of micronutrients. It consists of two units, a portable photometer or fluorometer (iCheck) and the disposable reagent vials in which the reaction is performed. The method consists of 3 steps: injection of the diluted sample into the reagent vial, reaction of the analyte with the reagents in the vial and measurement of the vial in the photometer (Figure 7.1).

Figure 7.1

Step analysis procedure using iCheck technology

The validation protocol for each iCheck and matrix combines assessments of precision, trueness and a comparison to a reference method. iCheck and iCheck reagent vials are produced according to a quality management system (DIN EN ISO 9001:20015) certified by TÜV Nord in Germany.

7.3 Methodology

7.3.1 Analysis of vitamin A in edible oil

iCheck Chroma 3 was used for the determination of vitamin A in edible oil. The determination of vitamin A is based on a colour reaction in which the reagents in the vial turn a brilliant blue (Carr-Price reaction), the intensity of which is dependent on retinol concentration. The iCheck Chroma 3 device measures the absorption of the colour in the reagent vial at 3 different wavelengths, over the course of 30 seconds. The device then calculates the vitamin A content through a sophisticated algorithm and displays the result in mg retinol equivalents/kg of oil. The linear range of the device is 3–30mg retinol equivalents (RE)/kg of oil.

This method has been validated against the reference method of HPLC (1, 2). The uncertainty of the iCheck Chroma 3 measurement is 30 per cent, at a 95 per cent confidence level. This means that if the observed concentration of vitamin A in the sample is 10mg RE/kg, the true concentration of vitamin A in the oil sample is in the range of 10mg RE/kg ± 30 per cent.

All oil samples were shaken for 15 minutes to ensure that they were homogeneous. Solidified oil samples were warmed to 45°C in an incubator before being shaken. The liquid composite oil samples were directly injected into

the reagent vial and measured with iCheck Chroma 3 according to the user manual. Every 10th sample was analysed in duplicate to ensure repeatability was within the acceptable range. As a quality control, the emitter and receptor of the iCheck Chroma 3 device were controlled by using a standard density glass filter (Chroma 3 Standard) at the beginning of each set of measurements. Additionally, a standard oil sample spiked with a known concentration of retinol palmitate was run after every 10th measurements as a control.

7.3.2 Analysis of vitamin A in sugar

iCheck Fluoro was used for the measurement of vitamin A in sugar. iCheck Fluoro quantitatively determines the concentration of vitamin A in food based on the measurements of the auto-fluorescence of vitamin A (retinol). Results are displayed in the measuring device iCheck Fluoro in µg retinol equivalents/l. This method has been validated against the reference method of HPLC (4).

The uncertainty of the method is 13 per cent for sugar at a 95 per cent confidence level. This means that if the observed concentration of vitamin A in the sample is 2mg/kg, the true concentration of vitamin A in the sample is in the range of 2mg/kg ± 13 per cent.

Before weighing in, the sugar samples were mixed thoroughly to ensure homogeneity. Approximately 20g sugar samples were weighed in and the exact weight noted. The sample was then completely diluted with water to a final volume of 400ml (1:20 dilution) to ensure that the vitamin A concentration of the final solution was within the linear range of iCheck Fluoro (50–3000µg RE/L). The sugar solutions were injected and analysed according to the iCheck Fluoro user manual. Every 10th sample was analysed in duplicate to assess precision. As a quality control, a standard quinine sulfate (Fluoro Standard) was measured to control the iCheck Fluoro devices.

Please note that to calculate the vitamin A concentration in the sugar samples, the measured concentrations were adjusted with the dilution factor (DF).

7.3.3 Analysis of iron in wheat and maize flour

iCheck Iron is a single wavelength photometer that measures absorption of a solution at 525nm. The iCheck Iron reagents vials contain chemicals that react with iron present in food and turn red. The chemical composition is bathophenantrolin in organic solvent, reducing and chelating agents. The intensity of red colour correlates with the concentration of iron in the sample.

Different iron forms (i.e. ferrous sulfate, ferrous fumarate, NaFeEDTA, natural intrinsic iron in plant or animal samples) have different solubility in water. Therefore, for those with poor solubility (i.e. ferrous fumarate) it takes longer to solubilise and react with bathophenantrolin, and consequently it takes longer to fully develop the red colour. While for NaFeEDTA that is well soluble in water the reaction is faster. To facilitate solubilisation of iron, hydrochloric acid may be used during the dilution step instead of water.

When the reaction is complete, the vial is placed in the iCheck photometer, the absorption is measured at 525nm and the concentration is displayed in mg (Fe)/l.

The uncertainty for i.e. NaFeEDTA in flours is 24 per cent, at a 95 per cent confidence level. This means that if the observed concentration of iron in the sample is 45mg/kg, the true concentration of iron in the sample is in the range of 45mg/kg ± 24 per cent.

The wheat and maize flour samples were diluted 1:10 with 0.2M hydrochloric acid to ensure that the iron concentration of the final solution was within the linear range of iCheck Iron, 1.5–12.0mg Fe/L. Hydrochloric acid was used to ensure

added (ferrous fumarate and NaFeEDTA and intrinsic iron is well-solubilised for the reaction with the chemicals in the iCheck Iron vial.

The diluted flour sample was injected and analysed according to the iCheck Iron user manual. Every 10th sample was analysed in duplicate to assess precision. The injected samples were incubated in the vials for 1 hour, centrifuged and then measured with iCheck Iron.

A spiked wheat or maize flour sample was used to control the accuracy of the results by the analyst. The spiked flour was measured at the beginning of each set of measurements and every 20th measurement.

7.4 Results

All the measurement results were delivered to the customer in excel files. A data dictionary was also provided.

Table 7.1 shows the relative frequency distributions of vehicle sample results analysed by BioAnalyt. The lower-bound thresholds of 3 RE mg/kg for vitamin A in oil and of 15mg FE/kg for iron in maize and wheat flour are relative to the limitations of the applied techniques of analysis. Table 7.2 also presents some general descriptive statistics from the unweighted sample results collected from laboratory analysis. Figures 7.1 and 7.2 display these relative distributions graphically.

Table 7.1

Relative frequency distribution of unweighted sample results by vehicle

	Nutrient concentration distribution			Total samples
Sugar (vitamin A)	≤ 3 RE mg/kg 38%	3 RE mg/kg - 6 RE mg/kg 12%	> 6 RE mg/kg 51%	N=788
Vegetable oil (vitamin A)	≤ 3 RE mg/kg 44%	3 RE mg/kg – 17.4 RE mg/kg 48%	> 17.4 RE mg/kg 8%	N=1003
Maize flour (iron)	≤ 15 FE mg/kg 73%	15 FE mg/kg - 20 FE mg/kg 9%	> 20 FE mg/kg 18%	N=1112
Wheat flour (iron)	≤ 15 FE mg/kg 26%	15 FE mg/kg – 33 FE mg/kg 35%	> 33 FE mg/kg 39%	N=224

Table 7.2

Descriptive statistics from unweighted sample results by vehicle

Vehicle	Mean	Median	IQR (Interquartile range)
Wheat flour (iron – FE mg/kg)	31.5	26.5	25
Maize flour (iron – FE mg/kg)	18.3	15	0.7
Sugar (vitamin A – RE mg/kg)	10.4	6.4	14
Vegetable oil (vitamin A – RE mg/kg)	8.1	5.5	9.9

Figure 7.2

Relative frequency of unweighted sample distributions for iron concentrations results from wheat and maize flour

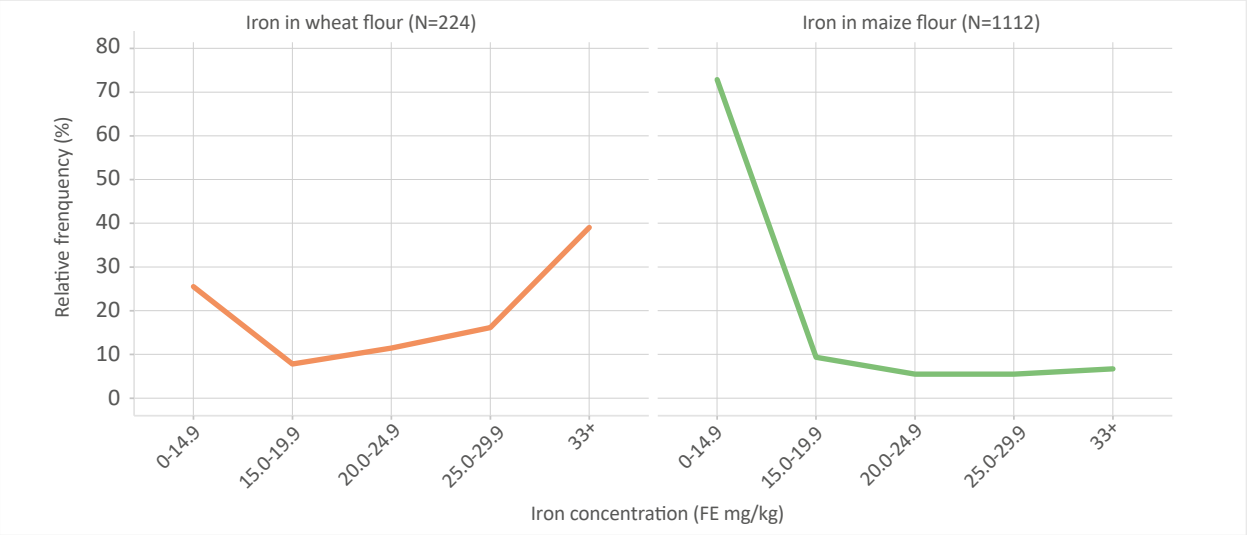
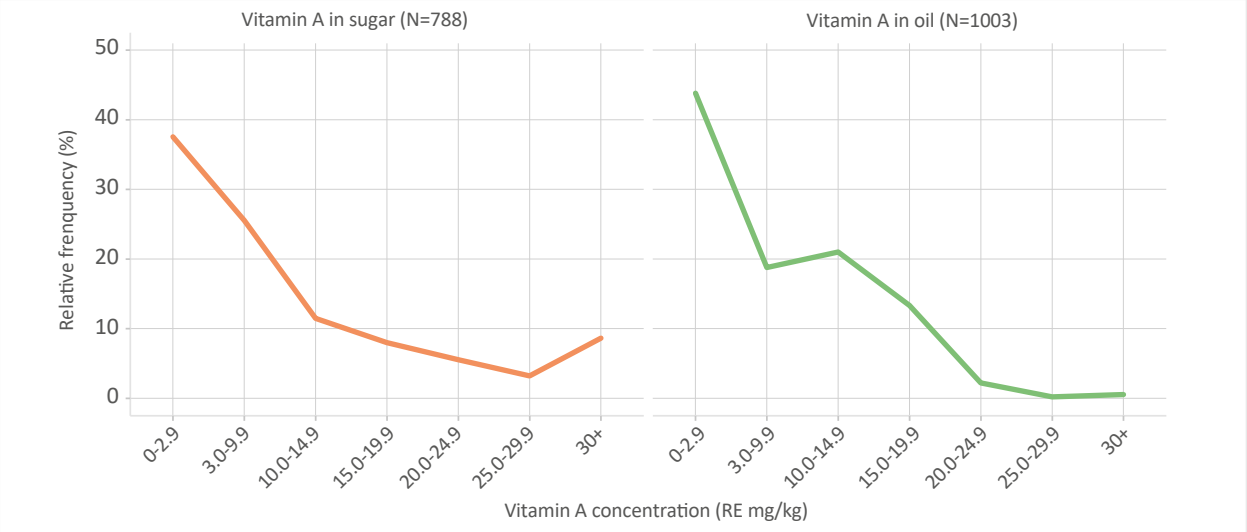


Figure 7.3

Relative frequency of unweighted sample distributions for vitamin A concentrations results from sugar and oil



8. SURVEY DATA ANALYSIS

The household survey data was analysed with the statistical software R and Stata, using models that incorporate complex sample design parameters: sample weights, clusters (control areas, enumeration areas and households) and their respective finite population corrections.

8.1 National Food Fortification Programme coverage

8.1.1 Concepts and definitions

Programme coverage is understood conceptually as the interaction between the programme output and the target population, throughout the entire process of its implementation (Tanahashi 1978).

Coverage assessment framework

In this study, coverages are defined as potential and actual coverage, in a four-stage model, following the five-stage Tanahashi (1978) framework to evaluate the health service coverage. The Fortification Assessment Coverage Toolkit (FACT) surveys inspired the framework and the measurement of coverage of this study, which made some adaptations to the definition of the stages. FACT was developed by the Global Alliance for Improved Nutrition (GAIN) and has been profusely employed in assessing the coverage of food fortification programmes (Aaron et al., 2017; NBS 2015).

Stages of the framework

Potential coverage refers to the households that consume vehicles independently of the fortification condition. The stages are defined according to households that consume:

Vehicles chosen for fortification, denominated here as **vehicles from any source**, it reflects the **availability coverage,** meaning the degree of consumption of the chosen vehicles by the households.

Vehicles chosen for fortification that are from **fortifiable** in large or median scale source. They refer to households that consume industrialised vehicles; it reflects the **accessibility coverage** to the vehicle. In terms of maize flour, both industrialised flours and home-grown grain that were ground at community mills are considered fortifiable vehicles.

Actual coverage refers to households that consume fortified vehicles. The stages are defined according to households that consume:

Fortified vehicles with nutrient concentration at any level This reflects the **contact coverage** of the households, meaning the contact they have with the output of the programme—that is, fortified vehicles in the market. Throughout the report the vehicles are denominated **fortified at any level.**

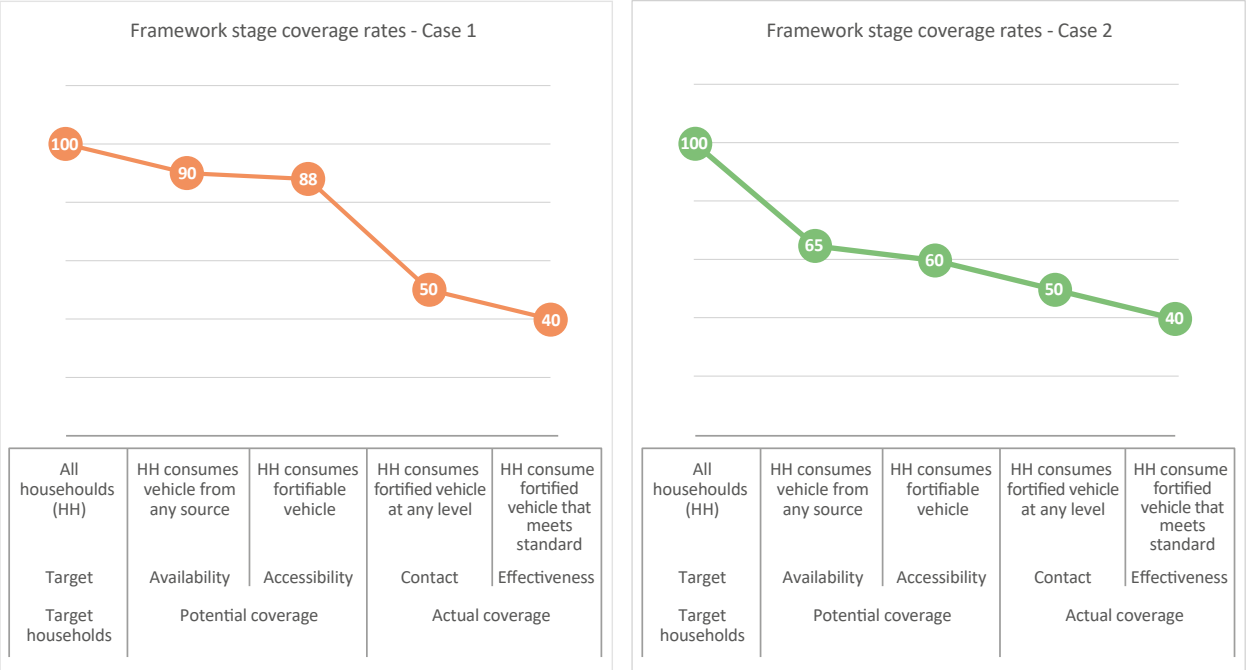
Fortified vehicles that meet the national standards of food fortification regarding the minimum concentration of micronutrients in the vehicles This reflects the **effectiveness coverage** of the NFFP, meaning consumption of the Programme's output—that is, fully fortified vehicles by the population. Throughout this report, the vehicles of this stage are considered **fortified**.

The coverage rate measurements used data from a specific household survey and the consumption rates are their proxies. The rates are defined as the number of households that consume vehicles that are specific of the stage out of the total households of the country. Specific coverage rates, in each stage—for subgroups such as rural/urban residence and vulnerability groups—consider the numerator and denominator of the specific groups.

The advantage of this framework is that, by measuring the coverage of the stages that represent progressively restrictive conditions of consumption, it allows for the identification of successes and bottlenecks of the programme's objectives. As illustrated in Figure 8.1, the set of coverage rates in Case 1 shows that the bottleneck is in the contact and effectiveness stages, possibly due to a lack of compliance by the producers of fortified vehicles, whereas those in Case 2 suggest that the vehicle does not constitute a product of regular consumption in the households. Despite the same effectiveness of the programmes, the actions to increase the coverage of fortified foods are quite different in each case. In the first case, activities of enforcement and/or monitoring and evaluation might be pursued, whereas in the second it might as well evaluate the rightness of vehicle's choice for fortification or consideration for other forms of consumption of the vehicles.

Figure 8.1

Hypothetical potential and actual coverages by stages of the framework and respective consumption indicators



8.1.2 Operationalisation

The domain of the NFFP in Mozambique so far has been the urban and peri-urban population, with plans to expand to the rural population. As a way of contributing to the expansion plan, this study included coverage in the rural areas. The stages are defined by the consumption of food from any source, of fortifiable, of vehicles fortified at any level and of fortified meeting national standards, herein simply called fortified. In the description below, the stages of the framework are better described, as well as the measurement that was used to assess the coverage. The (FF*xx*) represents the item of the questionnaire used to calculate the measurements of coverage. See Appendix 2 for the paper version of the questionnaire, which was transposed to a programmable tablet for application in field.

Potential coverage of the availability of the chosen vehicle or consumption of vehicle from any source

'Any source' refers to potential nutrient vehicles regardless of the source. The coverage rate represents the availability of these vehicles to the population or even the consumption habits of the population. Self-reported use of the food to prepare meals (FF1)—either "regularly" or "sometimes"—has been considered as a positive response. Measurement of coverage was calculated separately for urban and rural areas, as the number of households in each area that used the vehicle divided by the total number of households in the respective area, multiplying the result by 100.

Potential coverage of accessibility of the chosen vehicle or consumption of fortifiable vehicle

'Fortifiable vehicles' are those that are industrialised. Maize flour was considered fortifiable either if it was industrialised or ground in mills (FF4, FF5). This represents access to the vehicles that can be fortified in large or medium scale. Maize flour ground in mills is included, despite the urban and peri-urban domain of the NFFP, as a possible strategy of local supplementation in rural areas to contribute to the planned expansion of the target population.

Household consumption was positive if the reported source of the used food (FF4) had been purchased after being industrialised. Additionally, maize flour was also considered as a fortifiable vehicle if it was ground at a local mill (FF5).

Measurement of the coverage indicator by 100, for each area, had in the numerator the number of households that consumed fortifiable foods and the total number of households, in the denominator multiplied by 100.

Actual coverage of contact with the target household or consumption of fortified foods at any level

'Vehicles fortified at any level' represent the contact between the NFFP and the target population. The measurement of the coverage was based on the results of the nutrient concentration in the vehicle's sample collected at the household and measured at the laboratory. The food was considered fortified at any level if the concentration of vitamin A was 3mg/kg or higher and if the concentration of iron was 15mg/kg or higher.

The coverage rates are measured in a similar manner, except that the numerator is the number of households that consume fortified vehicles at any level. See Figure 8.2 for the path followed from the sample collection to the laboratory test, and the respective questionnaire item (FF*xx*).

The interviewer never asked directly if the household had consumed fortified foods, meaning that food samples were blind collected regarding the condition of fortification. Two situations had special treatments:

1. In the special case of households that had consumed more than one brand (FF3, FF14) of the vehicle or from different sources (FF3, FF4), the fortification level was calculated as the weighted average of the concentrations by the amount of the respective brand or source. Only 1 per cent of the sample sent for analysis was in this situation.

2. In cases where the vehicle sample was neither sent to the laboratory nor available at the household, if the brand of the purchased vehicle had been identified, the concentration was imputed using the median concentration value from laboratory analysis for the brand. A total of 3,127 samples were analysed by the laboratory and 869 cases were imputed.

Actual coverage of effectiveness of the programme or consumption of fortified vehicles

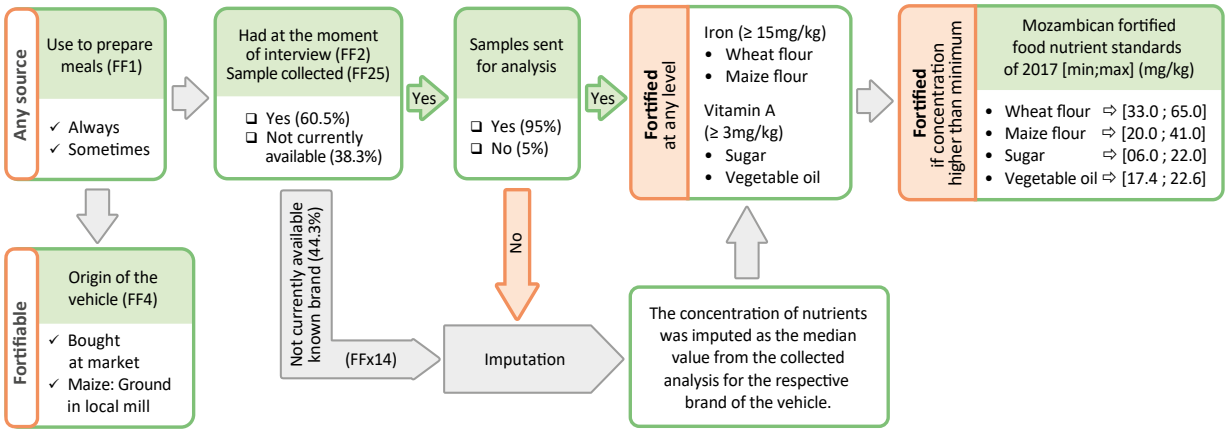
The assessment of (fully) fortified vehicles was performed by comparing the concentration values from the laboratory analysis with those in the 2017 addendum from the *Instituto Nacional de Normalização e Qualidade*—INNOQ (National Institute of Norms and Quality) to the 2016 Food Fortification Norm of Mozambique (Boletim da República, 2016; INNOQ, 2017). Vehicles were considered as fortified if they were in accordance with the fortification standards of 2017. The Mozambican standards for food fortification according to INNOQ (2017) are:

- Iron in wheat wlour: 33.0 to 65.0mg/kg.
- Iron in maize flour: 20.0 to 41.0mg/kg.
- Vitamin A in sugar: 06.0 to 22.0mg/kg.
- Vitamin A in vegetable oil: 17.4 to 22.6mg/kg.

Figure 8.2 shows the path followed to classify a vehicle as fortifiable and fortified. The (FF*x*) mark is the variable identification in the questionnaire.

Figure 8.2

Path diagram to assess fortifiable and fortified vehicles. Mozambique, 2018



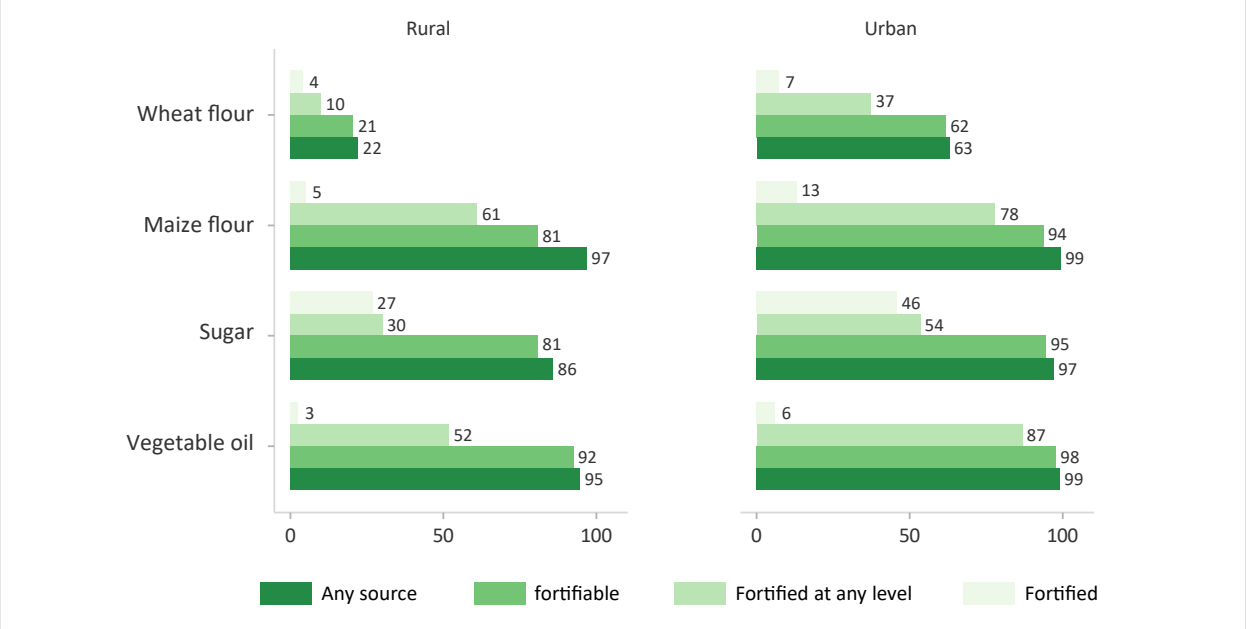
Note: (FFxx) refers to the questionnaire item.

8.1.3 Estimating coverage

The analysis of this section used the coverage estimates according to the explanation in the previous sections. Figure 8.3 depicts the coverage rates by indicators of the stages (type of vehicle consumed) by rural-urban placement of the household. Their respective confidence intervals at 95 per cent can be found in Table A4.1 in Appendix 4.

Figure 8.3

Coverage rate per 100 households by stage indicators (type of vehicle consumed) and rural-urban placement of the household. Mozambique, 2018



Note 1: The analysis of the wheat flour was based on samples taken in households. Derived food such as bread and pasta were not analysed.

Note 2: Consumption of vehicle of any source as indicator of availability coverage; of industrialised vehicles as of accessibility; of fortified vehicle at any rate as of contact and fortified as of effectiveness coverage

Source: Table A4.1 in Appendix 4.

Potential coverage or availability and accessibility of the programme by means of consumption indicators of vehicles from any source and of fortifiable vehicles

The high levels of potential coverage of vehicles from any source and of fortifiable vehicles are conspicuous in urban and rural areas, showing that the NFFP has chosen the right vehicles with high likelihood to benefit the population at large. The exception is wheat flour, which deserves methodological considerations, since the design of the survey considered the consumption of wheat flour using the same methodology as for other food vehicles. The Mozambican households do not often buy wheat flour itself, unless for baking cakes and biscuits (for special occasions such as holidays or for business). Instead, they usually consume wheat flour indirectly from bread or pasta, which were not elements of analysis. Hence, the assessment of wheat flour fortification requires a specific study analysing the most consumed derived products made from wheat flour in Mozambique.

Maize flour

In urban households, the potential coverage rate of maize flour from any source was 99 per cent and of fortifiable vehicles 94 per cent. The corresponding rates in rural areas were 97 and 81 per cent, respectively. The rate of locally-milled maize flour in the rural households was 59.2 per cent as opposed to 28.3 per cent in urban areas (not shown in Figure 8.3), meaning that locally-ground maize flour represents 73.3 per cent of the fortifiable vehicle. Incentives for the local millers to fortify ground maize is thus a promising avenue for the expansion of the programme, as mentioned in section 1.2.

Sugar

The potential coverage rates for sugar are 97 per cent and 95 per cent for urban areas and 86 per cent and 81 per cent for rural areas. The high and close coverage rates of the two sources that have been verified, in addition to indicating high availability and accessibility, might express low ingestion of alternatives for this vehicle, relying mostly on industrialised products.

Vegetable oil

The potential coverage rates for vegetable oil, as consumption of vehicle from any source and of fortifiable vehicle, are 99 per cent and 98 per cent respectively in urban households, and 95 per cent and 92 per cent in rural households. Vegetable oil had presented a coverage situation similar to the sugar consumption, exhibiting high and close coverage rates of the two sources.

Wheat flour

The figures show low consumption of wheat flour, especially in rural areas, and might tend to represent a situation of low access to the vehicle. The consumption rates for urban settlements were 63 per cent from any source and 62 per cent from fortifiable sources. For rural households, these rates were 22 per cent and 21 per cent, respectively. However, the methodological considerations discussed at the beginning of this section should be taken into account.

Actual coverage or contact and effectiveness of the programme regarding the target household reach, by means of consumption indicators of vehicles that are fortified at any level and those that are fully fortified

The contact coverage and the effectiveness of the programme represent the capacity of the programme to reach the targeted household. Because many households might have consumed lower concentrations of micronutrients than recommended by official standards, the actual coverage indicates how far or close the programme is to the target households. The effectiveness of the programme will show not only its reach but also the level of compliance to the national standards of the producers in the process of food fortification and distribution.

Maize flour

In urban households, the contact coverage rate of maize flour fortified at any level was 78 per cent and of the effectiveness rate was 13 per cent, which compared to the rate of accessibility of fortifiable flour (94 per cent) indicate that the major bottleneck of the programme is reaching the households with fully fortified food, although there is room to improve the contact coverage.

In the rural area, the respective coverage rates of contact and effectiveness are 61 per cent and 5 per cent, which compared to the 81 per cent of the accessibility rate, show that a considerable work must be done on the first coverage and clearly the bottleneck of the programme is in its effectiveness. It is worth noting, however that the contact coverage is the highest in the rural area if compared to the coverage of other vehicles.

The contribution to the effectiveness of locally-milled maize flour fortified with Premix was of 0.5, which is lower than the respective rate of 1.3 per cent in the urban area (not shown in Figure 8.3).

Sugar

The contact and effectiveness coverage rates for sugar in urban region are of 54 per cent and 45 per cent, which compared to the accessibility coverage of 95 per cent, show the need to improve the contact and effectiveness of the programme. However, considering the values of the coverage that are quite close, one way to interpret these figures is that the bottleneck is in the distribution of the fortified sugar rather than the fortification at the standard levels of vitamin A.

In rural areas, the contact and effectiveness coverage rates are 30 per cent and 27 per cent, which compared to the 81 per cent of the accessibility rate, show the need for more intense action in the distribution and the renewal of sugar stocks in the market.

Vegetable oil

In urban areas, the contact coverage from vegetable oil fortified at any level and the effectiveness coverage from food fortified according to Mozambican Standards are 87 per cent and 6 per cent; the accessibility coverage from industrialised oil is 98 per cent. This is a clear case for action to increase the level of fortification of the vehicle. The contact coverage of the oil was the highest among the four vehicles.

In rural areas, the contact and effectiveness rate are, respectively, 52 per cent and 3 per cent, whereas the accessibility rate was 92 per cent. This is a case to consider improving the distribution as well as the level of fortification with vitamin A.

Wheat flour

The figures show low rates of contact and effectiveness, depicting low flour consumption rates among the population. In urban areas, the respective rates were 37 per cent and 7 per cent, and the accessibility rate was of 62 per cent. In rural areas, these rates were 10 per cent and 4 per cent, with accessibility of 21 per cent. The low rates of coverage of wheat flour consumed in households indicate the need of a specific coverage study through consumption of derived products, especially bread.

8.2. Does the domestic storage of food influence the effectiveness coverage?

Among other factors that can influence the coverage is how the vehicle is stored at home. The ideal conditions of storage that protect the vehicle against light, humidity and the external environment are key factors to preserve the factory concentration of the nutrient. Table 8.1 verifies the storage conditions of vehicles that were fortified at any

level and compares the proportion of those that had been fortified according to Mozambican standards. This comparison was carried out with the hypothesis that most of the cases with vehicles classified as non-fortified according to Mozambican standards could have been caused by poor storage conditions, degrading the concentration of micronutrients.

For that purpose, the Table 8.1 shows the proportion of fully fortified samples out of those fortified at any level by condition of storage of vehicles and by threshold of concentration of the vehicle, which classifies as fortified all those samples that had concentration equal or superior to this threshold.

Table 8.1

Percent distribution of vehicles fortified at any level of wheat and maize flour (3mg/kg or above of vitamin A) and sugar and vegetable oil (15mg/kg or above of Iron), by classification as fortified according to the Mozambican threshold and house storage condition. Mozambique, 2018

Storage condition of the vehicle in the household	Wheat flour		Maize flour		Sugar		Vegetable oil	
	Fortification threshold 33.0mg/kg		Fortification threshold 20.0mg/kg		Fortification threshold 6.0mg/kg		Fortification threshold 17.4mg/kg	
	Fortified		Fortified		Fortified		Fortified	
	No	Yes	No	Yes	No	Yes	No	Yes
Light protected								
Yes	75%	63%	51%	74%	44%	55%	48%	45%
No	26%	37%	52%	30%	56%	45%	52%	55%
Original package								
Yes	65%	66%	26%	60%	55%	56%	64%	75%
No	36%	34%	78%	45%	45%	44%	37%	25%
Material of package								
Paper/cardboard	56%	43%	14%	43%	0%	1%	0%	1%
Plastic	39%	54%	75%	53%	89%	89%	89%	93%
Glass	1%	0%	1%	1%	6%	5%	10%	6%
Metal	2%	1%	5%	4%	4%	2%	0%	0%
Opacity of the package								
Yes	84%	79%	67%	92%	40%	34%	22%	23%
No	17%	21%	37%	13%	60%	66%	78%	77%
Closure of the package								
Airtight	67%	71%	56%	71%	62%	60%	82%	83%
Not sealed	34%	29%	48%	34%	38%	40%	19%	17%
Total samples	173		881		465		847	

Wheat flour: most of the samples that were fortified at any level in the households were stored with good protective conditions against light, humidity and exposure to external environment (above 60 per cent). There was no noticeable difference in these conditions between fortified and non-fortified classification, with difference of 15 per cent or less.

Maize flour: samples of maize flour stored in protective conditions against light, humidity and exposure to external environment, except for the material of the container, had higher classification as fortified than the non-fortified samples. The differences between the two groups were of 20 per cent or more.

Sugar: both fortified and non-fortified sugar had high protection against humidity (89 per cent) and air (around 60 per cent). With regards to protection against light, 44 per cent to 55 per cent had proper storage, and only around 40 per cent were stored in opaque packaging. There was no noticeable difference between the fortified and non-fortified groups.

Vegetable oil: as oil is usually sold and kept in plastic bottles, it did not have proper protection against light, the figures for adequate opacity of the container were 22 per cent and 23 per cent for non-fortified and fortified, respectively and 46 per cent and 45 per cent for light-protected place of storage. They were well protected against air exposure in both groups; about 82 per cent and 83 per cent were conditioned in airtight containers and 64 per cent and 75 per cent were kept in their original package.

Very high rates of good storage conditions were rare. Moreover, the results show that there is no striking difference in the storage conditions of the vehicles among those non-fortified and fortified; in some cases, the non-fortified vehicles were properly stored in a higher share of households. The exception was maize flour, which had a higher proportion of good storage conditions among vehicles classified as fortified, compared to non-fortified vehicles.

These indicators tend to exclude the possibility of the consequences that poor storage conditions of the vehicle may have on the classification as a non-fortified (i.e. poor storage conditions may lower nutrient levels). Also, a large-scale mass communication campaign about how to properly store (fortified) foods could be a good idea.

8.3 Population covered and the goals of the National Food Fortification Programme for 2018

The unit of analysis has, so far, been the household. In order to estimate the coverage among the population by October 2018 (when the survey was conducted), the individual data set was expanded by the estimation model, which uses the finite population calibrated weights. These weights used the Demographic Census Population of 28,861,863 inhabitants. The results are shown in Table 8.2, which presents the number of people that had consumed the fortifiable vehicle (according to the two Mozambican standards—Mozambican Norm of 2016 and updated INNOQ standards 2017), as well as those who had consumed foods that had been fortified at any level.

Table 8.2

Population covered by the NFFP, by type of vehicle and rural-urban placement of the household, by condition of fortification. Mozambique, 2018

		Condition of fortification			
Placement of household	**Vehicle**	**Fortifiable**	**Access to any level fortified**	**Fortified** (*Boletim da República*, 2016)	**Fortified** (INNOQ, 2017)
Urban	Wheat flour	5.969.697	3.634.005	1.437.499	680.773
	Maize flour	8.586.949	7.261.226	1.289.423	1.289.423
	Sugar	8.714.209	5.010.829	1.071.687	4.384.514
	Vegetable oil	8.989.052	7.993.389	3.106.576	527.335
Rural	Wheat flour	4.531.535	1.982.152	1.424.760	766.185
	Maize flour	15.934.270	12.175.468	1.037.562	1.037.562
	Sugar	16.182.537	6.295.151	999.563	5.663.408
	Vegetable oil	18.424.826	10.494.766	4.711.697	528.628
Total	Wheat flour	10.501.232	5.616.157	2.862.259	1.446.958
	Maize flour	24.521.219	19.436.694	2.326.985	2.326.985
	Sugar	24.896.746	11.305.980	2.071.250	10.047.922
	Vegetable oil	27.413.878	18.488.155	7.818.273	1.055.963

Source: Table A4.2 in Appendix 4.

The main objective is to compare data of the population covered by the NFFP according to consumption of fortified foods with the expected outcomes of the WFP interventions on the NFFP, which stated that by 2018 (Section 1.3):

- 11.9 million people shall have access to fortified wheat flour;
- 1.8 million people shall have access to fortified maize flour;
- 13 million people shall have access to fortified sugar;
- 11.5 million people shall have access to fortified vegetable oil.

The "Total" block in the column "Placement of the household" of Table 8.2 is the total population covered by the NFFP for each vehicle. The number of people who consume the vehicles that are fortifiable is quite close to the total population (28,861,863), whereas those who consume fortified foods according to the Mozambican standards, with exception of sugar, are far from WFP's objectives.

However, if we the population's access to or their contact with fortified foods, in spite of lower concentration levels (15mg/kg or more of iron for wheat and maize flour, and 3mg/kg or more of vitamin A for Sugar and vegetable oil), the picture changes. Comparing the actual number of people who had consumed fortified foods and the number of people expected by the programme: wheat flour is halfway; maize flour has surpassed the goal by about 17 million, sugar is about 2 million short and vegetable oil has surpassed the goal by about 5 million people. These results show that the contact with any level fortified food, with the exception of wheat flour, has either surpassed the goals or is close to attaining them.

8.4 Coverage estimation of vulnerable groups or the benefit incidence of the NFFP

The benefit incidence of the NFFP was estimated from the point of view that the coverage should reach regions and segments of the population targeted by the programme or beyond that. It also attempts to show how vulnerable population groups with low capability to acquire and consume fortified foods are reached. In that context, the estimation relied on calculating the programme's coverage among different population groups classified by their degree of vulnerability in order to show the groups that are benefiting from the programme.

8.4.1 Classification of vulnerable households

The concept of vulnerability in this study relies on the basic assumption that the segments of the population that might benefit from the NFFP are associated with the: 1) **capability** of people to acquire, adequately handle and consume nutrient vehicles; and 2) **hindrances** to the adequate intake of micronutrients by requiring higher consumption or jeopardising the absorption of the micronutrients.

The adopted concept implies a multidimensional approach of analysis that would group the study population in clusters of characteristics associated with different degrees of vulnerability. The fuzzy model known as Grade of Membership (GoM)[4] was selected as the model that would respond to the analytical needs. In a simplified way, the method estimates the characteristics of extreme profiles and the distance of each household to these profiles (see Appendix 3 for a detailed description of the method).

4. The literature on the theory and its technical application is vast. See for instance: Manton, K. G. et al. (1994). Guedes, G. R. et al. (2016); Cardoso, L.O. et al. (2011) and; Sawyer, D.O. et al. (2002).

The variables of **capability** take into account proxies of living conditions using housing infrastructure, urban-rural placement of the household, assets in the house, and education, similar to those recommended by Alkire and Santos (2014) in the multidimensional poverty index. The list of variables and the classification as adequate/inadequate to a good capability condition are:

1. Electricity: Variable used to evaluate as adequate if the household has electricity.

2. Access to safe water: Variable used to evaluate as adequate if the household's water supply is provided from a plumbing system, from a mineral water source, public source or from protected water wells with hand pumps.

3. Improved sanitation: Variable used to evaluate as adequate if the household is provided with an adequate sanitation system such as a toilet, with or without flush device.

4. Flooring condition: Variable used to evaluate the flooring conditions of the household, considered inadequate if the household floor is made of adobe, clay or of no material at all.

5. Living environment or placement of the household as the Urban/Rural classification.

6. Household assets: Variable used to evaluate the household consumption capability, considered adequate if the household has at least 5 assets from the following list: chair, couch, bed, radio, television, computer, telephone, cell phone, fridge, microwave/oven, washing machine, energy generator, solar panel, tractor, cart, bicycle, car or truck, boat, or terrain.

7. Children's education: Variable used to evaluate as inadequate if any children from the household were out of school or absent over the last month prior to the interview to supply care for household members or to work to provide financial help to the household.

8. Household head's education: Variable used to evaluate as adequate if any adult from the household had at least five years of schooling.

9. Access to health services and facilities: Considered inadequate if the household member reported requiring more than 1 hour to reach any health service and facility.

All the categories that are classified as inadequate have a **low** contribution to the capability, and conversely those that are classified as adequate have a **high** contribution.

Variables indicative of **hindrance** are those that might interfere with the adequate absorption of nutrients due to infectious disease, low consumption of food, low diversity of food, lacking synergies in the absorption of nutrients, and conditions that might require higher intake of nutrients. The list of variables and the classification as high/medium/low contribution to hindrance are:

1. Prevalence of infectious disease symptoms: considered **high** if any household member reported experiencing, simultaneously, fever and muscle pain over the last 30 days.

2. Pregnant or lactating women: Variable considered **high** if the household had any women of reproductive age who were pregnant or lactating.

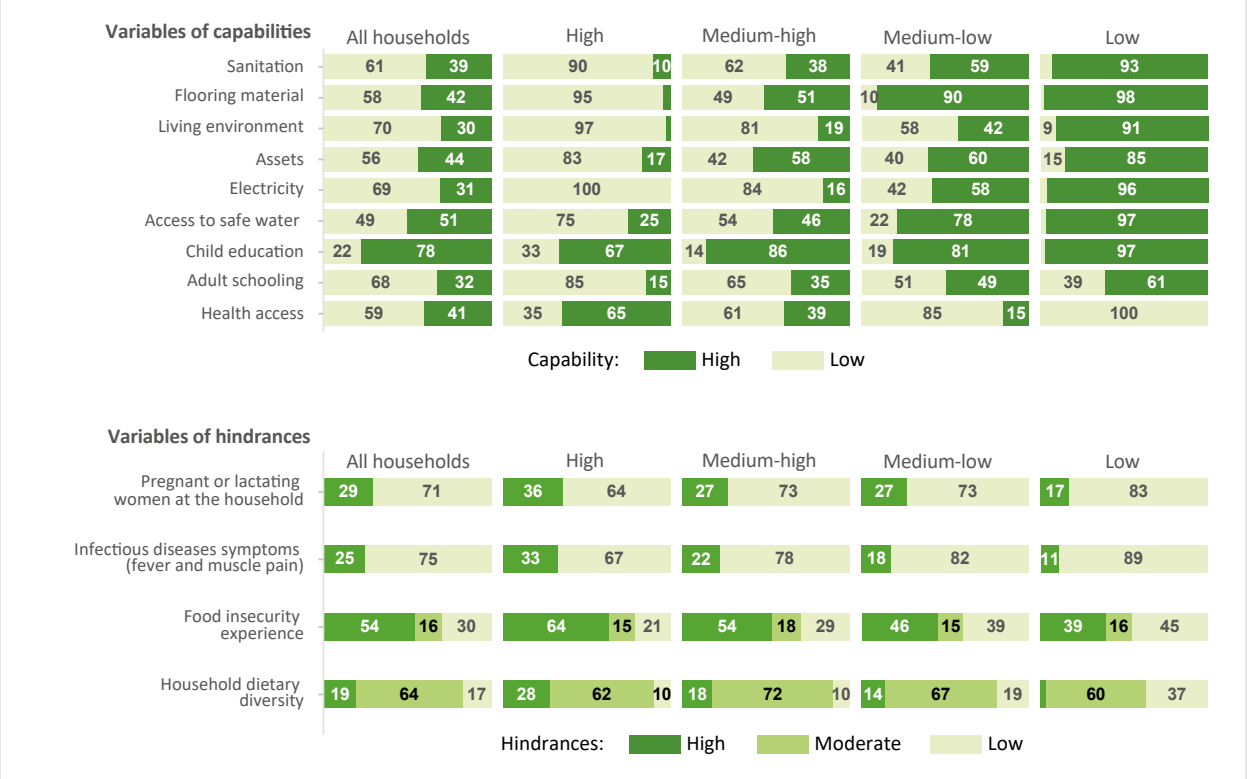
3. Food insecurity: Variable considered in three levels of the Food Insecurity Experience Scale (FIES) (Ballard, Kepple, and Cafiero, 2013) applied in the questionnaire—severe, moderate or mild, or no experience of food insecurity at all, classified respectively as **high, medium and low**.

4. Household dietary diversity: Variable considered in three levels of the Household Dietary Diversity Score (HDDS, 0-12) (FAO 2011): Low dietary diversity (HDDS < 6), average dietary diversity (5 < HDDS < 10) and high dietary diversity (HDDS > 9). Classification of contribution to hindrance was, respectively, **high, medium and low**.

The application of GoM (that supports a large number of variables relative to a small number of cases) identified four categories of vulnerability level: high, medium-high, medium-low and low. This categorisation was possible by means of quartiles of the distance of each household to the extreme profiles of high and low vulnerability (see Appendix 3).

Figure 8.4

Percentage categories of the variables indicative of capability to acquire fortified foods and variables indicative of hindrances to the absorption of nutrients by level of vulnerability. Mozambique, 2018



Source: Table A3.3 in Appendix 3.

Figure 8.4 presents the percent distribution of the characteristics of the households along the variables in the model by level of vulnerability defined by the same variables as in the GoM. It allows for the identification of a set of categories or characteristics that define the profiles of the groups classified by the level of vulnerability.

The **high vulnerability** population has a concentration of highly unfavourable characteristics in all the variables representing capability, not differing in most of the variables of hindrance in spite of the tendency to have a higher proportion of households with the presence of pregnant or lactating women, with symptoms of infectious diseases, with severe food security and low dietary diversity. This group can be identified as the **rural population with low capability to acquire fortified foods and high hindrances** and represents 28 per cent of the households.

The characteristics of the **medium-high vulnerability** population did not differ from the total population, neither in capacities nor hindrances. As per this methodology, it is possible to infer that the population of Mozambique in general has characteristics similar to the medium-high level of vulnerability. This group can be identified as the **rural population with medium capability to acquire fortified foods and high hindrances**. It represents 13 per cent of the households.

The most evident feature of the **medium-low vulnerability** population is the equal distribution between rural and urban placement of the households. It has a higher proportion of favourable conditions of capability and has easier access to health services. This group can be identified as the **peri-urban population with moderate to high capability to acquire fortified foods and high hindrances** and represents 12 per cent of the households.

The population with **low vulnerability** has a concentration of highly favourable characteristics in all variables representing capability and low hindrances. The capability variables are higher than the medium-low vulnerability group and can be identified as the **urban population with high capability to acquire fortified foods and low hindrances to the absorption of nutrients**. It represents 47 per cent of the households.

It must be stated that these four categories illustrate a continuous and gradual level of vulnerabilities between the two extreme profiles (high and low vulnerability). Hence, it does not exclude the possibility of existing households with high capability levels in rural areas or urban households with low capability and high hindrances. That said, belonging to a category does not mean that the household cannot share characteristics of another group of vulnerability. This is the basic principle of GoM models.

8.4.2 Estimates of the NFFP's coverage and benefit incidences among the vulnerable groups

The coverage rates among the vulnerable groups might indicate how the NFFP is reaching those households that present lower capabilities to acquire vehicles and the characteristics of hindrance to the absorption of nutrients, extending to rural areas, which currently are not the domain of the programme.

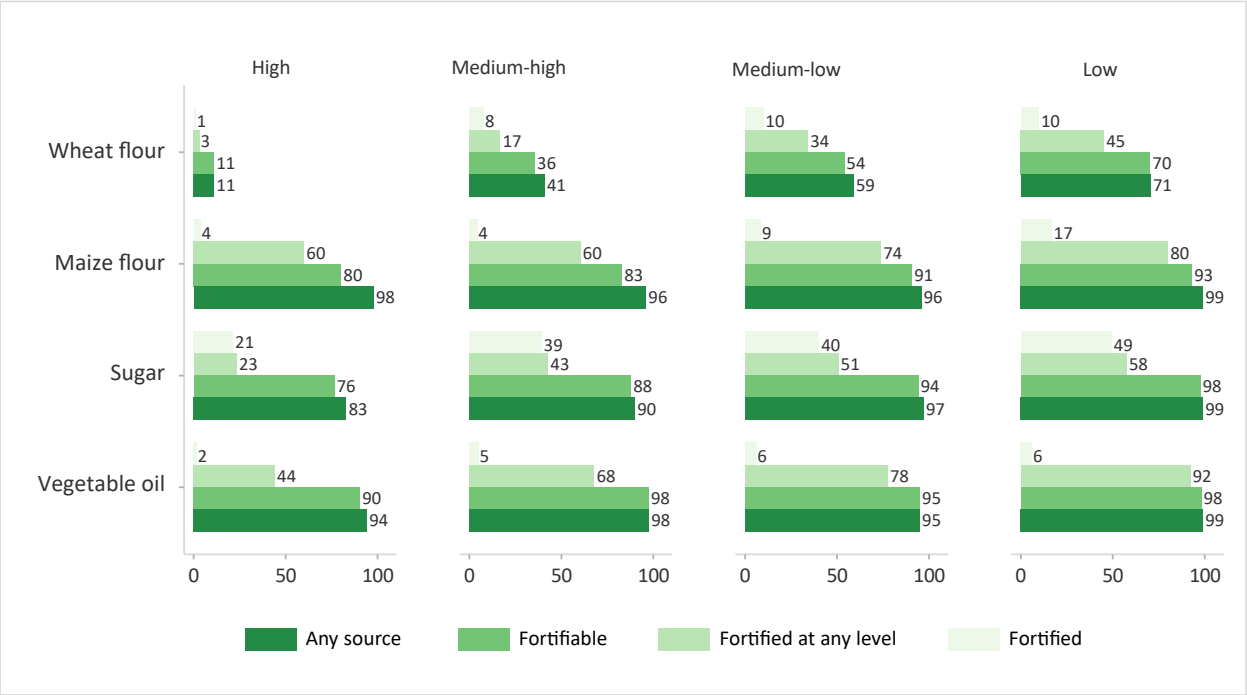
Figure 8.5 shows these coverage rates between different vulnerable groups. One should keep in mind that that the results should be analysed over a continuum of vulnerability. In the study, four points of the continuum are presented: high vulnerability refers to rural households with low capability and high hindrance; medium-high refers to rural households with medium capabilities and high hindrance; medium-low refers to peri-urban population with medium capabilities and high hindrance, and low refers to the urban households with high capabilities and low hindrance.

As an overall pattern of the relation between stages of the coverage, the figures in each level of vulnerability closely resemble those shown in Figure. 8.3: high level coverages of availability (consumption of food from any source) and accessibility (consumption of fortifiable foods) for all vehicles that are very close to each other, except maize flour for the two higher levels of vulnerability, which have lower coverage of fortifiable flour, possibly due to a higher rate of locally-milled flour in high and medium-high vulnerable groups. There is a relatively high contact coverage of vehicles fortified at any level of maize flour and vegetable oil, contrary to sugar and wheat flour. Low rates of effectiveness coverage are observed for fortified vegetable oil, maize and wheat flours. Sugar has effectiveness very close to the contact coverage.

The overall pattern prevails at all levels of vulnerability and there is an oscillating decrease in the coverages from low to high levels of vulnerability, mostly seen for the contact and effectiveness stages. The vegetable oil contact coverage of fortified at any level oil decreases from 92 per cent to 44 per cent throughout the groups from low to high vulnerability, the sugar from 58 per cent to 23 per cent, the maize flour from 80 per cent to 60 per cent. The coverage of maize flour was the highest among vehicles in all groups of vulnerability. Effective coverage rates are low for all levels of vulnerability, with a considerable decrease when compared to contact coverage. The exception is the case of sugar, which consistently had rates very close to each other. This vehicle had the highest coverage rate of effectiveness, despite low contact coverage.

Figure 8.5

Coverage rate per 100 households by stage indicators (type of vehicle consumed), rural-urban placement of the household and vulnerable groups. Mozambique, 2018



Note 1: The analysis of wheat flour was based on samples taken in households. Derived food such as bread and pasta were not analysed.

Note 2: Consumption of vehicles of any source as indicator of availability coverage; of industrialised vehicles (plus locally milled maize flour) as of accessibility; of fortified vehicles at any rate as of contact and fortified as of effectiveness.

Note 3: High vulnerability refers to rural households with low capability and high hindrance; medium-high refers to rural households with medium capabilities and high hindrance; medium-low refers to peri-urban population with medium capabilities and high hindrance, and low refers to the urban households with high capabilities and low hindrance.

Source: Table A4.3 in Appendix 4.

The same considerations about increasing effectiveness that were pointed out previously in section 8.1.3, when analysing the coverages for the aggregate of households, apply here. Special efforts in making the right fortified foods available to households at all levels of vulnerability, through enforcement, local and strategic distribution might be relevant.

The reach of fortified vehicles among poor rural households is notable, even though it is not an explicitly targeted population group. Considering that the high and medium vulnerability households are from rural areas, their low rate of coverage should not be overlooked. The national mandatory fortification programme combined with the high rate of consumption of fortifiable vehicles is an indication of the possibility of extending the benefits to the most vulnerable groups, especially in rural areas.

8.5 The contribution of the NFFP to households' recommended nutrients intake

The household nutrients contribution to the RNI (FAO/WHO, 1998) was estimated by the ratio between the **actual** daily nutrient intakes of the household and the **expected** nutrient intake of the household if its members had consumed the RNI.

The **actual** daily intake of the nutrients has been calculated by multiplying the concentration of micronutrients determined in the laboratory analysis by the household daily amount of the consumed vehicle (items FFth7, FF8, FF9, FF10, FF11, FF12, FF13 of the questionnaire).

As for the **expected** daily intake, since the questionnaire focused on the household level of vehicle intake and not on individuals, the RNI must be converted into a household measure to assess the supply of nutrients from each source for the household. In this sense, FAO/WHO (1998) offers a daily RNI scale of groups by age, sex and some specific characteristics (post-menopausal, breast-feeding) at the individual level. Tables 8.3 and 8.4 show the standard specific RNI by age and sex, which were used to calculate the household **expected** RNI.

Table 8.3

Recommended nutrient intakes (RNIs) for iron (at 12 per cent bioavailability) (mg/day) by groups of sex, age and special conditions

Age group	**RNI** (mg/day)	
	Male	**Female**
0-1	7.7	7.7
1-3	4.8	4.8
4-6	5.3	5.3
7-10	7.4	7.4
11-14	12.2	11.7
15-17	15.7	25.8
18+	11.4	24.5
Lactating	-	12.5
Postmenopausal*	-	9.4

Note: Women aged over 55 years old were considered in the postmenopausal group.

Source: FAO/WHO (1998).

Table 8.4

The recommended nutrient intakes (RNIs) for vitamin A (mean requirement) (mg/day)

Age group	**RNI** (mg/day)	
	Male	**Female**
0-1	0.18	0.18
1-6	0.20	0.20
7-9	0.25	0.25
10-18	0.36	0.36
19-64	0.30	0.27
65+	0.30	0.30
Lactating	-	0.45
Pregnant	-	0.37

Source: FAO/WHO (1998).

The **expected** intake by household members is the expected level of intake if members had consumed the RNI, by multiplying the RNI group information with the corresponding number of people of household in the group and adding them up.[5] Some households had extreme and implausible values for daily consumption of each vehicle. These outliers were excluded from the computing of RNI household coverage if they had values of daily consumption higher than

5. The amount of consumed vegetable oil, in particular, was computed in liters by the survey and had to be converted to its respective kilogram value since its vitamin A concentration from laboratory analysis is measured in milligrams per kilogram. This conversion was performed by applying an average density value for vegetable oil, based on a mean value for a selected group of oils assessed by Noureddini et al (1992).

a threshold established by the third quartile amongst the outliers. Therefore, households with daily consumptions of vehicles higher than 1.7kg for sugar, 6kg for maize flour, 1L for vegetable oil and 3.25kg for wheat flour were excluded from the calculations.

The actual household intake of nutrients divided by the expected household intake of RNI is the indicator expressing the percentage of household intake out of the expected RNI of the household and is considered as the contribution of the NFFP to the household RNI. The analyses focused on the percentage of the households in Mozambique with at least 50 per cent of the RNI, as seen in Tables 8.5 and 8.6.

Table 8.5

Proportions of households with at least 50 per cent of the daily RNI for vitamin A and iron, by placement of household. Mozambique, 2018

Placement of household	Households with nutrient intake values greater than 50% of RNI (%)	
	Vitamin A	Iron
Urban	45.00	23.92
Rural	25.43	20.36

Table 8.6

Proportions of households with at least 50 per cent of the daily RNI for vitamin A and iron, by vulnerability profile. Mozambique, 2018

Vulnerability profile	Households with nutrient intake values greater than 50% of RNI (%)	
	Vitamin A	Iron
High	23.71	18.16
Medium-high	34.93	21.64
Medium-low	32.56	28.91
Low	44.77	25.35

The results presented highlight the relevance of the four analysed vehicles to the supply of the daily recommended values of nutrient intake. As expected from previous results of fortification coverage, urban settlements represent the largest share of households that reach at least 50 per cent of the RNI values for each nutrient from the investigated vehicles. About 45 per cent of urban households reach at least 50 per cent of the RNI of vitamin A from consumption of vegetable oil or sugar and 23.92 per cent reach this threshold (50 per cent) of RNI of iron from wheat or maize flour. Rural settlements presented proportions of 25.43 per cent and of 20.36 per cent, respectively. A similar result was observed for vulnerability profiles. The share of households that reach half of the RNI for low vulnerable groups is about twice the share for the highly vulnerable groups regarding the intake of both vitamin A and iron. This result also marks an important disparity among groups, since the lower vulnerability profile represents groups with better indexes for household dietary diversity and food insecurity scale.

Comparing the results and discussions of Section 8, the consumption of sugar, vegetable oil, wheat flour and maize flour are of extreme importance for the daily intake of vitamin A and iron of all social groups. However, the groups that are better off in terms of access to fortified sources of vehicles also display better nutrient intake results.

8.6 Methodological limitations

The present study has some limitations that must be stated:

- The coverages that were based on consumption declared by the household do not represent the real intake of family members, as they might consume food outside the house or from derived products that were not assessed.
- The coverage was analysed in terms of household consumption. It probably does not express the real consumption of individual members, who might have different degrees of consumption.
- There was a short time span between the establishment of food fortification enforcement (December 2017) and the present assessment of coverage.
- The low coverage of wheat flour reflects the study design, which does not allow for the measurement of iron intake from derived products, such as bread and pasta.

Finally, the current analysis is based on a cross-section survey and does not permit a continuous assessment of fortification coverage. This could be evaluated by applying a longitudinal survey methodology, despite the high costs of this approach, for which this study could constitute a baseline.

9. CONCLUSIONS AND RECOMMENDATIONS

The analysis carried out in section 8 led to the following frame of findings and conclusions:

- The households in Mozambique have a high consumption rate of the vehicles chosen by the NFFP. This indicates a high potential coverage rate of availability;
- The consumption of industrialised vehicles that are prone to large-scale fortification is also high. This is verified in urban and rural areas; the coverage is higher than 94 per cent in urban areas and 81 per cent in rural areas, indicating a high potential coverage of accessibility of fortifiable foods;
- In the rural area, 73 per cent of the fortifiable maize flour is ground at the community mills
- The household classification of vulnerable groups in the study represents points in the gradient of very high vulnerability group to a very low vulnerability group and the results should be analysed as such.
- The vulnerable groups are: urban with high capability of consuming fortified foods and low hindrances to the absorption of nutrients (low vulnerability); peri-urban household with moderate capabilities and high hindrances (medium-low vulnerability); rural with moderate capabilities and high hindrances (medium-high vulnerability) and rural with low capabilities and high hindrances (high vulnerability). The hindrances are at low level only in groups of low vulnerability, a fact that might be taken into consideration in evaluating the impact of the programme.
- The accessibility coverage of fortifiable vehicles is high across all vulnerable groups, decreasing moderately from the low to the high vulnerability group.
- Availability and accessibility have high coverage, with very similar rates.
- There is an exception to the high coverage pattern of the fortifiable wheat flour. The consumption rate among the rural households with low capabilities is roughly 11 per cent, 34 per cent in the rural with moderate

capability households and 54 per cent in the peri-urban. This indicates that wheat flour has been consumed through derived products, such as bread and pasta.

- Consideration could be given to strategies such as mixed flour or incentives towards fortification of flour directed to industrial products such as bread flour, cake mixes and noodles, especially for the urban households.

- The population's consumption pattern of fortifiable foods might lead to a very successful universal fortification programme and indicates the right choice of vehicle by the NFFP.

- Attention must be given to the fact that the consumption in the rural area of locally-milled maize flour represents 73 per cent of the fortifiable vehicle. This could guide the expansion of the NFFP's domain, which is currently the urban and peri-urban areas.

- The effectiveness coverage of fortified foods, defined as the consumption of foods with nutrient intake concentrations above the lower limit of the Mozambican Standards of 2017, is very low if compared to the expected rate. High consumption of fortifiable foods in a context of a mandatory food fortification programme leads to expectations of higher intake.

- Home storage conditions of the vehicles did not seem to be the cause of the low rate of fortified foods.

- However, contact coverage of fortified foods at any level, as the household/population that consumes fortified food independently of the concentration level of nutrients—in this case, any level equal to or above 3mg/kg of vitamin A and equal to or above 15mg/kg of iron—clearly shows that the households that have access to and contact with fortified foods are not a problem.

- The goals set by the food fortification programme are that by the end of the WFP project in 2018: 11.9 million people would have access to fortified wheat flour; 11.5 million people would have access to fortified vegetable oil; 13 million people would have access to fortified sugar; and 1.8 million people would have access to fortified maize flour.

- The contact with fortified foods measured at any level of nutrient intake, showed that for maize flour the goal has been surpassed by about 17 million people and for vegetable oil, it has been surpassed by about 5 million people; for sugar the access is short by about 2 million people and wheat flour consumption is halfway. This is a rather different picture when compared to the intake of fortified foods according to the Mozambican standards: the consumption of vegetable oil and wheat flour are short by about 10 million people; consumption of sugar is short by about 3 million and the consumption of maize flour has surpassed the goal by about 500,000 people.

- The evidence leads to the conclusion that there is no problem in the population's access to and contact with fortified foods. The problem is how to get the population to have the right intake of the nutrients according to Mozambican standards. Moreover, wheat flour should be assessed separately in terms of derived products.

- Contributions of the NFFP to the daily RNI, measured as the proportion of households that have at least 50 per cent of RNI for vitamin A is 45 per cent in urban settlements and 25 per cent in rural ones. The percentages for iron are 24 per cent and 20 per cent, respectively.

- Contributions from the NFFP to the RNI across the vulnerability groups for vitamin A decrease from 45 per cent to 24 per cent, from the low vulnerable of the urban area through highly vulnerable of rural areas. For iron, there is less variation across the groups, from 25 per cent to 18 per cent.

- The NFFP's domain has so far comprised households in urban and peri-urban areas. However, the results of this study show how the benefits of the programme have been extended to rural areas and to all vulnerable groups. These benefits should not be underrated—despite their current low levels, they exhibit the potential for a more universal expansion.

Most of the results and conclusions of this study reflect issues related to the implementation of the programme and the consumption patterns of households. The enforcement of fortified foods was established in 2018, however the monitoring system has yet not been fully implemented to assess the consumption of imported products and/or the possible uncontrolled introduction of products in the market at lower prices. There is strong evidence that the programme's universality is not only possible, but that it also has the potential for very successful outcomes in compliance with MDG 1 and SDG 2.

Recommendations

One of the main conclusions of the study is that there is no problem in the population's access to and contact with the fortified vehicles; the problem lies in how and what to do for the population to obtain the right intake of nutrients, in accordance with the Mozambican Standards. Some questions could be addressed:

- Why is it that, even with high consumption of fortifiable foods in a mandatory NFFP, the levels of consumed nutrients still do not reach the country's standards?
- Where in the chain, from factory to the households, does the problem reside?
- Are the imported products in accordance with the Mozambican standards?
- Is it too early to have total compliance from producers?

Some of the recommendations are:

- Implementation of a continuous monitoring and evaluation system (M&AS).
- Implementation of a surveillance system for the production chain of the vehicles and imported foods, especially on the follow-up of the enforcement parameters.
- Elaboration of an informative mass communication programme directed at the population, regarding the importance of fortified foods and their proper storage.
- Occasional evaluation surveys with the target population to assess the coverage and effectiveness of the programme.
- A specific survey to assess the right consumption of wheat flour by targeting the consumption of derived products, such as bread and pasta.

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APPENDIX 1: SAMPLE SIZE AND SAMPLE WEIGHTS

General strategy

The sampling size was determined in two steps: first, a minimum sample size was estimated by using a two-stage sampling design which considers the Administrative Posts as Primary Sampling Units (PSU) and households as Secondary Sampling Units (SSU). This resulted in a total of 1,500 households. Then, the access to the Master Sample and Census data allowed the assessment of sampling error estimates for some indicators, considering the three-stage sampling design described in Section 4. In this second step, it was thus determined how to allocate the 1,500 households among PSUs and SSUs, or how many PSUs should be selected in order to give an acceptable sampling error.

Population data

Mozambique population data by province was available in The Open Data Africa website (AFDB 2017), an open on-line platform developed to provide socioeconomic indicators for African countries. The data was originally gathered by the National Institute of Statistics in Mozambique (INE).

Estimating sampling size

Based on the available data, a theoretical sampling strategy adopting a two-stage cluster sampling plan was used. For a sampling plan following this design, it is necessary to consider the value of the Intracluster Correlation, or ICC, as pointed out by Bianchini and Silva (2002) and WHO (2015). This measures the similarity of the households inside each PSU. Its value is expected to be higher for variables like poverty condition since socioeconomic status tends to me similar in a neighbourhood. On the other hand, demographic factors like marriage status tend to have more heterogeneity inside the PSUs (Bennett et al. 1991).

Method

A simple approach for estimating an overall size for two-stage cluster sampling is presented in Bianchini and Silva (2002). They consider a selection of PSUs with Probability Proportional to Size (PPS). It means that a *cluster* with more households is more likely to be selected than a smaller one. This approach is also considered by WHO (2015) for estimating vaccination coverage.

The method starts with an estimate of a minimum size necessary to proceed with a hypothetical Simple Random Sampling (SRS), which consists of a simple random draw of households. Despite its simplicity and greater statistical precision, it is a less feasible and more expensive sampling plan to proceed with in practice. In general, for the same statistical accuracy a two-stage cluster sampling requires more observations than one designed by an SRS. Indeed, *"a simple random sample of 600 houses covers a town more evenly than 20 city blocks containing an average of 30 houses"*, for example (Cochran 1977 p. 233).

After estimating a necessary SRS sample — represented here by n_{srs} — the required number for a PPS two-stage cluster sampling — here n_{pps2} — is determined by

$$n_{pps2} = [1 + (m - 1)ICC]n_{srs}$$

where

- m: the average size by PSU
- ICC: the intraclass correlation

The value for n_{srs}, according to Cochran (1977) and Bolfarine and Bussab (2005), is given by the following formula:

$$n_{srs} = \frac{N}{4(N-1)\frac{E^2}{z_\alpha^2} + 1}$$

where

- N: total number of households in Mozambique, which equals to approximately 3.6 million;
- E: maximum desirable error for the food fortification estimator;
- z_α^2: gaussian quantile associated with the probability that the real error exceeds the desirable one.

An optimal value for m can be determined by a procedure that in some way takes into account the amount of ICC and the costs by PSU and by interview[6] (Cochran 1977 p. 314), but requires some information detailed in the smaller geographical division with available data. For now, an average of households by PSU is established, considering some assumptions detailed below.

Sample size

For an SRS plan, the sample size was determined in such a way that any overall proportion estimator (e.g., proportion of families in extreme poverty situation) has a sampling error of at most 5 per cent. This error is exceeded with 5 per cent of probability.

Bennett et al. (1991) present some assumptions for ICC based on the factor being measured: *"Such socioeconomic variables may have a relatively high value of ICC around"*. Moreover, a similar study conducted in Tanzania established a total of households per PSU (NBS 2015). Also, a fixed number of interviews in every *cluster* in the PPS selection turns the sample self-weighting, i.e. with every second-stage unit having an equal chance of being drawn. Assuming ICC=0.2 and a fixed number of m=15 households by PSU, a sampling plan would have a total of 1463 interviews spread among 98 clusters. Those values were rounded to 1500 and 100, respectively.

Determining number of PSUs to select

The abovementioned sampling design was based on data available only at the level of Administrative Posts. Thanks to the access to census data, it was possible to assess the actual sampling error considering a three-stage sampling design, similar to INE's master sample.

The design consists of the selection of PSUs, represented by the control areas, with probability proportional to size. Then, in each selected PSU, only one SSU (enumeration area) is selected, also with probability proportional to size. Then, the Tertiary Sampling Units (TSU), i.e. the households, are randomly selected through a systematic random sampling. The table A1.1 shows alternatives for the number of TSUs and the corresponding number of PSUs.

Table A1.1

Number of TSUs and the corresponding number of PSUs

Number of TSUs	Number of PSUs
5	300
15	100
30	50

6. If, for example, the cost of visiting and listing households for each PSU is significantly more expensive than the cost per interview, then the final sample plan would have fewer PSUs with a greater average number of households each.

A set of proportion measures were selected in order to assess the sampling error of this three-stage sampling design. The objective was to measure the theoretical sampling error for each of those indicators by using population variances measured from 2007 census data. The indicators used in the pairing procedure were calculated from the 2007 Mozambique's census microdata, as follows:

1. Percentage of non-literate people older than 14 years.
2. Percentage of people living in households with poor walls.
3. Percentage of people living in households with poor floor.
4. Percentage of people living in households with poor roof.
5. Percentage of people living in households where there is a computer.
6. Percentage of people living in households where there is a radio.
7. Percentage of people living in households where there is a TV.

The table A1.2 shows the sampling errors for three scenarios considering 5, 15 and 30 TSUs and the corresponding number of PSUs. The best results come with fewer households selected by enumeration area and more control areas to visit. Due to budget limitations, it was not possible to considerer a sampling plan with more than 300 PSUs. On the other rand, the scenario with 30 TSUs by enumeration area results in sampling errors above 10 per cent. Therefore, the three-stage sampling design considered the dimensions of PSUs and TSUs as stated in the first step, i.e. 100 PSUs (control areas), one SSU (enumeration area) selected in each PSU, and 15 TSUs (households).

Table A1.2

Sampling errors for the three scenarios

Indicator	5 TSUs	15 TSUs	30 TSUs
Percentage of non-literate people older than 14 years	5.86	9.68	13.52
Percentage of people living in households with poor walls	4.27	7.32	10.32
Percentage of people living in households where there is a computer	0.59	1.01	1.42
Percentage of people living in households with poor floor	3.64	6.20	8.73
Percentage of people living in households where there is a radio	1.76	2.88	4.01
Percentage of people living in households with poor roof	3.98	6.81	9.60
Percentage of people living in households where there is a TV	2.21	3.81	5.38

Sampling weights

In a complex sampling design, as is the case in the food fortification survey, the analysis has to consider the sampling weights, the inverse of the probability selection, in order to calculate averages or proportions, as well as to make population expansion. The master sample has calculated the first stage probability selection, p_{psu}, determined in the following equation:

$$p_{psu} = \frac{n_h M_{hi}}{M_h}$$

where

- n_h is the sampling size in the strata h;
- M_{hi} is the total number of households in strata h, PSU i;
- M_h is the total number of households in strata h.

In the manual with recommendations for the use of the master sample, INE recommends selecting one among four pre-determined subsets in the sample. A number ranging from 1 to 4 has been randomly selected to determine which subset would be chosen. Then, a set of 100 PSUs were selected from the selected subset, with probability proportional to size. Here, "size" is the number of households. This selection determines a new first-stage probability. Then, the "updated" first-stage selection probability, p_{psu}^{1} given by:

$$p_{psu}^{(1)} = p_{psu} \times \frac{1}{4} \times \frac{M_i}{M^s}$$

where

- M_i is the numer of households in the *i*-th PSU
- M^s is the total number of households in the PSUs selected to the master sample

The final selection probability, p_{ij}^{select}, considers the selection probabilities in the second and third stages, respectively. So this probability is determined by:

$$p_{ij}^{select} = p_{psu}^{(1)} \times \frac{M_{ij}}{M_i} \times \frac{15}{M'_{ij}}$$

where

- M_{ij} is the number of households in the *i*-th PSU, *j*-th SSU, according to Census 2007
- M_{ij} is the updated number of households in the *i*-th PSU, *j*-th SSU as observed in fieldwork

Then, the sampling weight, w, is the inverse of the probability selection:

$$w_{ij} = \frac{1}{p_{ij}^{select}}$$

An effort has been made to make sampling expansions. For this purpose, the original sampling weight, w, was calibrated so that its sum equals the Mozambique population size observed in 2017 census, in the order of 28.861.863 people. The calibration method followed a commonly used procedure, also adopted by the Brazilian Institute of Geography and Statistics (IBGE). The calibrated weight, w_c is given by (IBGE 2014; IBGE 2016).

APPENDIX 2: QUESTIONNAIRE TRANSPOSED TO PROGRAMMABLE TABLET

Researcher: This questionnaire should be administrated to the family member(s) with the most knowledge of the family's agricultural production, preferably the head of household and/or his/her partner.

INTRODUCTION

No.	Question	Answer options	Code
I1	Questionnaire number	House 0001 to 1500 - household 01 to 10	´- - - - - -
I2	GPS code (activate GPS)		´- - - - - -
I3	Name of province	Niassa	1
		Cabo Delgado	2
		Nampula	3
		Zambézia	4
		Tete	5
		Manica	6
		Sofala	7
		Inhambane	8
		Gaza	9
		Maputo Provincia	10
		Maputo Cidade	11
I4	Name of district	*< Automatic list of options based on selected province >*	
I5	Name of administrative post	*< Automatic list of options based on selected district >*	
I6	Name of locality	*< Automatic list of options based on selected administrative post >*	
I7	Name of village	*< Automatic list of options based on selected locality >*	
I8	Enumeration area code		
I9	Household address	_____	
I10	Enumerator's surname, first name	_____	
I11	Enumerator number		|_|_|
I12	Supervisor number		|_|_|

Hello, my name is _____, I work for the company Intercampus who is collecting data for a study on behalf of the World Food Programme (WFP) Mozambique and the International Policy Centre for Inclusive Growth (IPC-IG). You have been randomly selected to participate in the study to evaluate food fortification in Mozambique. You answers can help to improve nutritional interventions in Mozambique.

The interview will have a duration of approximately 90 minutes and we will need to observe some of your living conditions. There is no right or wrong answer; we want to hear your opinion. Your only responsibility is to follow the instructions given by the enumerator, participate in the discussion and inform the enumerator if you feel uncomfortable or prefer to interrupt your participation. It is important to answer all the questions truthfully in order not to distort the results from the study. The information that you provide is strictly confidential and your name will not be published. There is no obligation to participate; all answers are voluntary, you can skip questions that you do not want to answer, and you can terminate the interview at any moment.

I13	Date of first visit (year, month, day)	_____	
I14	Is the person with the most knowledge of the household's food preparation and consumption present? *If 'no', reschedule the visit.* Is he/she willing to be interviewed? *If 'no', thank the respondent and cancel the interview.*	Yes	1
		Not present	2
		Declines participation	3
I15	Informed consent obtained? *If 'no', thank the respondent and cancel the interview.*	Yes	1
		Not present	0
I16	Result of first visit	Complete	1
		Incomplete	2
		Declined	3
		Head of household or partner absent	4
		Other (specify): _____	88
I17	Start time of the interview	_____	
I18	End time of the interview	_____	
I19	*If the reply to I16 was anything other than 'complete'*: Date of second visit (year, month, day)	_____	
120	Is the person with the most knowledge of the household's food preparation and consumption present? *If 'no', reschedule the visit.* Is he/she willing to be interviewed? *If 'no', thank the respondent and cancel the interview.*	Yes	1
		Not present	2
		Declines participation	3

I21	Result of second visit	Complete	1
		Incomplete	2
		Declined	3
		Head of household or partner absent	4
		Other (specify): _____	88
I22	Start time of the interview	_____	
I23	End time of the interview	_____	
I24	*If the reply to I21 was anything other than 'complete'*: Date of third visit (year, month, day)	_____	
I25	Is the person with the most knowledge of the household's food preparation and consumption present? *If 'no', reschedule the visit.* Is he/she willing to be interviewed? *If 'no', thank the respondent and cancel the interview.*	Yes	1
		Not present	2
		Declines participation	3
I26	Result of third visit	Complete	1
		Incomplete	2
		Declined	3
		Head of household or partner absent	4
		Other (specify): _____	88
I27	Start time of the interview	_____	
I28	End time of the interview	_____	
I29	Final interview result	Complete	1
		Incomplete	2
		Declined	3
		Head of household or partner absent	4
		Other (specify): _____	88
I30	Total time of complete interview	_____	

	Household composition										
No.	P1	P2	P3	P4	P5	P6	P7	P8	P9	P10	P11
Question	Order number	Main interviewee	Surname, first name	Relation with head of household	Sex	Date of birth	Calculated age	Presumed age	Civil status	Religion	Speaks Portuguese?
Answers by each member	´01		.	Head of household							
	´02		.	Spouse / partner						X	
	.		.							X	
	.		.							X	
	.		.							X	
	.		.							X	
	.		.							X	
	.		.							X	
	.		.							X	
	.		.							X	
										X	
Answer options and code		*Please mark the main interviewee. Note that only one person can be marked with the answer 'yes'.* 1. Yes 0. No		1. Head of household	1. Masculine	day/month/year	*Programme the tablet to calculate the age* *If the date of birth is unknown and the individual does not have a birth certificate, pass to question P8. Otherwise continue to question P9.*	*Reply in years for respondents 5 years or older, reply in months for infants under 5 years of age.*	1. Married	1. Catholic	1. Yes
				2. Spouse / partner					2. Common-law union / living with partner	2. Muslim	0. No
				3.Son / daughter					3. Divorced / Separated	3. Zione	
				4. Grandchild					4. Widow	4. Evangelical	
				5. Mother / father					5. Never married	5. Protestant	
				6. Brother / sister	2. Feminine				98. Doesn't want to answer	6. No religion	
				7. Nephew / niece					99. Doesn't apply (e.g. child)	88. Other (specify):	
				8. Son-in-law / daughter-in-law						98. Doesn't want to answer	
				9. Added member							
				88. Other (specify):							
				OBS. Always fill in the head of household in the first row and the partner in the second							

	Household composition	Education							
No.	P1	E1	E2	E3	E4	E5	E6	E7	E8
Question	Individual order number	Can read and write?	Currently attending school?	Attends school (6 years of age or older)			Does not attend school (6 years of age or older)		
				Attending what level / grade?	What series / class (of the level / grade selected in E3) has the individual finalised and passed?	If individual missed classes during the past 30 days, what was the main reason?	Why not currently attending school?	What level is the highest the indiviudal has attended?	What class / year (of the level / grade selected in E7) has the individual finalised and passed?
Answers by each member	´01								
	´02								
	.								
	.								
	.								
	.								
Code	COPY FROM HOUSEHOLD SECTION	1. No	1. Yes	1. Alfabetisation	Insert series / class that each individual has completed and passed	1. Illness	1. Illness	1. Alfabetisation	Insert class / year that each individual has completed and passed
		2. Can write own name	0. No	2. Primary school 1º Grade (5 years)		2. Work to support family business	2. Work to support family business	2. Primary school 1º Grade (5 years)	
		3. Can read only	If 'no' - skip to E6	3. Primary school 2º Grade (2 years)		3. Housework	3. Housework	3. Primary school 2º Grade (2 years)	
		4. Can read and write		4. General Secondary School 1º Cycle (3 years)		4. Own work	4. Own work	4. General Secondary School 1º Cycle (3 years)	
		97. Doesn't know		5. General Secondary School 2º Cycle (2 years)		5. Take care of siblings	5. Take care of siblings	5. General Secondary School 2º Cycle (2 years)	
		98. Doesn't want to answer		6. Elementary Technical School (2 years)		6. School far away or unsafe	6. School far away or unsafe	6. Elementary Technical School (2 years)	
				7. Basic Technical School (3 years)		7. No money to pay school fees	7. No money to pay school fees	7. Basic Technical School (3 years)	
				8. Intermediate Technical School (4 years)		8. Refuses to go to school	8. Refuses to go to school	8. Intermediate Technical School (4 years)	
				9. Teacher Training Course		88. Other (specify): _____	9. Finalised studies	9. Teacher Training Course	
				10. Superior		97. Doesn't know	88. Other (specify): _____	10. Superior	
						98. Doesn't want to answer	97. Doesn't know	99. None	
							98. Doesn't want to answer		

	Household composition	Fertility, infant mortality, and breastfeeding For women between 10 and 50 years of age *(born between 1967 and 2008)*								
No.	P1	M1	M2	M3	M4	M5	M6	M7	M8	M9
Question	Individual order number	How many children, born alive, did you give birth to?	When (what date) was the last of these children born?	Out of the children, born alive, that you gave birth to; how many are still alive today?	Are you currently pregnant?	*If the respondent is pregnant:* How many months have you been pregnant?	Are you currently breastfeeding?	*If the respondent is breastfeeding:* Does the child receive any liquids or foods / solids in addition to the breastmilk?	How many times per day do you breastfeed?	How many months have you been breastfeeding?
Answers by each member	´01									
	´02									
	.									
	.									
	.									
	.									
Code	COPY FROM HOUSEHOLD SECTION	*Please note: "Live birth refers to the complete expulsion or extraction from its mother of a product of conception, irrespective of the duration of the pregnancy, which, after such separation, breathes or shows any other evidence of life - e.g. beating of the heart, pulsation of the umbilical cord or definite movement of voluntary muscles - whether or not the umbilical cord has been cut or the placenta is attached. Each product of such a birth is considered live born." (World Health Organization, 1999).* ***A common error is that the mother does not declare children that died shortly after birth.***			1. Yes 0. No *If 'no' - skip to M6*	Number of months	1. Yes 0. No *If 'no' - skip to the next section (HEALTH)*	1. No (exclusively breastfed) 2. Yes, only additional liquids 3. Yes, additional liquids and foods / solids 97. Doesn't know 98. Doesn't want to answer	Number of times per day	Number of months

	Household composition	Health and morbidity								
No.	P1	S1	S2	S3	S4	S5	S6	S7	S8	S9
Question	Individual order number	Overall, how would you classify <name's> current health?	Which of the following symptoms did <name> show during the past 30 days? (MULTIPLE ANSWERS POSSIBLE)	Does <name> have any problems with eyevision during the day?	Does <name> have any problems with nightvision?	Do you think that this is a common problem overall in the community / among other community members?	Does <name> have night blindness (Nyctalopia)?	Does <name> have Bitot's spots?	Does <name> have a visible goitre / lump on the front of the neck?	Does <name> have white or pale gums?
Answers by each member	´01									
	´02					x				
	.					x				
	.					x				
	.					x				
	.					x				
						x				
						x				
						x				
						x				
						x				
Code	COPY FROM HOUSEHOLD SECTION	1, Very poor	1. Fever	0. No	0. No	0. No	0. No	0. No	0. No	0. No
		2. Poor	2. Cough	1. Yes	1. Yes	1. Yes	1. Yes	1. Yes	1. Yes	1. Yes
		3. Average	3. Headache	97. Doesn't know	97. Doesn't know	97. Doesn't know	97. Doesn't know	97. Doesn't know	97. Doesn't know	97. Doesn't know
		4. Good	4. Shivers	98. Doesn't want to answer	98. Doesn't want to answer	98. Doesn't want to answer	98. Doesn't want to answer	98. Doesn't want to answer	98. Doesn't want to answer	98. Doesn't want to answer
		5. Very good	5. Body ache			*ONLY MAIN INTERVIEWEE ANSWERS.*		*Please refer to photos in Annex.*	*Please refer to photos in Annex.*	*Please refer to photos in Annex.*
			6. Diarrhoea							
			7. Stomach ache							
			8. Blood in urine							
			9. Weakness							
			0. None							
			97. Doesn't know							
			98. Doesn't want to answer							

SOCIOECONOMIC INDICATORS AND HOUSEHOLD CHARACTERISTICS			
No.	**Question**	**Answer options**	**Code**
H1	What is your family's main income source? *Don't read the options - mark the option that best reflects the interviewee's reply.*	Crop production	1
		Livestock farming	2
		Fishery	3
		Forestry	4
		Artesanal activities	5
		Construction	6
		Transportation	7
		Service industry (shops, restaurants, etc.)	8
		Business / commerce	9
		Administration	10
		Remittances (money sent from abroad)	11
		Pension / retirement income	12
		Rental / tenancy (of land, equipment, buildings, etc.)	13
		Other, specify: _____	88
		Doesn't know	97
		Doesn't want to answer	98
		None (has no income)	99
H2	Does your family have any additional income source? *If 'yes', continue to the next question, if 'no', skip to H4*	Yes	1
		No	0
H3	What are your family's additional income sources? *Don't read the options - mark the option that best reflects the interviewee's reply.*	Crop production	1
		Livestock farming	2
		Fishery	3
		Forestry	4
		Artesanal activities	5
		Construction	6
		Transportation	7
		Service industry (shops, restaurants, etc.)	8
		Business / commerce	9
		Administration	10
		Remittances (money sent from abroad)	11
		Pension / retirement income	12
		Rental / tenancy (of land, equipment, buildings, etc.)	13
		Other, specify: _____	88
		Doesn't know	97
		Doesn't want to answer	98
		None (has no income)	99
H4	The external walls of the house are constructed with: *If possible, don't read the options - observe personally the material used for the walls. Mark the option that best reflects the material used.*	Cement blocks	1
		Bricks	2
		Wood / zinc	3
		Blocks of dry mud / adobe	4
		Reed / straw / sticks / bamboo / palm tree	5
		Wattle and daub (combination of e.g. wet soil, clay, sand, animal dung and straw)	6
		Tin / cardboard / paper / cloth / bark	7
		Other, specify: _____	88
		Doesn't know	97
		Doesn't want to answer	98

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H5	The floors of the house are constructed with: *If possible, don't read the options - observe personally the material used for the walls. Mark the option that best reflects the material used.*	Wood / parquet	1
		Marble / granite	2
		Cement	3
		Mosaic / tiles	4
		Mud	5
		Nothing	6
		Other, specify: _____	88
		Doesn't know	97
		Doesn't want to answer	98
H6	The roof of the house is constructed with: *If possible, don't read the options - observe personally the material used for the walls. Mark the option that best reflects the material used.*	Concrete slabs	1
		Tiles	2
		Lusalite sheets	3
		Zinc sheets	4
		Grass / reed / straw / palm tree	5
		Other, specify: _____	88
		Doesn't know	97
		Doesn't want to answer	98
H7a	How many rooms / sections does the house have (not counting the kitchen and bathroom)?		|_|_|
H7b	Out of these rooms / sections, how many are used for sleeping?		|_|_|
		Doesn't know	97
		Doesn't want to answer	98
H8	Does the house have electricity?	Yes	1
		No	0
		Doesn't know	97
		Doesn't want to answer	98
H9	What is the main drinking water source for the family members? *Don't read the options - mark the option that best reflects the interviewee's reply.*	Piped water inside house	1
		Piped water outside house (e.g. in the garden)	2
		Piped water at neighbour's house	3
		Water from standpipe / public tap	4
		Water from covered well / reservoir with hand pump	5
		Water from covered well / reservoir without pump	6
		Water from open (uncovered) well / reservoir	7
		Spring water	8
		Surface water (river, lake, lagoon)	9
		Rainwater	10
		Water from truck water tanks / barrels	11
		Bottled water	12
		Other, specify: _____	88
		Doesn't know	97
		Doesn't want to answer	98
H10	Do you usually treat the water before drinking or cooking with it?	Yes, always	1
		Yes, most of the time	2
		Yes, sometimes	3
		No	0
		Doesn't know	97
		Doesn't want to answer	98

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H11	*If respondent answered 'yes'*: How do you normally treat the water to make it safe for drinking? *Don't read the options - multiple answers possible*	Tratar com cloro/javel	1
		Ferver	2
		Deixar a garrafa no sol	3
		Tratar com "Certeza"	4
		Outro, especificar: _____	88
		Não sabe	97
		Não quer responder	98
H12	What type of latrine do the family members normally use? *Don't read the options - mark the option that best reflects the interviewee's reply.*	WC (toilet with flush system) inside house	1
		WC (toilet with flush system) outside house	2
		Toilet without flush system	3
		Improved latrine	4
		Traditional improved latrine	5
		Traditional not improved latrine	6
		No toilet/latrine	7
		Other, specify: _____	88
		Doesn't know	97
		Doesn't want to answer	98

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H13_1	How many of the following items in working condition does your family own?	Chair	|_|_|
H13_2		Sofa	|_|_|
H13_3		Bed	|_|_|
H13_4		Radio	|_|_|
H13_5		CD / cassette player	|_|_|
H13_6		TV	|_|_|
H13_7		Computer	|_|_|
H13_8		Fixed phone	|_|_|
H13_9		Mobile phone	|_|_|
H13_10		Lamp	|_|_|
H13_11		Refrigerator	|_|_|
H13_12		Stove (gas or electric)	|_|_|
H13_13		Microwave	|_|_|
H13_14		Shower (electric)	|_|_|
H13_15		Laundry machine	|_|_|
H13_16		Fan	|_|_|
H13_17		Energy generator	|_|_|
H13_18		Solar panel	|_|_|
H13_19		Oxen / cows	|_|_|
H13_20		Pigs	|_|_|
H13_21		Goats / sheep	|_|_|
H13_22		Horses / donkeys	|_|_|
H13_23		Hens / ducks	|_|_|
H13_24		Plough	|_|_|
H13_25		Chainsaw	|_|_|
H13_26		Tractor	|_|_|
H13_27		Other agricultural machine	|_|_|
H13_28		Cart / wagon	|_|_|
H13_29		Bicycle	|_|_|
H13_30		Motorcycle	|_|_|
H13_31		Car or truck	|_|_|
H13_32		Boat / canoe	|_|_|
H13_33		Plot / terrain	|_|_|
H14	Which means of transportation do you normally use to travel from your house to the nearest village? *Don't read the options - mark the option that best reflects the interviewee's reply.*	Car or truck	1
		Bus	2
		Boat / canoe	3
		Motorcycle	4
		Bicycle	5
		Walking	6
		Horse / donkey / oxen	7
		Other, specify: _____	88
		Doesn't know	97
		Doesn't want to answer	98

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H15	How much time does it take you to reach the nearest road accessible only in the dry season? *Select by foot or by car and type the time in hours and minutes (e.g. 90 minutes = 1 hour and 30 minutes)*	(hours by foot)	|_|_|
		(minutes by foot)	|_|_|
		(hours by car)	|_|_|
		(minutes by car)	|_|_|
H16	How much time does it take you to reach the nearest all-weather road (that is accessible year-round)? *Select by foot or by car and type the time in hours and minutes (e.g. 90 minutes = 1 hour and 30 minutes)*	(hours by foot)	|_|_|
		(minutes by foot)	|_|_|
		(hours by car)	|_|_|
		(minutes by car)	|_|_|
H17	How much time does it take you to reach the nearest asphalt road? *Select by foot or by car and type the time in hours and minutes (e.g. 90 minutes = 1 hour and 30 minutes)*	(hours by foot)	|_|_|
		(minutes by foot)	|_|_|
		(hours by car)	|_|_|
		(minutes by car)	|_|_|
H18	How much time does it take you to reach the nearest market? *Select by foot or by car and type the time in hours and minutes (e.g. 90 minutes = 1 hour and 30 minutes)*	(hours by foot)	|_|_|
		(minutes by foot)	|_|_|
		(hours by car)	|_|_|
		(minutes by car)	|_|_|
H19	How much time does it take you to reach the nearest hospital or clinic? *Select by foot or by car and type the time in hours and minutes (e.g. 90 minutes = 1 hour and 30 minutes)*	(hours by foot)	|_|_|
		(minutes by foot)	|_|_|
		(hours by car)	|_|_|
		(minutes by car)	|_|_|

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FOOD AND NUTRITION SECURITY			
No.	**Question**	**Answer options**	**Code**
FOOD CONSUMPTION, DIETARY DIVERSITY, AND NUTRITIONAL INTAKE			
FNS1_0	**How many days over the last 7 days did members of your household eat the following food items, prepared and/or consumed at home?** *(Note: do not count small amounts that are used as condiments)*		
FNS1_1	**CEREALS / GRAINS** (E.G. CORN, RICE, WHEAT, OR ANY OTHER GRAINS OR FOODS MADE WITH GRAIN PRODUCTS, SUCH AS BREAD, PASTA, PORRIDGE, PASTRY)	All answers shall have a numerical value between 0 and 7.	|_|
FNS1_2	**WHITE ROOTS AND TUBERS** (E.G. POTATO, YAM, CASSAVA)		|_|
FNS1_3	**ORANGE ROOTS AND TUBERS RICH IN VITAMIN A** (E.G. CARROT, PUMPKIN, SQUASH, SWEET POTATO)		|_|
FNS1_4	**DARK GREEN VEGETABLES** (E.G. LEAFY GREENS SUCH AS SPINACH, KALE, AMARANTH, CASSAVA LEAVES)		|_|
FNS1_5	**OTHER VEGETABLES** (E.G. TOMATO, ONION, EGGPLANT)		|_|
FNS1_6	**FRUITS RICH IN VITAMIN A** (E.G. RIPE MANGO, MELON, PAPAYA, RIPE APRICOT, DRIED PEACH, AND 100% NATURAL JUICE FROM THESE FRUITS)		|_|
FNS1_7	**OTHER FRUITS**		|_|
FNS1_8	**ORGAN MEAT** (E.G. LIVER, KIDNEYS, HEART OR OTHER ORGANS OR FOODS MADE WITH BLOOD)		|_|
FNS1_9	**MEAT** (COW/CALF, PIG, SHEEP/LAMB, GOAT, RABBIT, ZEBU, CHICKEN/HEN, DUCK, OTHER BIRDS, ANY INSECT)		|_|
FNS1_10	**EGGS**		|_|
FNS1_11	**FISH AND SEAFOOD**		|_|
FNS1_12	**LEGUMES, NUTS AND SEEDS** (E.G. BEANS, DRY PEAS, LENTILS, NUTS, SEEDS, OR FOODS MADE FROM THESE)		|_|
FNS1_13	**MILK AND MILK PRODUCTS** (E.G. CHEESE, YOGHURT, ETC. EXCLUDING BUTTER)		|_|
FNS1_14	**OILS AND FATS** (E.G. BUTTER, OIL, OR OTHER FATS, ADDED TO FOODS OR USED FOR COOKING)		|_|
FNS1_15	**SWEETS**		|_|
FNS1_16	**CONDIMENTS, SPICES, AND DRINKS** (E.G. SPICES SUCH AS SALT, PEPPER, PAPRIKA; DRINKS SUCH AS COFFEE AND TEA)		|_|
EXPENSES			
FNS2_0	**How much did you spend the past 30 days on the following items and in total?**		
FNS2_1	Food	The value of the expenses shall be inserted in meticais	|_||_||_||_|
FNS2_2	Clothing		|_||_||_||_|
FNS2_3	Health		|_||_||_||_|
FNS2_4	Education: fees, uniforms, materials		|_||_||_||_|
FNS2_5	Transportation		|_||_||_||_|
FNS2_6	Others		|_||_||_||_|
FNS2_9	Total		|_||_||_||_|
Situação alimentar no domicílio			
FNS3	During the past 12 months, was there a time when you or anyone in your household worried about not having enough to eat because of a lack of money or other resources?	Yes	1
		No	0
		Doesn't know	97
		Doesn't want to answer	98
FNS4	During the past 12 months, was there a time when you or anyone in your household were unable to eat healthy or nutritious food because of a lack of money or other resources?	Yes	1
		No	0
		Doesn't know	97
		Doesn't want to answer	98
FNS5	During the past 12 months, was there a time when you or anyone in your household ate only a few kinds of foods because of a lack of money or other resources?	Yes	1
		No	0
		Doesn't know	97
		Doesn't want to answer	98
FNS6	During the past 12 months, was there a time when you or anyone in your household had to skip a meal because there was not enough money or other resources to get food?	Yes	1
		No	0
		Doesn't know	97
		Doesn't want to answer	98
FNS7	During the past 12 months, was there a time when you or anyone in your household at less than you thought you should because of a lack of money or other resources?	Yes	1
		No	0
		Doesn't know	97
		Doesn't want to answer	98
FNS8	During the past 12 months, was there a time when your household ran out of food because of a lack of money or other resources?	Yes	1
		No	0
		Doesn't know	97
		Doesn't want to answer	98
FNS9	During the past 12 months, was there a time when you or anyone in your household were hungry but did not eat because there was not enough money or other resources for food?	Yes	1
		No	0
		Doesn't know	97
		Doesn't want to answer	98
FNS10	During the past 12 months, was there a time when you or anyone in your household went without eating for a whole day because of a lack of money or other resources?	Yes	1
		No	0
		Doesn't know	97
		Doesn't want to answer	98

FOOD FORTIFICATION

The questions in this section shall be repeated for each of the following foods:
- Wheat flour
- Maize flour
- Sugar
- Vegetable oil

No.	Question	Answer options	Code
	HOUSEHOLD CONSUMPTION OF FORTIFIED FOODS		
FF1	Does your family use <vehicle> to prepare food? *Don't read the options - select one option only*	Yes, regularly	1
		Yes, sometimes	2
		No, never	0
		Doesn't know	97
		Doesn't want to answer	98
FF2	Do you have any <vehicle> at home? Select one option only If answered 'yes' - continue to FF2 If answered 'no, none at the moment' - skip to FF4 If answered ' no, never have it', 'doesn't know', or 'doesn't want to answer' and also answered 'no, never', 'doesn't know', or 'doesn't want to answer' on FF1, skip to next food type or finalise questionnaire.	Yes	1
		No, none at the moment	2
		No, never have it	0
		Doesn't know	97
		Doesn't want to answer	98
FF3	Can you show me this <vehicle>? *Enumerator: Clarify to the respondent that the reason why we want to see the food is because the objective of the research is to study the nutritional content and levels of fortification in staple foods at the homes of the Mozambican population.* *If there are several products <vehicle>, from different sources or brand, open fields for each one* and ask questions in the sequence for each.	Yes	1
		No	0
FF4	When your family obtained this <vehicle>, where did you obtain it? *Read the options - multiple answers possible. (Last time the product was available at the household if not available currently)*	Purchased	1
		Produced at home	2
		Received from food aid	3
		Other (specify): _____	88
		Doesn't know	97
		Doesn't want to answer	98
FF5	*DISPLAY ONLY FOR MAIZE FLOUR AND IF ANSWER AT FF4 WAS 'PRODUCED AT HOME':* Where was the maize flour milled/ground? *Read the options - Select one option only.*	Milled / ground at home	1
		Milled / ground at home of neighbour / friend / relative	2
		Milled / ground at local mill	3
		Other (specify): _____	88
		Doesn't know	97
		Doesn't want to answer	98
FF6	DISPLAY ONLY FOR MAIZE FLOUR AND IF ANSWER AT FF4 WAS 'PRODUCED AT HOME': Was any premix (or vitamins in any other form) added to the maize flour when it as milled? Read the options - Select one option only for each sample.	Yes	1
		No	0
		Other (specify): _____	88
		Doesn't know	97
		Doesn't want to answer	98

DAILY AND WEEKLY CONSUMPTION			
FF7	*DISPLAY FOR ALL (EVEN IF FOOD IS NOT CURRENTLY AVAILABLE AT HOUSEHOLD)* In this household, what tool is normally used to measure a quantity of <vehicle>? Can you show me this tool / cup / spoon? *If 'no specific measuring tool is used' - skip to FF9*	Table spoon	1
		Glass	2
		Cup	3
		Bowl	4
		Jar / jug / pitcher	5
		Other (specify): _____	88
		No specific measuring tool is used	99
FF8	*Measure the size of the household tool using a standard measuring tool. Enumerator: 1. Bring a standard measuring tool and, using water, measure the relation between the standard measuring tool and the measuring tool used by the household. 2. Indicate the corresponding quantity in the questionnaire. For instance: half the standard measurement, double the standard measurement, and so on. 3. Note the corresponding quantity calculated by the tablet.*	The measuring tool used at the household corresponds to _____ of the standard measuring tool, which corresponds to _____ grams / millilitres	_|_|
FF9	When your family obtained this <vehicle > (last time, if the food is not available at the moment), how much did you obtain? *Indicate the quantity in kg/g, l/ml, or in the measure used by the household.*	Quantity in kilograms	_|_|
		Quantity in grams	_|_|_|
		Quantity in litres	_|_|
		Quantity in millilitres	_|_|_|
		Quantity in the household measuring tool referred to in FF7 (e.g. number of spoons, cups etc.)	_|_|
FF10	How long does this quantity normally last in the household?	Duration in days	_|_|
		Duration in weeks	_|_|
		Duration in months	_|_|
FF11	How much <vehicle > does your family normally consume / use to prepare food in one day? *Indicate the quantity in kg/g, OR l/ml, OR in the measure used by the household.*	Quantity in kilograms	_|_|
		Quantity in grams	_|_|_|
		Quantity in litres	_|_|
		Quantity in millilitres	_|_|_|
		Quantity in the household measuring tool referred to in FF7 (e.g. number of spoons, cups etc.)	_|_|
FF12	How many days per week does your family normally consume / prepare food with <vehicle >?	Number of days:	_|_|
FF13	How much <vehicle > do you estimate your family consumed / used to prepare food during the past 7 days? *Indicate the quantity in kg/g, OR l/ml, OR in the measure used by the household.*	Quantity in kilograms	_|_|
		Quantity in grams	_|_|_|
		Quantity in litres	_|_|
		Quantity in millilitres	_|_|_|
		Quantity in the household measuring tool referred to in FF7 (e.g. number of spoons, cups etc.)	_|_|

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BRAND AND PRODUCERS / DISTRIBUTORS OF THE FOODS CONSUMED BY THE HOUSEHOLD			
FFt14	DISPLAY ONLY FOR WHEAT FLOUR (EXCEPT IF ANSWER AT FF4 WAS 'PRODUCED AT HOME'): What is the brand of this wheat flour? If wheat flour is currently available at the household and the respondent has agreed to show the product, observe the brand. If not, ask the respondent to indicate the brand (of the last time the product was available at the household if not currently). In case more than one brand is used take sample of each brand and Select one option PER SAMPLE	Florbela	1
		Favorita	2
		Babita	3
		Other (specify): _____	88
		Doesn't know	97
		Doesn't want to answer	98
		Product has no label	99
FFm14	DISPLAY ONLY FOR MAIZE FLOUR (EXCEPT IF ANSWER AT FF4 WAS 'PRODUCED AT HOME'): What is the brand of this maize flour? If maize flour is currently available at the household and the respondent has agreed to show the product, observe the brand. If not, ask the respondent to indicate the brand (of the last time the product was available at the household if not currently). Select one option only.	Top Socore	1
		Super Mariana	2
		Nations Pride	3
		Withe Star	4
		Sutsa	5
		Other (specify): _____	88
		Doesn't know	97
		Doesn't want to answer	98
		Product has no label	99
FFa14	DISPLAY ONLY FOR SUGAR (EXCEPT IF ANSWER AT FF4 WAS 'PRODUCED AT HOME'): What is the brand of this sugar? If sugar is currently available at the household and the respondent has agreed to show the product, observe the brand. If not, ask the respondent to indicate the brand (of the last time the product was available at the household if not currently). Select one option only.	Açúcar nacional	1
		Autopac	2
		Pérola	3
		Selati	4
		Other (specify): _____	88
		Doesn't know	97
		Doesn't want to answer	98
		Product has no label	99
FFo14	DISPLAY ONLY FOR VEGETABLE OIL (EXCEPT IF ANSWER AT FF4 WAS 'PRODUCED AT HOME'): What is the brand of this vegetable oil? If vegetable oil is currently available at the household and the respondent has agreed to show the product, observe the brand. If not, ask the respondent to indicate the brand (of the last time the product was available at the household if not currently). Select one option only.	Maeva	1
		Dona	2
		Fló	3
		Sunseed	4
		Confiança	5
		Sungló	6
		Sungold	7
		Sunfry	8
		Sun star	9
		Other (specify): _____	88
		Doesn't know	97
		Doesn't want to answer	98
		Product has no label	99
FFt15	DISPLAY ONLY FOR WHEAT FLOUR (EXCEPT IF ANSWER AT FF4 WAS 'PRODUCED AT HOME'): Who is the producer / distributor of this wheat flour? If wheat flour is currently available at the household and the respondent has agreed to show the product, observe the producer / distributor. If not, ask the respondent to indicate the brand (of the last time the product was available at the household if not currently). Select one option only.	CIM	1
		Merec Industries	2
		Other (specify): _____	88
		Doesn't know	97
		Doesn't want to answer	98
		Product has no label	99

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FFm15	DISPLAY ONLY FOR MAIZE FLOUR (EXCEPT IF ANSWER AT FF4 WAS 'PRODUCED AT HOME'): Who is the producer / distributor of this maize flour? If maize flour is currently available at the household and the respondent has agreed to show the product, observe the producer / distributor. If not, ask the respondent to indicate the brand (of the last time the product was available at the household if not currently). Select one option only.	CIM (Companhia industrial da Matola)	1
		RIZ industria Lda	2
		Batho Batlhe	3
		Sasko	4
		Sutsa	5
		Other (specify): _____	88
		Doesn't know	97
		Doesn't want to answer	98
		Product has no label	99
FFa15	DISPLAY ONLY FOR SUGAR (EXCEPT IF ANSWER AT FF4 WAS 'PRODUCED AT HOME'): Who is the producer / distributor of this sugar? If sugar is currently available at the household and the respondent has agreed to show the product, observe the producer / distributor. If not, ask the respondent to indicate the brand (of the last time the product was available at the household if not currently). Select one option only.	Autopac Maputo	1
		Sasseka	2
		Selati	3
		Other (specify): _____	88
		Doesn't know	97
		Doesn't want to answer	98
		Product has no label	99
FFo15	DISPLAY ONLY FOR VEGETABLE OIL (EXCEPT IF ANSWER AT FF4 WAS 'PRODUCED AT HOME'): Who is the producer / distributor of this vegetable oil? If vegetable oil is currently available at the household and the respondent has agreed to show the product, observe the producer / distributor. If not, ask the respondent to indicate the brand (of the last time the product was available at the household if not currently). Select one option only.	Southern refinaries	1
		Olam	2
		Sea lake	3
		Basra	4
		Other (specify): _____	88
		Doesn't know	97
		Doesn't want to answer	98
		Product has no label	99
FF16	DISPLAY TO ALL (EXCEPT IF ANSWER AT FF4 WAS 'PRODUCED AT HOME'): Does the packaging have a fortification logo? If <vehicle > is currently available at the household and the respondent has agreed to show the product, observe the logo. If not, ask the respondent to indicate whether <vehicle > (of the last time the product was available at the household if not currently) has a fortification logo. Select one option only.	The product has a label - fortification logo observed by the enumerator	1
		The product has a label - fortification logo NOT observed by the enumerator	2
		The product has no label	3
		Other (specify): _____	88
		Doesn't know	97
		Doesn't want to answer	98
FAMILIARITY WITH THE OFFICIAL MOZAMBICAN FORTIFICATION LOGO			
FF17	*Show the fortification logo to the respondent:* Have you ever seen this logo? *Select one option only* *If 'yes' - continue to FF18* *If 'no' - skip to FF20*	Yes	1
		No	0
FF18	What does this logo mean? *Don't read the options - multiple answers possible*	Nothing	99
		Fortified / has added nutrients	1
		Good for the health	2
		High quality	3
		Low quality	4
		More expensive	5
		Other (specify): _____	88
		Doesn't know	97
		Doesn't want to answer	98
FF19	Does this logo influence your decision of whether to buy a product? *Don't read the options - multiple answers possible*	No, it doesn't influence my decision	0
		Yes, it incentivises me to buy the product	1
		Yes, it deters me from buying the product	2
		Other (specify): _____	88
		Doesn't know	97
		Doesn't want to answer	98

FOOD SAMPLE COLLECTION			
FF20	*DISPLAY IF ANSWER TO FF3 WAS 'YES':* *Enumerator: Observe how <vehicle > is stored at the household.* *Select the option that most corresponds.*	Stored in a dark place (e.g. cupboard, refrigerator)	1
		Stored in a bright place (e.g. table)	2
FF21	*DISPLAY IF ANSWER TO FF3 WAS 'YES':* *Enumerator: Observe the packaging of <vehicle >.* *Select the option that most corresponds.*	Original packaging (e.g. from the factory)	1
		Re-packaged (e.g. placed in different container at the market / store or at home)	2
FF22	*DISPLAY IF ANSWER TO FF3 WAS 'YES':* *Enumerator: Observe the material of the packaging of <vehicle >.* *Select the option that most corresponds.*	Paper / cardboard	1
		Plastic	2
		Glass	3
		Metal	4
		Other (specify): _____	88
FF23	*DISPLAY IF ANSWER TO FF3 WAS 'YES':* *Enumerator: Observe the packaging of <vehicle>.* *Select the option that most corresponds.*	Packaging (original or other) is opaque (light doesn't enter)	1
		Packaging (original or other) is transparent (light can enter)	2
FF24	*DISPLAY IF ANSWER TO FF3 WAS 'YES':* *Enumerator: Observe the packaging of <vehicle>.* *Select the option that most corresponds.*	Packaging (original or other) is well sealed / airtight (air doesn't enter)	1
		Packaging (original or other) is open / not well sealed (air can enter)	2
FF25	DISPLAY IF ANSWER TO FF3 WAS 'YES': May I collect a small sample of <vehicle>? Enumerator: Explain to the respondent that the household will be compensated for the samples. If 'yes' - continue to FF26 If 'no' - skip to next food type or finalise questionnaire.	Yes	1
		No	0
FF26	*Enumerator: Observe the condition of <vehicle>.*	Seems clean (e.g. no discolouration, foul smell or other is observed)	1
		Shows signs of not being clean (e.g. discolouration, foul smell or other is observed)	2
FF27	*Enumerator: Before collecting a sample:* *Wash hands and apply hand sanitizer. Ask the repondent for permission to homgenise the product (i.e. mix / stir the product inside the packaging). Apply the label.* *Collect a bit of <vehicle> from different sections of the product until the desired quantity (50g/ml) is obtained.* *Sample collected?*	Yes	1
		No	0

Enumerator: Thank the interviewee(s) for the interview.

APPENDIX 3: DETAILED APPLICATION OF GRADE OF MEMBERSHIP (GOM) MODEL

Fuzzy sets and the Grade of Membership model

The main characteristic of fuzzy sets consists in the fact that the elements of the sets have degrees of membership to multiple subsets, in contrast to the crisp sets, where one element belongs exclusively to a specific subset. They are used in statistics to deal with complex sources of heterogeneity in the data (Manton, Woodbury, and Tolley 1994).

To apply the GoM model to our case, in order to estimate the degrees of membership of the fuzzy sets, we must initially consider a dataset with the following characteristics:

- J discrete response variables (measured on each individual);
- L_j response categories;
- i households in the sample;
- K extreme profiles.

Model parameters

The K extreme profiles represent the reference profiles to which the fuzzy sets are associated by a Grade of Membership score g_{ik}, e.g., the degree to which the household i belongs to the k^{th} profile. Furthermore, the following conditions must apply:

- $g_{ik} \geq 0$ for each i, k;
- $\sum_{k=1}^{k} g_{ik} = 1$ for each i.

Thus, the closer to 1 the degree g_{ik} gets, the stronger the association of household i with the extreme profile k.

For each variable j for household i, Y_{ijl} is defined as the response (categories of the variable) represented by a set of L_j binary random variables. The probability of a response l for the j^{th} variable with the k^{th} extreme profile is defined λ_{kjl}, for which the conditions bellow apply:

- $\lambda_{kjl} \geq 0$ for each k, j, l;
- $\sum_{l=1}^{L_j} \lambda_{kjl} = 1$ for each k, j.

Maximum likelihood model

The probability of a response of level l to the j^{th} question by household i, conditional on g_{ik} scores, is given by the bilinear form:

$$Pr(Y_{ijl} = 1) = \sum_{k=1}^{k} g_{ik}.\lambda_{kjl}$$

Hence, the parameters λ_{kjl} and g_{ik} can be iteratively estimated by Maximizing the Multinomial Likelihood:

$$L(y) = \prod_{i=1}^{I} \prod_{j=1}^{J} \prod_{l=1}^{L_j} \left(\sum_{k=1}^{k} g_{ik} . \lambda_{kjl} \right)^{y_{ijl}}$$

In the present study, we want to estimate the characteristics of the extreme profiles that would represent high and low vulnerabilities (K=2), for this, 13 variables were chosen (J=13). The model estimates the probabilities of a category (*l*) belonging to each of the profiles (λ_{kjl}) ; the set of categories with high probabilities represents the association to the unobservable dimensions of high or low vulnerability.

Simultaneously, for each household (*i*), according to the responses to the categories of the 13 variables, the model estimates the grade of membership g_{ik} to the each one of the profiles. Thus, a household with grade of membership to the extreme profile of high vulnerability of 0.75 means that they have 75 per cent of the characteristics of this profile, therefore 25 per cent of the characteristics of low vulnerability.

Outputs and description of extreme profiles

The model outputs are the λ_{kjl} probabilities of the response category of the variables for each profile, and the estimated grades of membership g_{ik} for each household of the dataset. To evaluate the estimated profiles, we compare the λ_{kjl} generated with the marginal frequencies (MF) of each variable response (Cardoso et al, 2011). The authors use a threshold of 20 per cent for the ratio $\lambda_{kjl}/\mathrm{MF}$ to consider the category as characteristic of the profile.

Table A3.1 shows these estimated probabilities and marginal frequencies. The category of the variable is considered characteristic of the profile when the estimated probabilities are greater than the marginal frequencies by a threshold level of 45 per cent. However, results greater than 1.2 are also highlighted. From those rules, we can describe the two extreme profiles constructed by the GoM Model:

Extreme profile 1

Resilient/Non-Vulnerable Profile: Urban households that did not present deprivation of household infrastructure or of access to educational and health services and neither presented an association with severe or moderate food insecurity status or with a low dietary diversity;

Extreme profile 2

Rural Vulnerable Profile: this profile is mostly composed of rural households with poor household conditions and infrastructure (access to safe water and electricity), poor access to health and educational services and is associated with a severe level of food insecurity and with low dietary diversity. This profile is also more vulnerable to experiencing the symptoms related to infectious diseases and has a higher prevalence of pregnant or lactating women.

The other output of the model is the assignment of Grades of Membership to both extreme profiles, for each of the households in the dataset. These grades of membership represent the degree of membership of a particular household to that specific profile. By specifying quartile intervals for the grades of membership, we have defined four categories of vulnerability.

Table A3.1

Probability λ_1jl of a variable category to belong to an extreme profile. Mozambique, 2018

Variables	Categories	Marginal frequencies (MF)	Profile 1	Profile 2	Ratio	
			λ_{1jl}	λ_{2jl}	λ_{1jl}/MF	λ_{2jl}/MF
Sanitation	Adequate	0.568	0.999	0.001	1.759	0.002
	Inadequate	0.432	0.001	0.999	0.002	2.313
Flooring material	Adequate	0.64	0.999	0.001	1.561	0.002
	Inadequate	0.36	0.001	0.999	0.003	2.775
Placement of household	Rural	0.41	0.001	0.999	0.002	2.437
	Urban	0.59	0.999	0.001	1.693	0.002
Assets	5 items or more	0.561	0.981	0.004	1.75	0.006
	Less than 5 items	0.439	0.018	0.998	0.041	2.271
Electricity	Yes	0.549	0.999	0.001	1.821	0.002
	No	0.451	0.001	0.999	0.002	2.213
Access to safe water	Adequate	0.673	0.999	0.177	1.484	0.263
	Inadequate	0.327	0.001	0.823	0.003	2.519
Child education (child school attendance)	At least one out of school	0.151	0.001	0.363	0.007	2.411
	All attending school	0.849	0.999	0.637	1.176	0.75
Adult schooling	5 years or more	0.435	0.647	0.12	1.488	0.275
	Less than 5 years	0.565	0.353	0.88	0.625	1.557
Time to access health services	1 hour or more	0.211	0.001	0.554	0.005	2.623
	Less than one hour	0.789	0.999	0.446	1.267	0.565
Pregnant or lactating women at the household	Yes	0.247	0.164	0.364	0.666	1.476
	No	0.753	0.836	0.636	1.109	0.844
Infectious diseases symptoms (fever and muscle pain)	Yes	0.186	0.101	0.309	0.541	1.661
	No	0.814	0.899	0.691	1.105	0.849
Food insecurity experience scale (FIES)	Severe	0.503	0.393	0.659	0.781	1.31
	Moderate	0.339	0.447	0.186	1.32	0.549
	No or mild	0.158	0.156	0.161	0.986	1.02
Household dietary diversity scale (HDDS)	Low	0.141	0.001	0.333	0.007	2.371
	Moderate	0.622	0.585	0.674	0.941	1.084
	High	0.237	0.375	0.049	1.581	0.207

Table A3.2

Categories of vulnerability according to intervals of grades of membership to each extreme profile. Mozambique, 2018

Category of vulnerability	Grades of membership—profile 1(g_{i1})	Grades of membership—profile 2 (g_{i2})
High	[0.00 to 0.25)	[0.75 to 1.00)
Medium-high	[0.26 to 0.50)	[0.50; to 0.74)
Medium-low	[0.51 to 0.75)	[0.25 to 0.49)
Low	[0.76 to 1.00]	[0.00 to 0.24)

After defining the four vulnerability profiles associated with the intervals defined by the grade of memberships, we detailed their characteristics by comparing the distribution of the categories of the variables in each profile.

Table A3.3 shows the percent and the 95 per cent confidence interval for each variable by the four vulnerability levels, considering the sample design and weights.

Table A3.3

Percent distribution with 95 per cent confidence interval of the characteristics of variables of the total population and categories of vulnerability. Mozambique, 2018

Variables	Characteristics	Total population	Vulnerability			
			High	Medium-high	Medium-low	Low
Sanitation	Adequate	39.0±08.2	10.4±08.0	37.9±12.9	58.6±12.2	93.2±03.7
	Inadequate	61.0±08.2	89.6±08.0	62.1±12.9	41.4±12.2	06.8±03.7
Flooring material	Adequate	42.3±09.4	04.8±03.3	51.1±13.9	90.4±06.1	97.8±01.8
	Inadequate	57.7±09.4	95.2±03.3	48.9±13.9	09.6±06.1	02.2±01.8
Living environment	Rural	69.9±09.0	97.1±03.5	81.3±10.6	57.8±17.8	9.0±06.1
	Urban	30.1±09.0	02.9±03.5	18.7±10.6	42.2±17.8	91.0±06.1
Assets	5 items or more	43.9±05.9	17.2±05.3	57.9±13.5	60.4±10.6	85.3±03.9
	Less than 5 items	56.1±05.9	82.8±05.3	42.1±13.5	39.6±10.6	14.7±03.9
Electricity	Yes	30.9±08.0	.000±00.0	16.1±12.9	57.5±17.1	96.3±02.2
	No	69.1±08.0	100.0±0.0	83.9±12.9	42.5±17.1	03.7±02.2
Access to safe water	Adequate	50.6±10.0	25.4±13.7	45.7±14.9	78.4±10.8	96.7±02.0
	Inadequate	49.4±10.0	74.6±13.7	54.3±14.9	21.6±10.8	3.3±02.0
Child education (child school attendance)	At least one out school	21.7±04.7	33.2±06.3	14.3±06.5	19.0±06.1	02.9±01.4
	All attending school	78.3±04.7	66.8±06.3	85.7±06.5	81.0±06.1	97.1±01.4
Adult schooling	5 years or more	32.3±05.3	14.7±05.3	35.3±09.6	49.3±08.0	61.1±05.1
	Less than 5 years	67.7±05.3	85.3±05.3	64.7±09.6	50.7±08.0	38.9±05.1
Time to access health services	1 hour or more	40.6±09.8	64.6±11.6	39.4±15.7	15.0±10.6	00.0±00.0
	Less than one hour	59.4±09.8	35.4±11.6	60.6±15.7	85.0±10.6	100.0±0.0
Pregnant or lactating women at the household	Yes	29.1±04.7	35.6±06.9	27.1±08.4	27.3±10.0	17.4±03.1
	No	70.9±04.7	64.4±06.9	72.9±08.4	72.7±10.0	82.6±03.1
Infectious diseases symptoms (fever and muscle pain)	Yes	24.6±06.7	32.8±10.6	22.4±09.6	18.1±06.5	11.2±03.5
	No	75.4±06.7	67.2±10.6	77.6±09.6	81.9±06.5	88.8±03.5
Food insecurity experience scale (FIES)	Severe	54.5±06.3	63.6±08.6	53.6±11.2	46.0±13.9	38.9±05.7
	Moderate	15.7±02.7	15.2±04.3	17.5±06.5	15.0±06.1	15.8±03.1
	No or Mild	29.8±05.7	21.2±07.8	28.9±11.6	39.0±15.7	45.4±05.9
Household dietary diversity scale (HDDS)	Low	19.1±05.3	27.9±08.6	18.1±06.9	13.9±07.8	03.2±01.6
	Moderate	63.6±04.5	62.0±07.1	72.0±07.6	67.2±12.2	60.0±05.3
	High	17.3±04.1	10.1±04.9	09.9±06.5	18.9±11.6	36.9±05.7
Number of cases		1,500	419	197	182	702

The Table A3.3 shows that:

- High-level vulnerability is characterised as the rural population with low capability to acquire fortified foods and to handle them, and with a higher degree of hindrances to the absorption of nutrients;
- Medium-high level is the rural population with moderate capability to acquire and handle fortified foods;
- Medium-low level is the peri-urban population with high capability; and
- Low level is the urban population with high capability and low hindrances.

The population covered by the NFFP along these four levels of vulnerability showed how the benefits of the programme have reached diverse segments of the population.

APPENDIX 4: TABLES OF FOOD FORTIFICATION COVERAGE BY SOCIAL STRATA (SECTION 8)

This appendix presents the tables with estimated coverage values for each placement of household and vulnerability conditions. The estimates are all presented within 95 per cent confidence intervals.

Table A4.1

Coverage rate per 100 households by stage indicators (type of vehicle consumed) and rural-urban placement of the household. Mozambique, 2018

Placement of household	Vehicle	Coverage rate of vehicle			
		Any source	Fortifiable	Fortified at any level	Fortified
Urban (N=1776198)	Wheat flour	63.0±7.3	61.8±7.4	37.4 (±7.4)	5.9±2.2
	Maize flour	99.4±0.6	93.7±2.5	78.0 (±7.6)	10.1±2.9
	Sugar	97.1±1.8	94.6±2.2	53.5 (±4.9)	46.2±4.7
	Vegetable oil	99.1±0.6	97.8±1.4	86.8 (±4.3)	4.6±2.5
Rural (N=4123392)	Wheat flour	22.2±7.4	20.6±7.1	10.1 (±4.7)	3.3±2.0
	Maize flour	96.9±3.9	80.8±7.6	61.1 (±12.7)	3.8±2.2
	Sugar	85.9±6.5	80.9±7.4	30.1 (±7.6)	26.1±7.8
	Vegetable oil	94.7±3.9	92.5±4.7	51.9 (±10.0)	1.5±1.2

Table A4.2

Population covered by NFFP, by type of vehicle and rural-urban placement of the household, by condition of fortification. Mozambique, 2018

Placement of household	Vehicle	Population covered by NFFP, by type of vehicle			
		Fortifiable	Access to any level fortified	Fortified (*Boletim da República*, 2016)	Fortified (INNOQ, 2017)
Urban	Wheat flour	3,634,005 (±925,586)	5,969,697 (±1,303,486)	1,437,499 (±519,561)	680,773 (±220,143)
	Maize flour	7,261,226 (±1,555,438)	8,586,949 (±1,693,001)	1,289,423 (±370,134)	1,289,423 (±370,134)
	Sugar	5,010,829 (±1,003,391)	8,714,209 (±1,677,066)	1,071,687 (±384,662)	4,384,514 (±900,336)
	Vegetable oil	7,993,389 (±1,534,368)	8,989,052 (±1,738,363)	3,106,576 (±696,427)	527,335 (±228,287)
Rural	Wheat flour	1,982,152 (±1,052,152)	4,531,535 (±1,969,418)	1,424,760 (±856,289)	766,185 (±424,609)
	Maize flour	12,175,468 (±4,218,920)	15,934,270 (±4,396,603)	1,037,562 (±649,773)	1,037,562 (±649,773)
	Sugar	6,295,151 (±2,195,296)	16,182,537 (±4,520,456)	999,563 (±526,717)	5,663,408 (±2,099,948)
	Vegetable oil	10,494,766 (±3,436,848)	18,424,826 (±5,034,591)	4,711,697 (±1,885,845)	528,628 (±425,144)

Table A4.3

Coverage rate per 100 households by stage indicators (type of vehicle consumed), rural-urban placement of the household and vulnerable groups. Mozambique, 2018

Vehicle	Source	Groups of vulnerability of the household			
		High	Medium-high	Medium-low	Low
		Rural with low capability to acquire fortified food	Rural with moderate capability to acquire fortified food	Peri-urban with moderate capability to acquire fortified food	Urban with high capability to acquire fortified food and low hindrances to absorption of nutrients
Wheat flour	Any source	11.1 (±4.5)	40.9 (±10.8)	59 .0(±9.4)	70.6 (±6.3)
	Fortifiable	11.0 (±4.5)	35.6 (±11.8)	53.9 (±8.0)	70.3 (±6.5)
	Fortified at any level	3.3 (±2.2)	16.8 (±9.2)	34.2 (±10.2)	45.2 (±7.1)
	Fortified	1.1 (±1.2)	8 (±4.7)	9.8 (±4.5)	9.7 (±2.7)
Maize flour	Any source	97.8 (±3.7)	96.1 (±4.5)	95.8 (±5.1)	99.1 (±1)
	Fortifiable	80.2 (±9.6)	83.0 (±9.4)	90.7 (±5.9)	93.1 (±2.5)
	Fortified at any level	60.1 (±13.5)	60.4 (±15.5)	73.9 (±12.5)	80 .0(±7.6)
	Fortified	3.8 (±2.4)	4.4 (±3.1)	8.6 (±4.1)	16.7 (±3.7)
Sugar	Any source	83.0 (±7.4)	90.0 (±5.9)	97.1 (±4.1)	99.1 (±0.8)
	Fortifiable	76.5 (±9.2)	87.9 (±5.7)	94.2 (±4.7)	97.6 (±1.4)
	Fortified at any level	23.4 (±8)	42.8 (±9.2)	50.8 (±7.8)	57.6 (±4.5)
	Fortified	21.3 (±7.8)	39.2 (±9.8)	40.2 (±7.3)	49.3 (±4.7)
Vegetable oil	Any source	94.2 (±4.7)	97.7 (±3.9)	95.0 (±5.1)	99.1 (±0.8)
	Fortifiable	90.4 (±6.1)	99.2 (±1.2)	95.7 (±4.5)	98.2 (±1.0)
	Fortified at any level	44.1 (±11.4)	67.9 (±8)	77.5 (±8.4)	92.2 (±2.4)
	Fortified	1.7 (±1.6)	5 (±3.1)	6.1 (±4.1)	6.0 (±2.7)

International Policy Centre for Inclusive Growth

SBS, Quadra 1, Bloco J, Ed. BNDES, 13º andar
70076-900 Brasília, DF - Brazil
+55 61 2105 5000

ipc@ipc-undp.org • www.ipc-undp.org