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Estimation of per capita cereal grain consumption among four different population groups in Kenya and Bangladesh

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An abstract submitted to the Faculty of the
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in partial fulfillment of the requirements for the degree of
Master of Public Health
2021

Abstract

Background and objective: Fortification of grains including wheat flour (WF), maize flour (MF) and rice (R), can reduce micronutrient deficiencies. Accurate grain-consumption estimates ensure reliable fortification design and impact assessment. The objective was to compare multiple approaches for estimating grain consumption in Kenya and Bangladesh.
Methods: Analysis and comparison of three approaches per country: 1) Existing dietary/proxy databases, 2) Milling associations' data on grains available for human consumption, and 3) FAO's food balance sheet data.
Results: For Approach 1, three datasets were analyzed for Kenya (Kenya National Micronutrient Survey 2011, Kenya Hunger Safety Net Programme Survey 2016, GENuS 2011) and two for Bangladesh (Bangladesh Integrated Household Survey 2018-19, GENuS 2011).
For example, for KNMS, the average (SD) consumption of WF, MF and R was 56.7 (91.4), 167.6 (163) and 21.9 (63.5) grams/capita/day, respectively, while for BIHS, it was 28.2 (44.8), 0.2 (3.6) and 300.6 (226.8) g/c/d, respectively. In GENuS for Bangladesh, the median consumption was 35.7, 0.84, and 472.9 g/c/d for WF, MF and R, respectively.
Consumption was estimated for sub-groups. For example, for KNMS, the average (SD) consumption of WF, MF and R for pre-adolescents and adolescents was 75.2 (105), 219.7 (152.4), and 23.2 (93.2) g/c/d, respectively and for women, it was 71.4 (103), 180 (175.9), and 26.6 (66.4) g/c/d, respectively. From Approach 2, WF, MF and R available in Kenya in 2018 was 116.8, 245.7, and 58 g/c/d, respectively, while in Bangladesh from mid-2018 to mid-2019 it was 109 g/c/d (WF) and 599.8 g/c/d (R). In Approach 3, the 2018 supply of wheat and wheat products, maize and maize products, and rice and rice products in Kenya was 110, 206.5, and 60 g/c/d, respectively, and in Bangladesh was 51.2, 1.9, and 711.5 g/c/d, respectively.
Conclusion: In Kenya and Bangladesh, grain consumption estimates from dietary or comparable surveys were lower than those estimated from milling association availability figures and FAO food balance sheet information, with the exception of rice in Kenya. These data suggest that depending on the source of grain-intake information, the potential coverage, reach, and impact of fortified grains can vary.

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Acknowledgment

Many thanks to my thesis chair Dr. Helena Pachón. Without her support, I could not have finished the thesis. I wish to thank colleagues from Nutrition International who filled data gaps in Approach 1 and gathered the data for Approach 2: Jacqueline Kung'u, Joy Kiruntimi, Mandana Arabi, Manpreet Chadha, Martha Nyagaya, Mary Kihara and Manoj Kumar Raut. I also appreciate the support from Matthew R. Smith in understanding the GENuS database, Becky Tsang in sharing datasets, and Alexandra Doyle for answering our questions on the Kenya Hunger Safety Programme Phase 2 2016 dataset.

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Chapter 1. Introduction and Literature Review

Global Micronutrient Situation

Micronutrients are vitamins and minerals which the human body needs in small amounts to function optimally.[1] Micronutrient deficiencies cause poor health outcomes in individuals, with repercussions for societies. Iron deficiency affects 24.8% of the world's population and disproportionately affects children and women living in low- and middle-income countries (LMIC) where iron-rich foods are not broadly consumed.[2,3] 42% children and 40% pregnant women have anemia.[4] Anemia, whether caused by nutrient deficiencies or non-nutritional factors, is a major contributor to maternal and child mortality among LMIC.[5] Vitamin A deficiency impairs innate immunity and causes night blindless and xerophthalmia.[6,7] Also, Vitamin A deficiency affect 127 million children and 7 million pregnant women.[8] Folate is an important mineral involved in DNA synthesis.[9] Folate deficiency in the pregnant woman causes neural tube defects in her children and can increase the risk of diabetes-associated congenital disabilities and autism.[9] As zinc is important for the immune system, development and growth, and zinc deficiency cause these poor health outcomes.[10]

Food Fortification

Food fortification is the addition of micronutrients to food to improve its nutritional quality and reduce the risk of micronutrient deficiencies and their consequences.[11] Food fortification is a cost-effective intervention for reducing micronutrients deficiencies.[12] From the 1920s to 1930s, iodine was added to salt to reduce goiter and vitamin D was added to milk to reduce vitamin D deficiencies.[13] Then, in the 1940s, the fortification of wheat flour with several nutrients started.[13] Today, there are around 140 countries with guidance or regulations for fortification.[14] At least one kind of cereal grain is mandatory in 86 countries.[15]

Fortification of Cereal Grains

Cereal grains include but are not limited to wheat flour, maize flour and rice. Cereal grains are good vehicles for micronutrients because people consume them as staple foods daily worldwide.[16] In practice, many micronutrients are added to cereal grains through fortification, such as iron, vitamin B12, vitamin A, zinc, etc.[17] In planning food fortification programs, it is essential to know the amount of the food consumed by the target beneficiaries so that recommended nutrient levels can be added.[18] Unfortunately, not all countries have nationally representative food-consumption surveys. In these cases, FAO food balance sheets provide information on the amount of food supply for human consumption.[19] While it is a national figure, it cannot provide estimates on the amount of food available for different population groups that may be targeted in a fortification program, such as women of childbearing age.

Cereal Grains in Kenya and Bangladesh

In Kenya, the most frequently consumed cereal grains are maize and maize products.[20] Kenya consumed the most cereal grains in the eastern African countries about 121.3 kg/capita/year in 2001-03.[21] Between 1960 to 2000, maize consumption did not change a lot, but the consumption of wheat more than doubled and rice consumption was significantly increased in Eastern African countries.[21] However, the consumption of maize reduced. In 2009, the maize consumption was 88 kg/capita/year.[22] In 2018, the maize consumption was 60 kg/capita/year.[20]

In Bangladesh, the most consumed cereal grain is rice.[23] From 1961 to 2013, wheat consumption doubled.[24] For rice and rice products, the per capita consumption declined from 458.5 to 367.2 grams per capita per day from 2000 to 2016.[23] For wheat and wheat products, the per capita consumption increased from 17.2 to 19.8 grams per capita per day from 2000 to 2016.[23] Maize is not a major staple food in Bangladesh and half of people consumed maize only once a week.[25]

Study Objectives

The objectives of this study were to identify and review the most accurate sources of cereal grain consumption among different population groups in two illustrative countries. Also, comparing the cereal grain consumption from three research approaches to identify the most accurate data sources for planning food fortification programs.

Chapter 2. Manuscript

STUDENT CONTRIBUTION: The student designed the protocol, submitted the IRB determination, collected the data for Approach 1 and 3, analyzed the data, and wrote the draft of the manuscript including all tables and figures.

Abstract

Fortification of grains including wheat flour (WF), maize flour (MF) and rice (R), can reduce micronutrient deficiencies. Accurate grain-consumption estimates ensure reliable fortification design and impact assessment. The objective was to compare multiple approaches for estimating grain consumption in Kenya and Bangladesh.

Analysis and comparison of three approaches per country: 1) Existing dietary/proxy databases, 2) Milling associations' data on grains available for human consumption, and 3) FAO's food balance sheet data.

For Approach 1, three datasets were analyzed for Kenya (Kenya National Micronutrient Survey 2011, Kenya Hunger Safety Net Programme Survey 2016, GENuS 2011) and two for Bangladesh (Bangladesh Integrated Household Survey 2018-19, GENuS 2011).

For example, for KNMS, the average (SD) consumption of WF, MF and R was 56.7 (91.4), 167.6 (163) and 21.9 (63.5) grams/capita/day, respectively, while for BIHS, it was 28.2 (44.8), 0.2 (3.6) and 300.6 (226.8) g/c/d, respectively. In GENuS for Bangladesh, the median consumption was 35.7, 0.84, and 472.9 g/c/d for WF, MF and R, respectively.

Consumption was estimated for sub-groups. For example, for KNMS, the average (SD) consumption of WF, MF and R for pre-adolescents and adolescents was 75.2 (105), 219.7

(152.4), and 23.2 (93.2) g/c/d, respectively and for women, it was 71.4 (103), 180 (175.9), and 26.6 (66.4) g/c/d, respectively.

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In Approach 3, the 2018 supply of wheat and wheat products, maize and maize products, and rice and rice products in Kenya was 110, 206.5, and 60 g/c/d, respectively, and in Bangladesh was 51.2, 1.9, and 711.5 g/c/d, respectively.

In Kenya and Bangladesh, grain consumption estimates from dietary or comparable surveys were lower than those estimated from milling association availability figures and FAO food balance sheet information, with the exception of rice in Kenya. These data suggest that depending on the source of grain-intake information, the potential coverage, reach, and impact of fortified grains can vary.

Introduction

Food fortification is the addition of micronutrients to foods while they are being processed, to increase nutrient intake and reduce micronutrient deficiencies.[26] Staple foods are selected for fortification because, by definition, they are consumed by large proportions of populations. Industrially processed cereal grains, such as rice, wheat flour, and maize flour, are mandated to be fortified in 86 countries.[15]

An important step in designing a food fortification program is setting a standard that indicates nutrients, nutrient levels, and fortification compounds to be added to fortified foods.[18] This process requires an accurate estimate of the consumption of the target food, especially among beneficiary groups such as children and women of childbearing age. For mature fortification programs, more accurate estimates of who consumes foods and what amounts they consume allow for more reliable calculations of the potential coverage, reach, and impact of fortified food. For the cereal grains, there is no one source of such intake estimates for different population groups across countries. The best available estimate for close to 200 countries is the amount of grains available for human consumption, as generated from FAO food balance sheets.[27]

FAO food balance data are helpful for ranking countries with relatively high versus relatively low amounts of grains available for human consumption. However, this crude, national-level figure ignores the differences in cereal grain consumption among population groups within countries.[27] For example, older adults, women and children tend to consume less food than adult men. Thus, the use of one grain availability figure for a country may underestimate or overestimate grains intake for a specific population group.

Additionally, the FAO food balance data provides the food supply estimate, but not the food amount consumed. For example, the potential food waste in the households is ignored.[28] Thus, the actual human food consumption may different from the food supply quantity from FAO. The comparison between the FAO food balance data and food intake is important to justify the accuracy of FAO food balance data in setting food fortification standards for a country.

Several global efforts are underway to provide estimates of food intake for different population groups in countries such as Global Health Data Exchange, WHO/FAO GIFT, Tufts Global Dietary Database, etc.[29,30,31] The publicly available databases generated by these initiatives can be analyzed to estimate cereal grain intake for multiple populations in multiple countries. In so doing, this work has the potential to overcome the limitations of FAO food balance sheets data in setting food fortification standards.

Methods

Ethics

All of the datasets we analyzed were de-identified. Emory University's Institutional Review Board determined that this project was public health practice and did not require further review.

Study Design

This study compared and contrasted the cereal grain consumption results from three different approaches in two illustrative countries. The cereal grains analyzed were wheat flour, maize flour and rice. The approaches provided estimates of cereal grain consumption, availability or supply quantity for the total population (Approaches 2 & 3) or for specific population groups (Approach 1). The analysis focused on the overall population and four population groups: school age children (children of primary school age, pre-adolescents and adolescents), women of childbearing age, adult men and older adults. The estimates were generated using different methods: analysis of existing databases for Approach 1, conversations with milling associations for Approach 2, and downloading of food balance sheets data from the Food and Agriculture Organization (FAO) of the United Nations for Approach 3.

In summary, Approach 1 was an observational and descriptive study. Multiple cross-sectional surveys were analyzed to estimate the daily consumption of cereal grains by different population groups. Approach 2 was conducted by contacting milling associations and asking them to provide estimates on the amount of each cereal grain available for human consumption over a one-year period or on average per month. Approach 3 was conducted by downloading FAO food balance sheet data from the years 2014-2018 for the food supply in kilograms per capita per year to estimate for each of the cereal grains the amount available for human consumption.

Approach 1: Analyzing existing databases for consumption of cereal grains in four different population groups.

This project was conducted in collaboration with Nutrition International (NI), a Canadian-based non-governmental organization. NI supports staple food fortification in seven countries in Africa and Asia: Senegal, Ethiopia, Kenya, Bangladesh, India, Pakistan, and Indonesia. Two illustrative countries for this project were selected among these seven. Seventeen databases were explored for cereal grain consumption information among different population groups in the aforementioned countries (**Table 1**).

Table 1. Seventeen databases explored for cereal grain consumption information for seven countries.

No.	Database	Website address
1	FAO/WHO GIFT	http://www.fao.org/gift-individual-food-consumption/en/
2	HIES/HCES Survey Data	http://www.fao.org/economic/ess/ess-fs/fs-methods/adept-fsn/en/
3	Fortification Assessment Coverage Toolkit (FACT)	https://www.gainhealth.org/media/news/release-fortification-assessment-coverage-toolkit-fact
4	Food System Dashboard	https://foodsystemsdashboard.org/
5	Fortify MIS	https://fortifymis.org/user/login
6	Global Nutrition Report (Report and Country Nutrition Profile)	https://globalnutritionreport.org/
7	Scaling Up Nutrition: monitoring, evaluation, accountability and learning	https://scalingupnutrition.org/Progress-impact/monitoring-Evaluation-Accountability-Learning-Meal/
8	NutriDash	https://www.unicefnutridash.org/login
9	UNICEF Data Website	https://data.unicef.org/topic/nutrition/iodine/
10	World Food Progamme: 5 year country strategy plans	https://www.wfp.org/country-strategic-planning
11	WHO: Vitamin and Mineral Information System	https://www.who.int/vmnis/database/en/
12	WHO: Global Nutrition Policy Review	https://www.who.int/publications/i/item/9789241514873
13	WHO/CDC eCatalogue of indicators for micronutrient programmes	https://extranet.who.int/indcat/Default.aspx
14	Tufts Global Dietary Database	https://www.globaldietarydatabase.org/

15	Global Health Data Exchange	http://ghdx.healthdata.org/
16	GENuS	https://dataverse.harvard.edu/dataverse/GENuS
17	International Household Network	http://catalog.ihsn.org/catalog

For each of the 17 databases, we acquired permission (when required) to use the databases and downloaded the databases, codebooks, reports and other relevant documentation. We assessed the following criteria to select the two countries for further analysis: assessment of intake, purchase or expenditures data for at least one of the three cereal grains; and data were nationally representative (**Table 2**).

Table 2. Number of datasets reviewed for each country and an assessment of whether they met each of the key inclusion criteria for the study.

Region	**Country name**	**Criteria 1: Assessment of purchase[a], consumption expenditure[b], intake[c] for maize flour, rice or wheat flour (n of datasets)**	**Criteria 2: Nationally representative data (n of datasets) among datasets that met Criteria 1**
Asia	Bangladesh	Consumption expenditure (n=5); Consumption expenditure & Purchase (n=1)	n=6
	India	Consumption expenditure (n=2); Intake (n=3)	n=3
	Indonesia	Consumption expenditure (n=3)	n=3
	Pakistan	Consumption expenditure (n=4); Intake (n=1); Purchase (n=1)	n=5
Africa	Ethiopia	Intake (n=3); Consumption expenditure (n=1)	n=1
	Kenya	Consumption expenditure (n=5); Intake (n=4)	n=6

	Senegal	Consumption expenditure (n=2)	n=2

[a] Purchase: food purchase by individuals and households.
[b] Consumption expenditure: food consumption of individuals and households including all sources for obtaining food – self produced, purchased, gifted, etc.
[c] Intake: food intake in a 24-hour period.

Kenya and Bangladesh had the highest number of datasets (n=6) that met both criteria. They were not only the two countries with the most datasets overall, but also the Asian and African country with the most datasets, respectively. Bangladesh's datasets included two surveys from the Bangladesh Household Income and Expenditure Survey (HIES) series (2010 and 2016-17), three surveys from the Bangladesh Integrated Household Survey (BIHS) series (2011-12, 2015, and 2018-19) and four surveys from the Kenya Hunger Safety Net Programme Impact Evaluation/survey series (2009-10, 2010-11, 2012 and 2016). Because we were unable to access and download the complete HIES 2016-17 data and the HIES 2010 dataset was incomplete, we excluded them both from data analysis.

For both countries, we only analyzed the most recent survey in a series. For Bangladesh, we analyzed the Bangladesh Integrated Household Survey (BIHS) 2018-19 and GENuS 2011. For Kenya, we analyzed Hunger Safety Net Programme Survey 2016 (Phase 2), Kenya National Micronutrient Survey (KNMS) 2011 and GENuS 2011.

Quantitatively, we generated descriptive statistics for two datasets for Bangladesh and three datasets for Kenya. To do this, three datasets (Kenya National Micronutrients Survey 2011, Kenya-Hunger Safety Net Programme Survey 2016, and Bangladesh Integrated Household Survey 2018-19) were converted to and analyzed in SAS (version 9.4) and two GENuS datasets were converted to and analyzed in Excel (version 16.45). First, we categorized the whole population into four groups by age and sex: (1) children including two subgroups: children of primary school age (5-9.9 y) and pre-adolescents and adolescents (10-18.9 y), (2) women of childbearing age (15-49.9 y), (3) adult men (15-49.9 y), and (4) Older adults (50+ years). Then, we calculated the unadjusted per capita daily consumption of cereal grains for each population group and overall. If the datasets or reports mentioned sample weights, the adjusted consumption estimates were generated. Qualitatively, we assessed the pros and cons of each database for generating such intake figures.

This analysis focused on foods that could potentially be fortified. Wheat and maize grains, for example, cannot be fortified—it is the flour that is fortified. For rice, this analysis focused on whole-grain rice, not rice flour. Because we do not know how much cereal grains were fortified or not, we combined fortified cereal grains with unfortified cereal grains.

Kenya National Micronutrient Survey (KNMS 2011)

The KNMS 2011 applied a 24-hour dietary recall to assess dietary intake in pre-adolescents and adolescents (39 individuals) and women of childbearing age (510 individuals).[32] The KNMS 2011 dataset included 13,777 food records for 826 individuals.[32] The study documentation indicated that a second recall day was administered on a sub-set of the population. In fact, only three people had both the first day and the second day recall, so we deleted the second day recall for those individuals, leaving a total of 13,751 records.[32] We limited the analysis to the following foods: rice grain, wheat flour, maize flour and foods where rice grain, wheat flour or maize flour were ingredients (e.g., pasta). This resulted in 2224 records from 549 individuals included in the analysis (**Table 3** and **Table 4**). None of the individuals had missing values for sex or age. We used sample weights to calculate the adjusted cereal grain consumption.

The survey classified the amount of processed and unprocessed foods (**Table 3** and **Table 4**). However, study documentation did not explain what the terms processed and unprocessed mean.

Therefore, for wheat and maize flour, we assumed there was no difference between the weight of processed and unprocessed flour (**Table 3**). For rice grain, the weight of processed rice was assumed to be different than the weight of the unprocessed rice, because cooked rice has a larger volume than uncooked rice. This assumption is based on the Kenya Food Composition Table 2018.[33] For bread and dried pasta (where flour is an ingredient), the weight of the processed flour was assumed to be different than the weight of the unprocessed flour; processed values were converted to unprocessed values (**Table 4**). For other foods where flour is an ingredient (e.g., chapati), we assumed there was no difference between the weight of processed and unprocessed flour.

For foods where flour is an ingredient, we made an assumption of the grain that constituted the flour: maize or wheat (**Table 4**). We also assumed that 90% of the food (e.g., biscuit) was made up of the flour (e.g., wheat flour). For maize grains, we use the extraction rate 0.675 to maize flour to calculating the amount of maize flour consumption.[34]

The amount of unprocessed grain consumed daily by different population groups was calculated in grams. Whole grains (e.g., maize grains) were included in the analysis after applying the extraction rate to covert to flour.[34] We excluded rice flour, because we estimated the fortified food or food that can be fortified industrially and rice flour cannot be fortified industrially.

Table 3. For the Kenya National Micronutrient Survey 2011 (KNMS 2011), the number of records of processed and unprocessed rice grain, rice flour, wheat flour, maize flour and maize grains that were included in the analysis.[32]

Food[a]	**Processed[b] (n)**	**Unprocessed[c] (n)**
Wheat flour white	0	30
Wheat flour white, process	231	3
Rice grain, polished, QUALITATIVE-INFO = White/refined	0	106
Rice grain, polished, PROCESS = Boiling, QUALITATIVE-INFO = White/refined[d]	111	4
Maize flour, INGREDIENT = Pulses flour, INGREDIENT = Soyabeans for consumption (dry)	0	17
Maize flour, PROCESS = Boiling, QUALITATIVE-INFO = Integral /not refined, QUALITATIVE-INFO = White	2	0
Maize flour, PROCESS = Boiling, QUALITATIVE-INFO = White, QUALITATIVE-INFO = Integral /not refined	729	0
Maize flour, PROCESS = Boiling, QUALITATIVE-INFO = White, QUALITATIVE-INFO = White/refined	2	0
Maize flour, PROCESS = Boiling, QUALITATIVE-INFO = White/refined	203	0
Maize flour, QUALITATIVE-INFO = White, QUALITATIVE-INFO = Integral /not refined	0	157
Maize flour, QUALITATIVE-INFO = White/refined	0	60
Maize flour, QUALITATIVE-INFO = Yellow, QUALITATIVE-INFO = Integral /not refined	0	4
Maize grain, PROCESS = Boiling, PROCESS = Drying (dehydration), QUALITATIVE-INFO = White, PART-CONSUMED-ANALYSED = With skin	31	0
Maize grain, PROCESS = Boiling, QUALITATIVE-INFO = White, QUALITATIVE-INFO = Fresh [e]	119	1
Maize grain, PROCESS = Boiling, QUALITATIVE-INFO = White, QUALITATIVE-INFO = Fresh [e]	26	0
Maize grain, PROCESS = Boiling, QUALITATIVE-INFO = White, QUALITATIVE-INFO = Fresh, PHYSICAL-STATE = Whole/unsplit form, including artificial forms [e]	3	0
Maize grain, PROCESS = Drying (dehydration), PROCESS = Boiling, QUALITATIVE-INFO = White, PART-CONSUMED-ANALYSED = W/o skin [e]	3	0
Maize grain, PROCESS = Drying (dehydration), QUALITATIVE-INFO = White, PART-CONSUMED-ANALYSED = W/o skin [e]	0	16

Maize grain, PROCESS = Drying (dehydration), QUALITATIVE-INFO = White, PART-CONSUMED-ANALYSED = With skin [e]	32	0
Maize grain, PROCESS = Roasting, QUALITATIVE-INFO = White, QUALITATIVE-INFO = Fresh, PART-CONSUMED-ANALYSED = With cob [e]	29	0
Maize grain, QUALITATIVE-INFO = White, QUALITATIVE-INFO = Fresh [e]	0	14
Maize grain, QUALITATIVE-INFO = White, QUALITATIVE-INFO = Fresh, PART-CONSUMED-ANALYSED = With cob [e]	0	1
Total	1521	413

[a] 100% of the amount consumed was assumed to be flour for wheat and maize, and 100% was assumed to be the grain for rice. This is the food name as described in the database.[32]

[b] Number of records where the "edible amount of the [grains] (or the ingredient of a mixed dish/recipe) [was] consumed after processing/cooking".[32]

[c] Number of records where the "edible (e.g., without bones, peels) amount of the [grains] (or the mixed dish/recipe ingredient) [was] consumed before processing".[32]

[d] To convert from processed to unprocessed, we used the following edible conversion factors from the Kenya Food Composition Tables 2018: 1 gram of unprocessed rice grain = 2.98 grams of processed rice grain.[34]

[e] The extraction rate for converting maize grain to maize flour in Kenya is 0.675.[33]

Table 4. For the Kenya National Micronutrient Survey 2011 (KNMS 2011), the number of records of processed and unprocessed foods where rice grain, wheat flour or maize flour were ingredients (e.g., pasta) that were included in the analysis.[32]

Flour-containing food[a]	Grain in ingredient, stated[d]	Grain in ingredient, assumed[e]	Processed[b] (n)	Unprocessed[c] (n)
Biscuits	NA	Wheat	4	2
Wheat wholemeal flour	Wheat	NA	0	1
Cereal bars plain	NA	Wheat	2	5
Chapati	Wheat and similar	NA	1	0
Doughnuts	NA	Wheat	5	1
Dried pasta, PROCESS = Boiling, QUALITATIVE-INFO = White/refined	NA	Wheat	0	6

Dried pasta, PROCESS = Boiling, QUALITATIVE-INFO = Integral /not refined[f]	NA	Wheat	1	0
Dried pasta, QUALITATIVE-INFO = White/refined[f]	NA	Wheat	9	1
Fried dough sweet, QUALITATIVE-INFO = Hard	NA	Wheat	4	6
Fried dough sweet	NA	Wheat	2	4
Fried dough sweet, INGREDIENT = Salt, INGREDIENT = Vegetable fats and oils, edible	NA	Wheat	1	0
Mixed breakfast cereals	NA	Wheat	1	0
Muffins	NA	Wheat	13	1
Pancakes	NA	Wheat	0	1
Plain cakes	Wheat	NA	10	2
Porridge (in dry form, to be diluted)	NA	Maize	0	15
Porridge (ready to eat), INGREDIENT = Maize flour, QUALITATIVE-INFO = White, QUALITATIVE-INFO = Integral /not refined	Maize Flour	NA	2	0
Scones and similar	Wheat	NA	5	4
Traditional unleavened breads	Wheat	NA	1	0
Wafers	NA	Wheat	1	0
Wheat bread and rolls, brown or whole meal	NA	Wheat	12	0
Wheat bread rolls, white refined flour	NA	Wheat	158	9
Total			232	58

Abbreviation: NA, not applicable.

[a] For these foods that contain flour but are not exclusively made of flour, it was assumed that 90% of the amount consumed was flour.
[b] Number of records where the "edible amount of the [grains] (or the ingredient of a mixed dish/recipe) [was] consumed after processing/cooking".[32]
[c] Number of records where the "edible (e.g., without bones, peels) amount of the [grains] (or the mixed dish/recipe ingredient) [was] consumed before processing".[32]
[d] The flour-containing food was noted in the KNMS 2011 database as containing flour from this grain.[32]
[e] The flour-containing food was not noted in the KNMS 2011 database as containing flour from this grain; the grain was assumed.
[f] To convert from processed to unprocessed, we used the following edible conversion factor from the Kenya Food Composition Tables 2018: 1 gram of dried, unprocessed pasta = 2.9 grams of processed pasta.[34]

Kenya-Hunger Safety Net Programme Survey (KHSNP) 2016, Phase 2

The KHSNP 2016 assessed households' weekly food consumption between 13 February and 29 June 2016.[35] The KHSNP 2016 dataset included 64,213 records from 5,979 households.[35] We limited the analysis to the following foods: maize flour (pre-packed), maize flour (posho), wheat flour, rice (pre-packed), rice (loose), pasta (pre-packed), pasta (loose (macaroni)), bread and other ready-made food (biscuits and snacks). This resulted in 12,921 records from 5,569 households included in the analysis (**Table 5**).

Because KHSNP 2016 assessed the food consumption at the household level and provided the sex and age of every member of the household, we used the adult male equivalent (AME) fractions to calculate the apparent food consumption per person based on their sex and age.[36] If one household included more than one person belonging to the population groups of interest (i.e. children, women of childbearing age, adult men, older adults), we only counted the apparent grain consumption of one person in the household. Because KHSNP 2016 assessed households' food consumption over seven days, we divided the consumption amount by seven to generate daily apparent intake per person in grams. We used population weight to calculate the adjusted apparent cereal grain consumption.

For foods where flour is an ingredient, we made an assumption of the grain that constituted the flour (**Table 5**). We assumed that 90% of the food (e.g., bread) was made up of the flour. For the other ready-made food (e.g., biscuits, snacks), we assumed that 90% of them was made up of the flour.

Table 5. For the Kenya-Hunger Safety Net Programme Survey (KHSNP) 2016, the type of grain in the food and the percentage of food which made up by cereal grains that were included in the analysis.[35]

Food[a]	**100% cereal grains**	**Grain in ingredient, assumed (if no)**	**% of food made up by cereal grains**
Maize flour (pre-packed)	Yes	NA	100
Maize flour (posho)[b]	Yes	NA	100
Wheat flour	Yes	NA	100
Rice (pre-packed)	Yes	NA	100
Rice (loose)	Yes	NA	100
Pasta (pre-packed)	No	Wheat	90
Pasta (loose (macaroni))	No	Wheat	90
Bread	No	Wheat	90
Other ready-made food (biscuits, snacks)	No	Wheat	50

Abbreviation: NA, not applicable.

[a] Foods included in the analysis were maize flour, wheat flour and rice as well as flour-containing food: pasta (pre-packed), pasta (loose (macaroni)), bread and other ready-made food (biscuits, snacks).

[b] Maize flour (posho) is defined as maize flour milled in small hammer mills.[21]

The food amounts in the KHSNP 2016 dataset were described with 20 different units, both conventional and unconventional. The conventional units were kilograms, grams, litre, millilitre and Tin (2kg). The unconventional units were single unit, packet, bunch, small tin (tomato paste), cup, head, table spoon, tea spoon, bag (polythene), bottle, jerrycan, small sack (less than

20kg), big sack (more than 20kg), and bucket(debe) **(Table 6)**. The other (specify) unit included plate, plates, big plates, JUGs, JUG, water glass, pieces, and a loaf (**Table 7**).

Because the dataset provided information on how much local currency was used to purchase a fixed amount of food, we used currency and food amount to calculate the number of grams in unconventional units. We completed this calculation for each of the four counties in the survey. For example, in county 1, household 1 consumed 1000 grams of maize flour which cost 500 Kenya Shillings (KSH). Household 2 consumed 10 single units of maize flour which cost 200 KSH. We used the equation 1000 grams / 500 KSH = X grams / 200 KSH, to calculate X = 400 grams for household 2. If 10 single units of maize flour weigh 400 grams, then 1 single unit is equal to 40 grams. We applied this methodology to generate **Table 6** and **Table 7**.

For other ready-made food, we were unable to calculate the grams in single unit, packet, and small sack (less than 20kg) (**Table 6**). We were also unable to calculate the grams in a loaf of bread (**Table 7**). This information was obtained from a local market in Kenya where a packet of biscuits and a loaf of bread were purchased and the grams in each were noted. However, because it was not possible to identify a single unit and small sack (less than 20kg) for other ready-made food (e.g., biscuits) in a local market, we deleted from the analysis all single unit (n=42) and small sack (less than 20kg) (n=1) observations for ready-made food.

Table 6. For the Kenya-Hunger Safety Net Programme Survey (KHSNP) 2016, the weight in kilograms of unconventional units for the foods in the analysis, by each of four geographic counties (C1-C4).

Food	**Unconventional units**												
	Single unit	**Packet**	**Bunch**	**Small tin (tomat**	**Cup**	**Heap**	**Table spoon**	**Bag**	**Bottle**	**Jerry can**	**Small Sack (less than 20kg)**	**Big sack (more than**	**Bucket (debe)**

				o paste)								**20 kg)**	
Maize flour (pre-packed)	C2: 0.9 kg C3: 1.0 kg	C1: 0.9 kg C2: 1.0 kg C3: 1.1 kg	0[a]	0	C1: 0.4 kg C2: 0.4 kg	0	0	C1: 1.2 kg	C2: 1.0 kg	0	0	0	0
Maize flour (Posho)	C2: 1.1 kg	C1: 1.4kg C2: 1.2 kg C3: 2.7 kg C4: 0.8kg	C2: 26.5 kg	C3: 1.1 kg	C1: 0.8 kg C2: 0.5 kg	0	0	C1: 1.3 kg C4: 1.0 kg	0	0	C1: 15.2kg C2[e] 26 kg	C1: 35.4 kg	C1: 5.7 kg
Wheat Flour	C1: 0.1 kg C3: 0.9 kg	C1: 0.7kg C2: 1.0 kg	0	0	C1: 0.4 kg C2: 0.4 kg	0	0	C2: 1.1kg C3: 0.9 kg C4: 4.4 kg	0	0	0	0	0
Rice – pre – packet	0	C3: 1.1 kg	0	0	C1: 0.6 kg	0	0	C1: 0.7 kg	0	0	0	0	0
Rice – loose	C2: 0.9 kg	C4: 1.1 kg	0	0	C1: 0.5 kg C2: 0.4kg	C3[d]: 1.1kg	C2[d]: 1.2 kg	C1: 0.6 kg C4: 1.1 kg	0	0	0	0	0

Pasta – pre-packed	C2: 1.1 kg C3: 1.7 kg C4: 0.4 kg	C1: 0.389kg C2: 1.03 kg C4: 0.5176kg	0	0	C3: 2.9 kg	0	0	C1: 0.4 kg C3: 1.5 kg C4: 0.7 kg	0	C3: 0.04 kg	0	0	0
Pasta – loose	C2: 0.4 kg	C1: 0.7 kg C2: 0.8 kg C3: 0.9 kg	0	0	0	0	0	0	0	0	0	0	0
Bread	C1: 0.5 kg C2, C3, C4: same with C1[b]	C1: 0.5 kg C2, C3, C4: same with C1[b]	0	0	0	0	0	C1: 0.4 kg C4: same with C1[b]	0	0	0	0	0
Other ready made foods (biscuits, snacks)	Unknown[f]	C1[c]: 0.1 kg C2, C3, C4: same with C1[b]	0	0	0	0	0	0	0	0	Unknown[f]	0	0

[a] 0 means no household reported the food in this unconventional unit.
[b] No conventional unit was reported for this food in counties 2, 3, or 4. The grams calculated for county 1 were used for counties 2-4.
[c] Market weight of a packet of Biscuits (Manji Brand) is 0.08 kilograms measured by Mary Kihara (email communication, March 2021).
[d] The calculated weight of a heap and tablespoon is larger than the weights for heap and tablespoon than reported in the Kenya food composition table 2018.[38]

[e] The small sack was labeled less than 20kg, but the calculated unit of small sack was larger than 20kg.
[f] We could not find foods in these unconventional units at a local market in Kenya, therefore these foods were excluded from the analysis.

Table 7. For the Kenya-Hunger Safety Net Programme Survey (KHSNP) 2016, the weight in kilograms of unconventional units (special) for the foods in the analysis, by each of four geographic counties (C1-C4).

Food	**Special Units**							
	Big Plates	**JUGS**	**JUG**	**Plate**	**Plates**	**Water Glass**	**A loaf**	**Pieces**
Maize flour (Posho)	C1: 1.3kg	C1: 2.4kg	C1: 2.4kg	C1: 0.5kg	C1: 1.4kg	0	0	0
Wheat Flour	C1: 1.1kg	0	0		0	0	0	0
Rice - loose	C1: 0.9kg	0	0		0	C1: 0.7kg	0	0
Bread	0	0	0		0	0	C3[a] 0.6kg	C1: 0.03kg

[a] A loaf of bread of Supaloaf brand is 0.6 kilograms weighted by Joy Kiruntimi (email communication, March 2021).

Bangladesh Integrated Household Survey (BIHS) 2018-19

The BIHS 2018-19 assessed households' food consumption over 7 days.[39] The BIHS 2018-19 dataset included 210,837 records from 5,605 households.[39] We limited the analysis to the following foods: rice grain, wheat flour, maize flour and foods where rice grain and flour were ingredients (e.g., pasta). This resulted in 11,711 records from 5,605 households included in the analysis.[39] One hundred percent of the rice grain, wheat flour, and maize flour were assumed to contain rice, wheat and maize, respectively. Flour-containing foods (e.g., biscuits) were assumed to contain between 1-99% of rice grain or wheat flour (**Table 8**); this assumption was made by cognizant in-country NI staff.

The food units included three conventional units (kilograms, grams, litres) and the "number" of those units. Per the codebook, "number" is the average weight of the food in grams. For example, if number was 5 and the average weight in grams was 100 grams, the total food consumed was 500 grams.

Because BIHS 2018-19 assessed the food consumption at household level and provided the sex and age of every individual in households, we used the adult male equivalent (AME) fractions to calculate apparent food consumption per person based on their sex and age.[36] If one household included more than one person belonging to any of the four population groups of interest (children, women of childbearing age, adult men, older adults), we only calculated grain consumption of one person in the household. Because BIHS 2018-19 assessed households' food consumption over seven days, we divided the apparent consumption amount by seven to estimate daily apparent intake. We used population weight to calculate the adjusted apparent cereal grain consumption.

This dataset has an important limitation. For all of the foods that were purchased outside of the households, the conventional units and "amount" were not reported; only the monetary amount spent (in local currency) was reported. Since the weight of these purchased foods was not provided, we excluded these foods from the analysis (**Appendix 1**). Doing so underestimated the consumption of rice and wheat flour.

Table 8. For the Bangladesh Integrated Household Survey (BIHS) 2018-19, the number of records for each food item included in the analysis which contain rice grain, wheat flour and maize flour.[39]

Food[a]	**Number of records (n)**	**Cereal grain**	**What percentage of the food is made up of the grain?(%)[c]**
Atta	1795	Wheat flour	100
Cerelac[b]	40	Wheat flour	50[c]
Chaatu (Corn flour)	50	Maize flour	100

Chira (flattened)	549	Rice	100
Maida	389	Wheat flour	100
Muri/Khoi (puffed rice)	3506	Rice	100
Non-parboiled rice (coarse)	943	Rice	100
Parboiled rice (coarse)	3131	Rice	100
Suji (cream of wheat/barl)	205	Wheat flour	100
Wheat[d]	9	Wheat	75
Semai/noodles[b]	1094	Wheat flour	70[c]

[a] This is the food name as described in the database.[39]
[b] These foods contain flour but are not exclusively made of flour was noted by Jala Bhai (email communication, March 2021).
[c] The proportion of food that is made of rice grains, wheat flour, and maize flour; this value was noted by Jala Bhai (email communication, March 2021).
[d] We used the extraction rate 0.75 to convert wheat to wheat flour.[33]

Global Expanded Nutrient Supply (GENuS) for Bangladesh and Kenya 2011

GENuS contains calculated edible food in grams per person per day for 225 food items from 175 countries.[40] GENuS expanded FAO food balance sheet data with FAO production and trade data to identify 225 food items and used the Global Dietary Database (GDD) to calculate the amount of edible food in each country.[40,41] There were a total of 32 datasets with results classified by age and sex.[40] For example, for ages 0-4 years and 5-9 years, the amount of edible food for both sexes was recorded in one dataset. Then, from age (in years) 10-15, 16-19, 20-24, 25-29, 30-34, 35-39, 40-45, 46-49, 50-54, 55-59, 60-64, 65-69, 70-74, 75-79, and 80+, the edible food for females and males was recorded in different datasets.[40]

The GENuS methodology converted national point estimates for the amount of food available for human consumption to edible food for 20+ population groups (stratified by age and sex) in each country.[41] The food consumption was assumed by average amount for children of primary school age and preadolescents and adolescents, because the GDD data did not exist for individuals less than 20 years of age.[41] Then, based on the FAO food balance sheet and FAO production and trade data, GENuS food groups included rice (milled equivalent), wheat, maize, corn (maize) flour and wheat flour. We assumed that rice, wheat and maize were unprocessed grains. We used country-specific extraction rates to convert the wheat to wheat flour and maize to maize flour.[33] Because GENuS did not include maize flour in Bangladesh, we limited the country's analysis to the following foods: rice, wheat, maize flour and wheat flour. For Kenya, we limited the analysis to the following foods: rice, wheat, maize, maize flour and wheat flour.

We used the median food consumption and weighted the four population groups based on their proportion in the population (e.g., population pyramid) for Kenya and Bangladesh to calculate the per capita cereal grain consumption (**Table 9 and Table 10**).[42,43] For example, for women of childbearing age (15 – 49 years old) in Kenya, the population pyramid estimated that 5.3% of females in the population in 2011 were between 15-19 years, 4.9% were between 20-24 years, 4.3% were between 25-29 years, 3.5% were between 30-34 years, 2.8% were between 35-39 years, 2.1% were between 40-44 years, and 1.7% were between 45-49 years. The total proportion of women of childbearing age out of the total female population was 24.6%.[42]

Table 9. For the GENuS database, the population groups, population pyramid, and median per capital cereal grain consumption in Kenya.[40]

Population groups	Sex; Age (years)	Median food consumption of cereal grains (g/person/day) [a] [1]	Proportion of the opulation (%)[b] [2]	Proportion in the population group (%)[c] [3]	Median per capita cereal grain consumption in population groups before applying the extraction rate (g/person/day)[d] [4]	Median per capita cereal grain consumption in population groups after applying the extraction rate[e] (g/person/day)[5]
Children of primary age	Both sexes; 5-9	Rice: 19.8 Maize: 122.7 Wheat: 7.7 Maize flour: 54.8 Wheat flour: 54.8	14.4	14.4	Rice: 19.8 Maize: 122.7 Wheat: 7.7 Maize flour: 54.8 Wheat flour: 54.8	Rice: 19.8 Maize flour: 137.6[f] Wheat flour: 60.6[g]
Preadolescents and adolescents	Male; 10-14	Rice: 24.5 Maize: 153.3 Wheat: 9.6 Maize flour: 67.7 Wheat flour: 68.5	6.4	23.3	Rice: 24.8 Maize: 154.7 Wheat: 9.7 Maize flour: 68.3 Wheat flour: 69.13	Rice: 24.8 Maize flour: 172.7 Wheat flour: 76.4
	Male; 15-19	Rice: 30.5 Maize: 190.4 Wheat: 12.0 Maize flour: 84.1 Wheat flour: 85.1	5.3			
	Female; 10-14	Rice: 22.1 Maize: 138.0 Wheat: 8.7 Maize flour: 60.9 Wheat flour: 61.7	6.3			

	Female; 15-19	Rice: 22.5 Maize: 140.6 Wheat: 8.8 Maize flour: 62.1 Wheat flour: 62.8	5.3			
Women of childbearing age	Female: 15-19	Rice: 22.5 Maize: 140.6 Wheat: 8.8 Maize flour: 62.1 Wheat flour: 62.8	5.3	24.6	Rice: 21.5 Maize: 134.6 Wheat: 35 Maize flour: 59.4 Wheat flour: 60.159	Rice: 21.5 Maize flour: 150.3 Wheat flour: 86.4
	Female: 20-24	Rice: 20.1 Maize: 125.4 Wheat: 7.9 Maize flour: 55.4 Wheat flour: 56	4.9			
	Female: 25-29	Rice: 20.7 Maize: 129.5 Wheat: 36.1 Maize flour: 57.2 Wheat flour: 57.9	4.3			
	Female: 30-34	Rice: 21.3 Maize: 133 Wheat: 8.4 Maize flour: 58.7 Wheat flour: 59.4	3.5			

	Female: 35-39	Rice: 21.8 Maize: 136.2 Wheat: 8.6 Maize flour: 60.1 Wheat flour: 60.9	2.8			
	Female: 40-44	Rice: 22.8 Maize:142.7 Wheat: 9 Maize flour: 63 Wheat flour: 63.8	2.1			
	Female: 45-49	Rice: 23.4 Maize: 146.5 Wheat: 9.2 Maize flour: 64.7 Wheat flour: 65.5	1.7			
Adult men	Male: 15-19	Rice: 30.5 Maize: 190.4 Wheat: 12 Maize flour: 84.1 Wheat flour: 85.1	5.3	24.5	Rice: 27.6 Maize: 172.5 Wheat: 10.8 Maize flour: 76.2 Wheat flour: 77.1	Rice: 27.6 Maize flour: 192.7 Wheat flour: 85.2
	Male: 20-24	Rice: 25.4 Maize: 158.7 Wheat: 10 Maize flour: 70.1 Wheat flour: 70.9	4.9			
	Male: 25-29	Rice: 26.3 Maize: 164.6 Wheat: 10.3 Maize flour: 72.7	4.3			

		Wheat flour: 73.6				
	Male: 30-34	Rice: 26.9 Maize: 167.8 Wheat: 10.5 Maize flour: 74.1 Wheat flour: 75	3.5			
	Male: 35-39	Rice: 27.5 Maize: 171.7 Wheat: 10.8 Maize flour: 75.8 Wheat flour: 76.7	2.8			
	Male: 40-44	Rice: 28.2 Maize: 176.2 Wheat: 11.1 Maize flour: 77.8 Wheat flour: 78.7	2.1			
	Male: 45-49	Rice: 29.5 Maize: 184.1 Wheat: 11.6 Maize flour: 81.3 Wheat flour: 82.3	1.6			
Older adults	Female: 50-54	Rice: 22.6 Maize: 141.5 Wheat: 8.9 Maize flour: 62.5 Wheat flour: 63.2	1.3	7.5	Rice: 26.1 Maize: 163.2 Wheat: 10.3 Maize flour: 72.1 Wheat flour: 72.9	Rice: 26.1 Maize flour: 182.3 Wheat flour: 80.6

	Female: 55-59	Rice: 22.9 Maize: 143 Wheat: 9 Maize flour: 63.2 Wheat flour: 63.9	1			
	Female: 60-64	Rice: 24.8 Maize: 155.1 Wheat: 9.7 Maize flour: 68.5 Wheat flour: 69.3	0.7			
	Female: 65-69	Rice: 26.1 Maize: 163.2 Wheat: 103 Maize flour: 72.1 Wheat flour: 72.9	0.4			
	Female: 70-74	Rice: 26.5 Maize: 165.4 Wheat: 10.4 Maize flour: 73 Wheat flour: 73.9	0.3			
	Female: 75-79	Rice: 17.2 Maize: 169.7 Wheat: 10.7 Maize flour: 74.9 Wheat flour: 75.9	0.2			
	Female: 80+	Rice: 28 Maize: 174.7 Wheat: 11 Maize flour: 77.1 Wheat flour: 78.1	0.1			

	Male: 50-54	Rice: 27.1 Maize: 169.5 Wheat: 10.7 Maize flour: 74.9 Wheat flour: 75.8	1.2			
	Male: 55-59	Rice: 29.1 Maize: 170.3 Wheat: 10.7 Maize flour: 75.2 Wheat flour: 76.1	0.9			
	Male: 60-64	Rice: 29.1 Maize: 181.7 Wheat: 11.4 Maize flour: 80.2 Wheat flour: 81.2	0.6			
	Male: 65-69	Rice: 30.9 Maize: 193.4 Wheat: 12.2 Maize flour: 85.4 Wheat flour: 86.4	0.4			
	Male: 70-74	Rice: 31.3 Maize: 195.4 Wheat: 12.3 Maize flour: 86.3 Wheat flour: 87.3	0.2			

	Male: 75-79	Rice: 31.3 Maize: 195.4 Wheat: 12.3 Maize flour: 87.2 Wheat flour: 88.3	0.1			
	Male: 80+	Rice: 31.6 Maize: 197.5 Wheat: 12.8 Maize flour: 90 Wheat flour: 91.1	0.1			

[a] The median rice and wheat flour consumption as reported by GENuS – Edible Food by Age and Sex 2011 (the name of the actual subdatasets we used in GENuS).[40]
[b] The proportion of the Kenya population disaggregated by age and sex.[42]
[c] The proportions of four population groups in Kenya calculated by adding together all proportions of the relevant age and sex groups.[42]
[d] Calculation for rice and wheat consumption among four different population groups: [4]=[1]* ([2]/[3]).
[e] The extraction rate used to convert wheat grain to wheat flour was 0.75 in Kenya.[33] The comparable extraction rate for maize was 0.675 in Kenya.[33]
[f] Maize flour [5] = Maize [4] * Extraction rate + Maize flour [4].
[g] Wheat flour [5] = Wheat [4] * Extraction rate + Wheat flour [4].

Table 10. For the GENuS database, the population groups, population pyramid, and median per capital cereal grain consumption in Bangladesh.[40]

Population groups	**Sex; Age (years)**	**Median food consumption of cereal grains (g/person/day)[a] [1]**	**Proportion of the opulation (%)[b] [2]**	**Proportion in the population group (%)[c] [3]**	**Median per capita cereal grain consumption in population groups before applying the extraction rate (g/person/day)[d] [4]**	**Median per capita cereal grain consumption in population groups after applying the extraction rate[e] (g/person/day)[5]**

Children of primary age	Both sexes; 5-9	Rice: 399.3 Maize: 1.5 Wheat: 35 Maize flour: NA Wheat flour: 3.1	10.6	10.6	Rice: 399.3 Maize: 1.5 Wheat: 35 Maize flour: NA Wheat flour: 3.1	Rice: 399.3 Maize flour: 1.1[f] Wheat flour: 29.3[g]
Preadolescents and adolescents	Male; 10-14	Rice: 499.1 Maize: 1.9 Wheat: 43.7 Maize flour: NA Wheat flour: 3.8	5.4	20.8	Rice: 506.8 Maize: 1.9 Wheat: 44.4 Maize flour: NA Wheat flour: 3.9	Rice: 506.8 Maize flour: 1.4 Wheat flour: 37.2
	Male; 15-19	Rice: 619.7 Maize: 2.4 Wheat: 54.3 Maize flour: NA Wheat flour: 4.8	5.2			
	Female; 10-14	Rice: 449.2 Maize: 1.7 Wheat: 39.4 Maize flour: NA Wheat flour: 3.5	5.2			
	Female; 15-19	Rice: 457.5 Maize: 1.7 Wheat: 40.1 Maize flour: NA Wheat flour: 3.5	5			
Women of childbearing age	Female: 15-19	Rice: 457.5 Maize: 1.7 Wheat: 40.1 Maize flour:	5	27.5	Rice: 434 Maize: 1.5 Wheat: 35 Maize flour:	Rice: 434 Maize flour: 1.1 Wheat flour:

		NA Wheat flour: 3.5			NA Wheat flour: 3.3	29.6
	Female: 20-24	Rice: 405 Maize: 1.5 Wheat: 35.5 Maize flour: NA Wheat flour: 3.1	4.8			
	Female: 25-29	Rice: 411.9 Maize: 1.6 Wheat: 36.1 Maize flour: NA Wheat flour: 3.2	4.6			
	Female: 30-34	Rice: 421.9 Maize: 1.6 Wheat: 37 Maize flour: NA Wheat flour: 3.2	4.1			
	Female: 35-39	Rice: 443.3 Maize: 1.7 Wheat: 38.9 Maize flour: NA Wheat flour: 3.4	3.5			
	Female: 40-44	Rice: 448.8 Maize: 1.7 Wheat: 39.3 Maize flour:	3			

		NA Wheat flour: 3.5				
	Female: 45-49	Rice: 472.8 Maize: 1,8 Wheat: 41.4 Maize flour: NA Wheat flour: 3.6	2.5			
Adult men	Male: 15-19	Rice: 619.7 Maize: 2.4 Wheat: 54.3 Maize flour: NA Wheat flour: 4.8	5.2	27.8	Rice: 544.9 Maize: 2.1 Wheat: 47.8 Maize flour: NA Wheat flour: 4.2	Rice: 544.9 Maize flour: 1.5 Wheat flour: 40
	Male: 20-24	Rice: 502.2 Maize: 1.9 Wheat: 44 Maize flour: NA Wheat flour: 3.9	4.9			
	Male: 25-29	Rice: 510.7 Maize: 2 Wheat: 44.8 Maize flour: NA Wheat flour: 3.9	4.5			
	Male: 30-34	Rice: 529.2 Maize: 2 Wheat: 46.4 Maize flour: NA Wheat flour: 4.1	4			

	Male: 35-39	Rice: 526.1 Maize: 2 Wheat: 46.1 Maize flour: NA Wheat flour: 4	3.4			
	Male: 40-44	Rice: 554.3 Maize: 2.1 Wheat: 48.6 Maize flour: NA Wheat flour: 4.3	3.1			
	Male: 45-49	Rice: 571.7 Maize: 2.2 Wheat: 50.1 Maize flour: NA Wheat flour: 4.4	2.7			
Older adults	Female: 50-54	Rice: 444 Maize: 1.7 Wheat: 38.9 Maize flour: NA Wheat flour: 3.4	1.8	13.2	Rice: 522.7 Maize: 2 Wheat: 45.8 Maize flour: NA Wheat flour: 4	Rice: 522.7 Maize flour: 1.4 Wheat flour: 38.4
	Female: 55-59	Rice: 461 Maize: 1.8 Wheat: 40.4 Maize flour: NA Wheat flour: 3.5	1.2			

	Female: 60-64	Rice: 497.2 Maize: 1.9 Wheat: 43.6 Maize flour: NA Wheat flour: 3.8	1			
	Female: 65-69	Rice: 517.4 Maize: 2 Wheat: 45.4 Maize flour: NA Wheat flour: 4	0.9			
	Female: 70-74	Rice: 527.5 Maize: 2 Wheat: 46.2 Maize flour: NA Wheat flour: 4.1	0.7			
	Female: 75-79	Rice: 532 Maize: 2 Wheat: 46.6 Maize flour: NA Wheat flour: 4.1	0.4			
	Female: 80+	Rice: 550.8 Maize: 2.1 Wheat: 48.3 Maize flour: NA Wheat flour: 4.2	0.3			
	Male: 50-54	Rice: 517.5 Maize: 2 Wheat: 45.4 Maize flour:	2			

		NA Wheat flour: 4				
	Male: 55-59	Rice: 521.1 Maize: 2 Wheat: 45.7 Maize flour: NA Wheat flour: 4	1.3			
	Male: 60-64	Rice: 560.6 Maize: 2.1 Wheat: 49.1 Maize flour: NA Wheat flour: 4.3	1.1			
	Male: 65-69	Rice: 585.2 Maize: 2.2 Wheat: 51.3 Maize flour: NA Wheat flour: 4.5	1			
	Male: 70-74	Rice: 609.7 Maize: 2.3 Wheat: 53.4 Maize flour: NA Wheat flour: 4.7	0.7			
	Male: 75-79	Rice: 613.3 Maize: 2.3 Wheat: 53.8 Maize flour: NA Wheat flour: 4.7	0.5			

	Male: 80+	Rice: 630.3 Maize: 2.4 Wheat: 55.2 Maize flour: NA Wheat flour: 4.9	0.3			

[a] The median rice and wheat flour consumption as reported by GENuS – Edible Food by Age and Sex 2011 (the name of the actual subdatasets we used in GENuS).[40]
[b] The proportion of the Kenya population disaggregated by age and sex.[43]
[c] The proportions of four population groups in Kenya calculated by adding together all proportions of the relevant age and sex groups.[43]
[d] Calculation for rice and wheat consumption among four different population groups: [4]=[1]*([2]/[3]).
[e] The extraction rate used to convert wheat grain to wheat flour was 0.75 in Bangladesh.[33] The comparable extraction rate for maize was 0.70 in Bangladesh.[33]
[f] Maize flour [5] = Maize [4] * Extraction rate + Maize flour [4].
[g] Wheat flour [5] = Wheat [4] * Extraction rate + Wheat flour [4].

Pros and Cons of each Dataset

What follows are strengths and limitations of each of the datasets used in Approach 1. These pros and cons refer to our ability to use them to estimate cereal grain consumption overall and for different population groups.

Kenya National Micronutrient Survey (KNMS 2011)

1. Pros
    - The data were nationally representative.
    - The dataset recorded individual information with the 24-hour recall methodology.
    - The units of the food amount consumed were clear.
    - The dataset included sample weights to adjust results.
2. Cons

- The sample size in the dataset was small (39 pre-adolescents and adolescents and 510 women of childbearing age).
- There were no data on adult men, older adults and children of primary school age.
- The data were collected ten years ago.
- The dataset documentation did not provide clear definitions of what constituted processed and unprocessed food.

Kenya-Hunger Safety Net Programme Survey (KHSNP) 2016, Phase 2

1. Pros
    - The dataset has a large sample size (n=64,213) and covers all four population groups of interest.
    - The data were nationally representative.
    - The age and sex of each household member were recorded in the dataset, allowing for application of the adult male equivalent methodology.
    - One of the maize flour products included was posho, which allows estimation of maize flour processed in small mills.
    - The dataset included sample weights for adjusting results.

2. Cons
    - The description of food items was vague. For example, it was hard to determine what grains, if any, were included in “other ready-made food (e.g., biscuit and snacks)”.

- The dataset did not mention if the foods were processed food or unprocessed food.
- The number of grams in unconventional units was not provided in the documentation.

Bangladesh Integrated Household Survey (BIHS) 2018-19

1.Pros

- The dataset has a large sample size (n=11,711) and covered all four population groups of interest.
- The age and sex of each household member were recorded in the dataset, allowing for application of the adult male equivalent methodology.
- Many food items were recorded in the dataset, making it much easier to identify which foods are or include cereal grains.
- The units of the food amount consumed were clear.
- The dataset included sample weights for adjusting results.
- The dataset is only three years old.

2.Cons

- Many food items were written in the native language; a native speaker is necessary to interpret if the foods are grains or contain grains in their ingredients.
- For foods purchased outside of the household, the monetary cost of purchasing the food was reported in the dataset, not the quantity of the food. Further

information, not provided in the dataset or documentation, is needed to convert these monetary values to grams.

GENuS database for Bangladesh and Kenya 2011

1.Pros

- The dataset included maize (grains), wheat (grains), rice (grains), corn (maize) flour and wheat flour per capita per person per day, which required the least amount of manipulation among all datasets.
- The dataset provided age- and sex-specific information by 5-year ranges. This matched our four population groups by age and sex.

2.Cons

- The GENuS dataset does not report mean food consumption per person per day; the median consumption is reported, but lack of inter-quartile range.
- The GENuS dataset did not include the number (or percentage) of people in age-sex specific groups per country.

Approach 2: Contacting milling associations for the estimated amount of cereal grains available for human consumption.

After identifying two countries from Approach 1, NI country staff contacted milling associations to request information on the yearly or monthly amount of each cereal grain available for human consumption in those countries. This information was requested for calendar year 2019 or earlier, to avoid potential disruptions caused by COVID-19.

For Kenya, data were provided on the total amount of rice, wheat flour and maize flour (expressed in metric tons, MT) available for human consumption from January to December in both 2018 and 2019 by Mary Kihara (email communication, March 2021). Data were provided for Bangladesh on the total amount (MT) of rice and wheat flour available for human consumption from July 2018 to June 2019 by Ahmmed Guljer (email communication, March 2021).

We divided the total amount available for human consumption by the country's total population to calculate per capita consumption of each cereal grain in the general population. The annual total population at mid-year was obtained from the United Nations Population Division. For Kenya, we used the total population figures from 2018 and 2019.[44] For Bangladesh, we calculated the mean of the population in 2018 and 2019.[45] All data we received from the milling associations was populated in an Excel file. Then, we conducted the quantitative analysis using Excel. Since the milling associations did not provide grain available information for different population groups, the per capita grain available was estimated for each country overall (and not by population group).

Approach 3: FAO food balance sheet data.

We downloaded FAO data from the years 2014-2018 for the per capita amount of each of the cereal grains available for human consumption in both Kenya and Bangladesh: wheat and wheat products, maize and maize products, and rice and rice products.[46] These categories refer to the cereal grain and food products made with cereal grain as ingredients.

Because the FAO food balance sheet data do not include amounts for any population groups, we used the per capita cereal grain consumption information for the general population. We downloaded the food supply quantity in kilograms per capita per year.[47,48] We converted the amounts to grams per capita per day by multiplying by 1000 (from kg to g) and dividing by 365 (from year to day). We limited the analysis to the following food items: wheat and products, rice and products, and maize and products.

Analyses

Three analyses were completed. First, the per capita cereal grain consumption overall and for four different population groups was compared among several databases for each country (Approach 1). Second, the overall per capita cereal grain consumption was compared among the methods described in Approach 1, Approach 2 and Approach 3. Third, we enumerated the pros and cons of using each of the databases in Approach 1 to estimate grain intake.

Results

Approach 1

Descriptive statistics were calculated for per capita grain consumption among four population groups and overall from three datasets for Kenya (**Appendix 2, Appendix 3, Appendix 4**) and two dataset for Bangladesh (**Appendix 5, Appendix 6, Appendix 7**). Results for all three approaches were graphed for wheat flour, maize flour and rice for Kenya **(Figure 1, Figure 2, Figure 3)** and Bangladesh **(Figure 4, Figure 5, Figure 6)**. Three surveys (Kenya National Micronutrient Survey 2011, Kenya Hunger Safety Programme Phase 2 2016, Bangladesh Integrated Household Survey 2018-19) had sample weights; therefore, both unadjusted and adjusted analyses were completed and presented. The GENuS data were reported as unadjusted. For Kenya, the cereal grains available and supply quantity from Approach 2 and Approach 3 is always higher than the cereal grains consumption in Approach 1. The only exception is that KHSNP 2016 reported the highest amounts of rice consumption among all three approaches. For Approach 1, adult men consume the highest amount of wheat flour, maize flour and rice. Pre-adolescents and adolescents, women of childbearing age and adult men consume similar amount of wheat flour, maize flour and rice. Children of primary school age consume always the smallest amount of wheat flour, maize flour and rice. Maize flour is the most consumed cereal grains and rice is the least consumed cereal grains in Kenya.

For Bangladesh, the cereal grains available and supply quantity from Approach 2 and Approach 3 is always higher than the cereal grains consumption in Approach 1. For Approach 1, adult men consume the highest amount of wheat flour, maize flour and rice. Pre-adolescents and adolescents, women of childbearing age and adult men consume similar amount of wheat flour, maize flour and rice. Children of primary school age consume always the smallest amount of wheat flour, maize flour and rice. Children of primary school age consume always the smallest amount of wheat flour, maize flour and rice. Rice is the most consumed cereal grains and maize is the least consumed cereal grains in Bangladesh.

Figure 1 Per capita wheat flour consumption overall and among four population groups (school-age children, women of childbearing age, adult men and older adults) from three databases (Kenya Nation Micronutrient Survey 2011, Kenya Hunger Safety Net Program Phase 2 2016, GENuS), milling associations and FAO food balance sheets in Kenya.

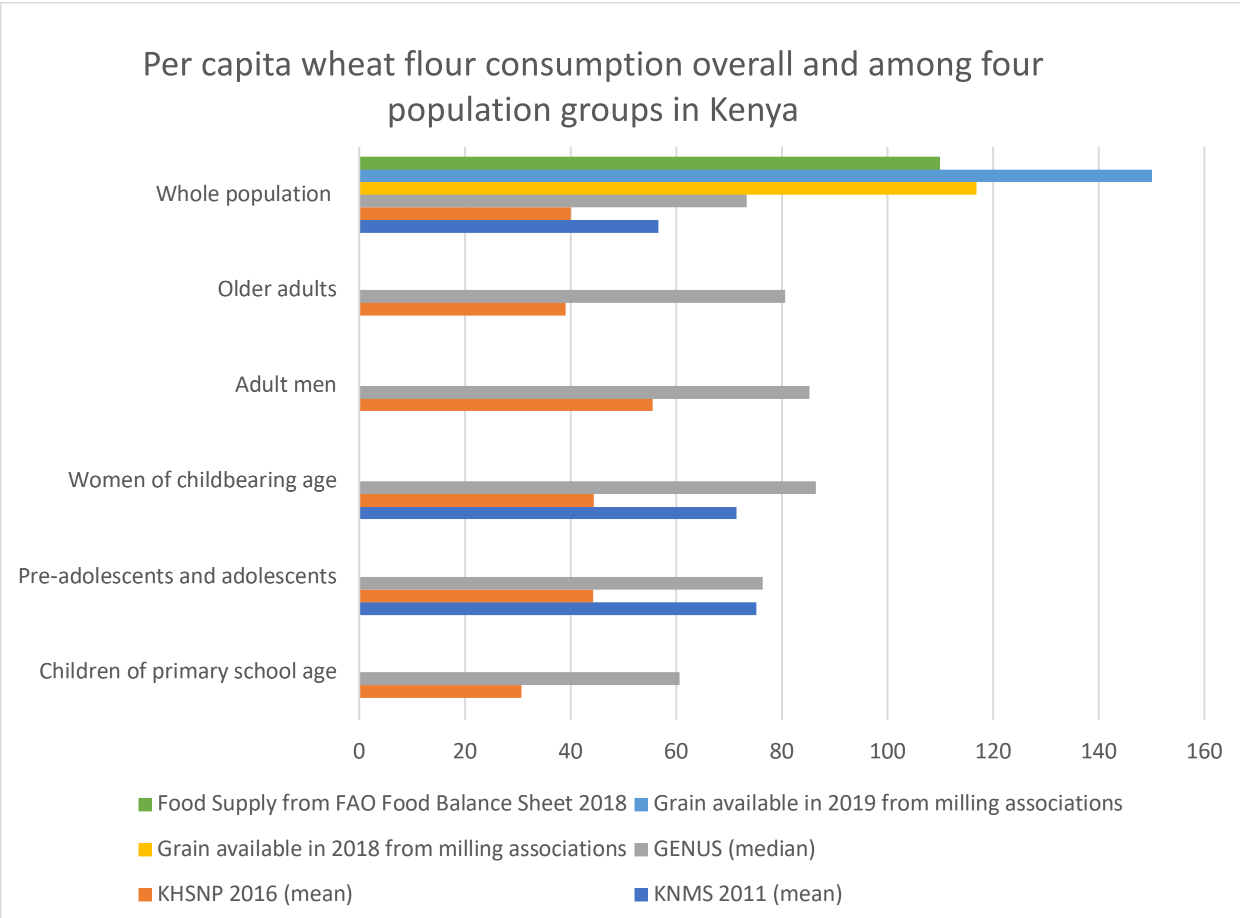


Figure 2. Per capita maize flour consumption overall and among four population groups (school-age children, women of childbearing age, adult men and older adults) from three databases (Kenya Nation Micronutrient Survey 2011, Kenya Hunger Safety Net Program Phase 2 2016, GENuS), milling associations and FAO food balance sheets in Kenya.

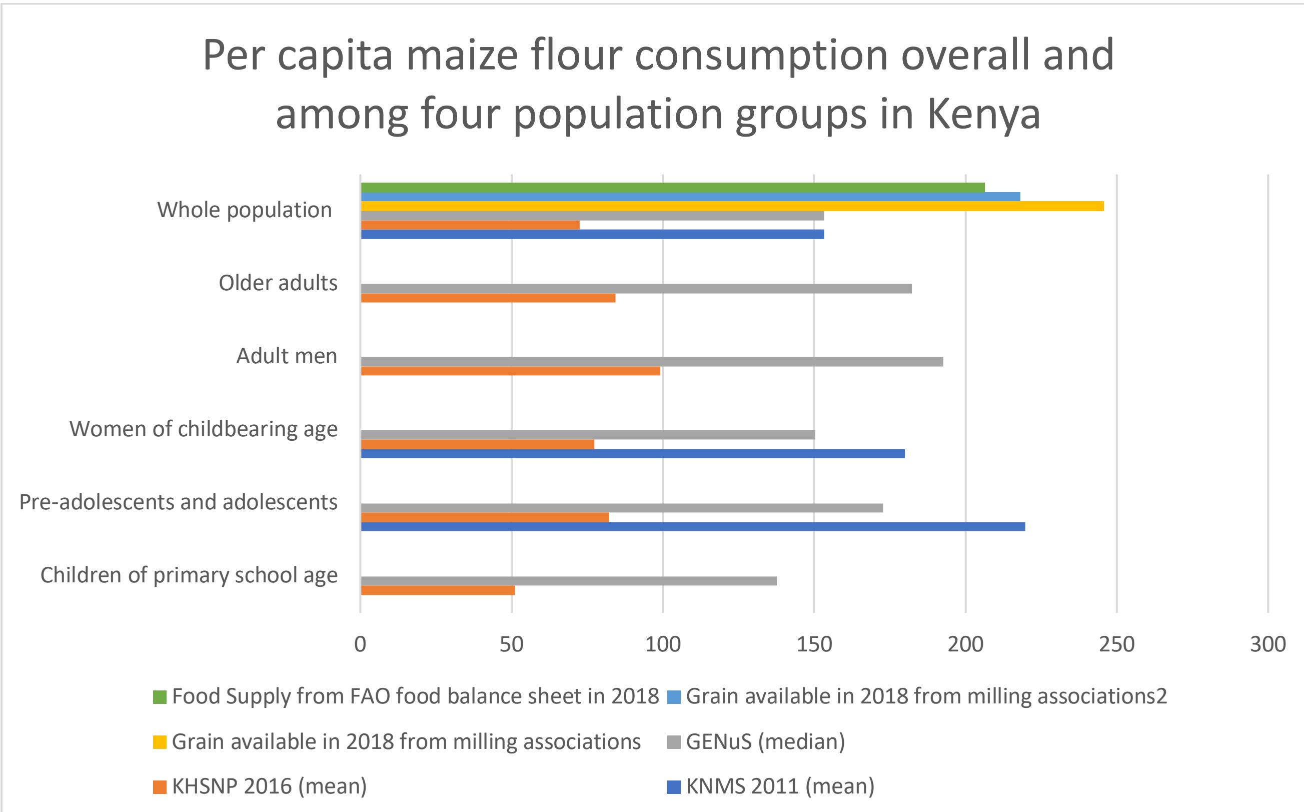


Figure 3. Per capita rice consumption overall and among four population groups (school-age children, women of childbearing age, adult men and older adults) from two databases (Kenya Nation Micronutrient Survey 2011, Kenya Hunger Safety Net Program Phase 2 2016, GENuS) milling associations and FAO food balance sheets in Kenya.

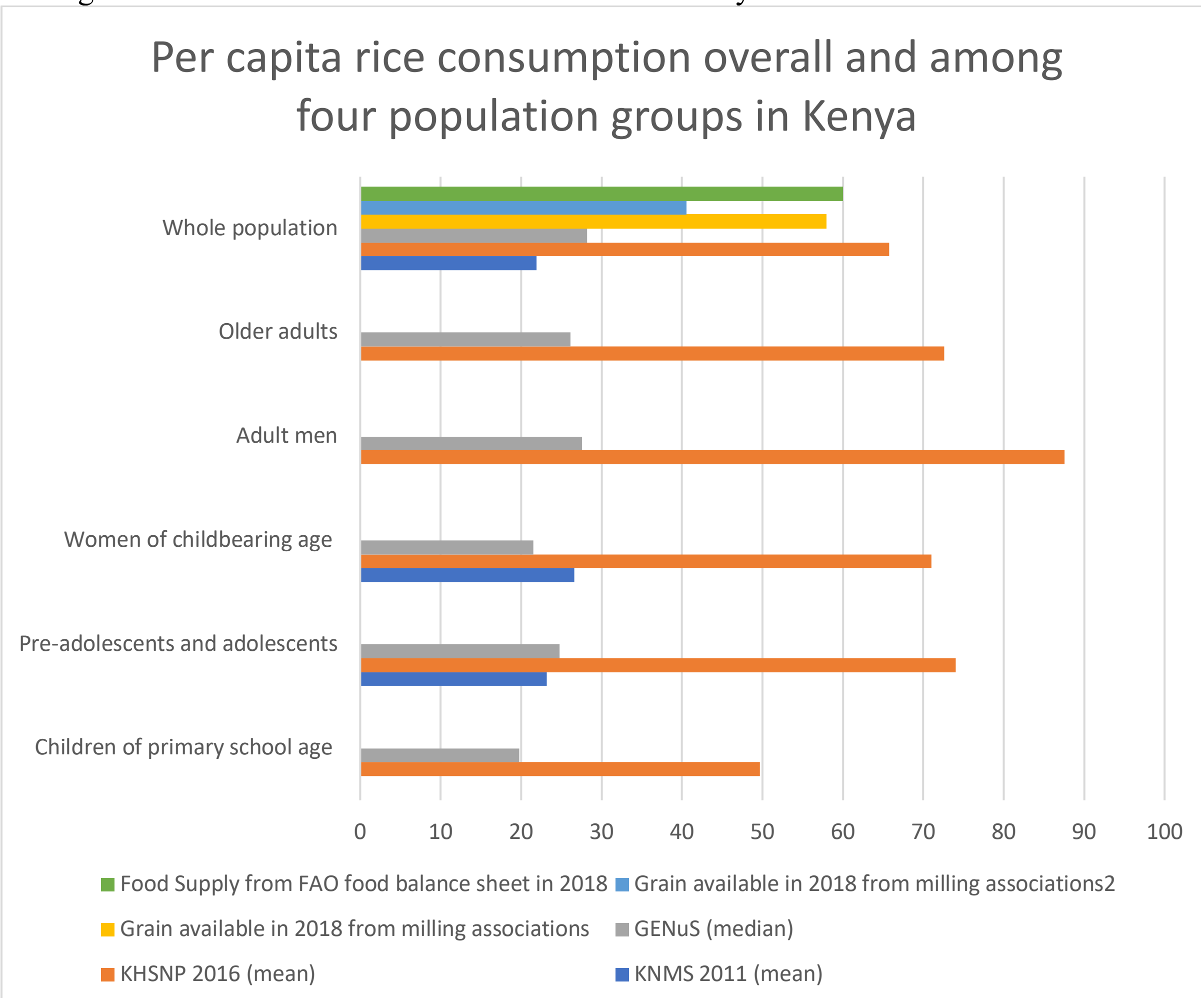


Figure 4. Per capita wheat flour consumption overall and among four population groups (school-age children, women of childbearing age, adult men and older adults) from two databases (Bangladesh Integrated Household Survey 2018-19, GENuS), milling associations and FAO food balance sheets in Bangladesh. BIHS excluded the observations where foods containing wheat flour were purchased outside of the home.

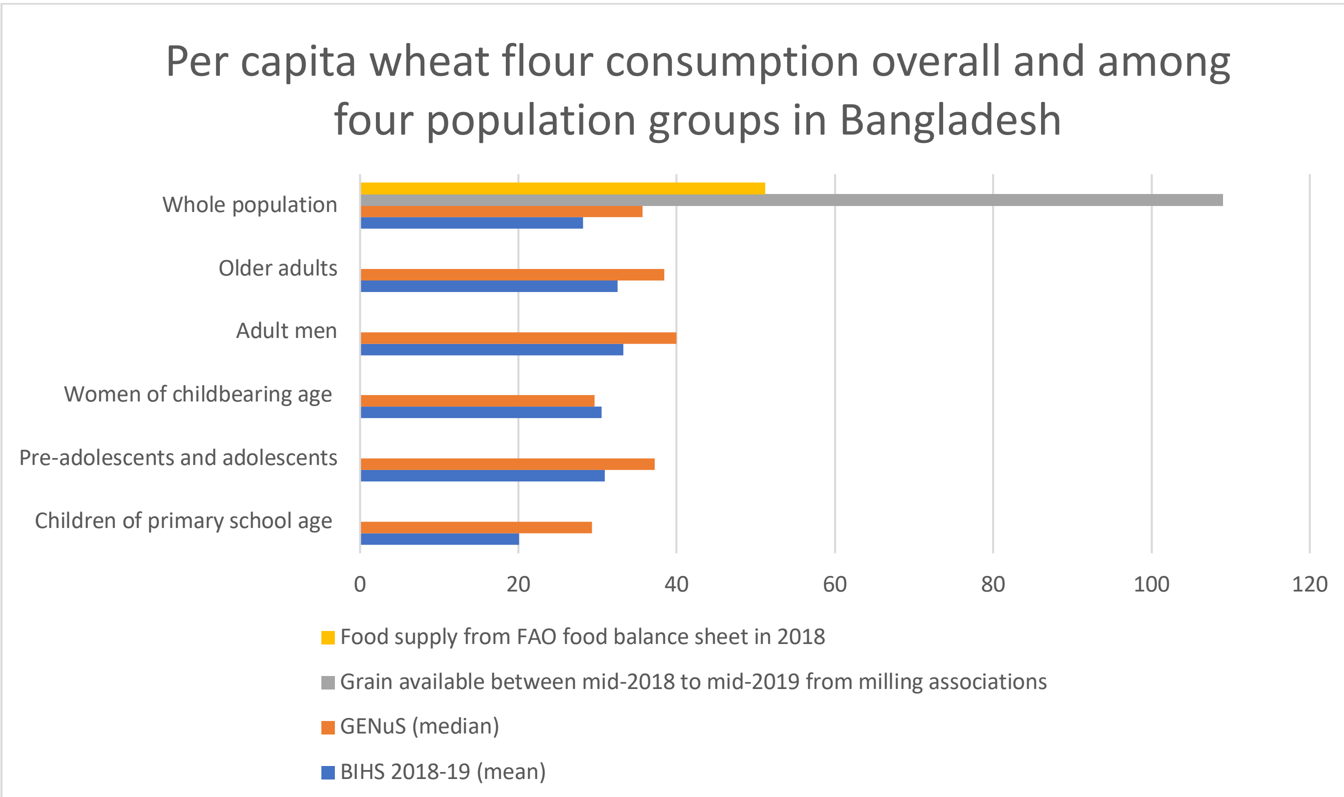


Figure 5. Per capita maize flour consumption overall and among four population groups (school-age children, women of childbearing age, adult men and older adults) from two databases (Bangladesh Integrated Household Survey 2018-19, GENuS) milling associations and FAO food balance sheets in Bangladesh.

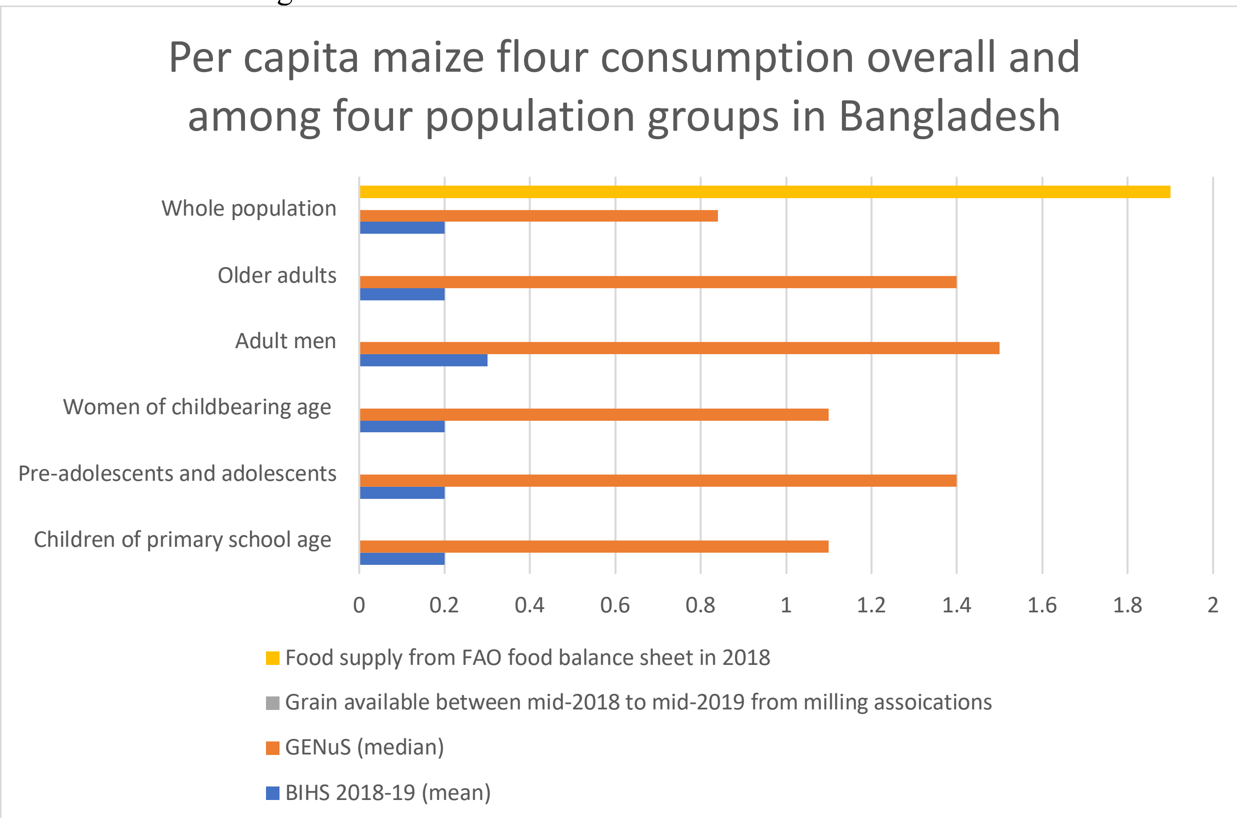
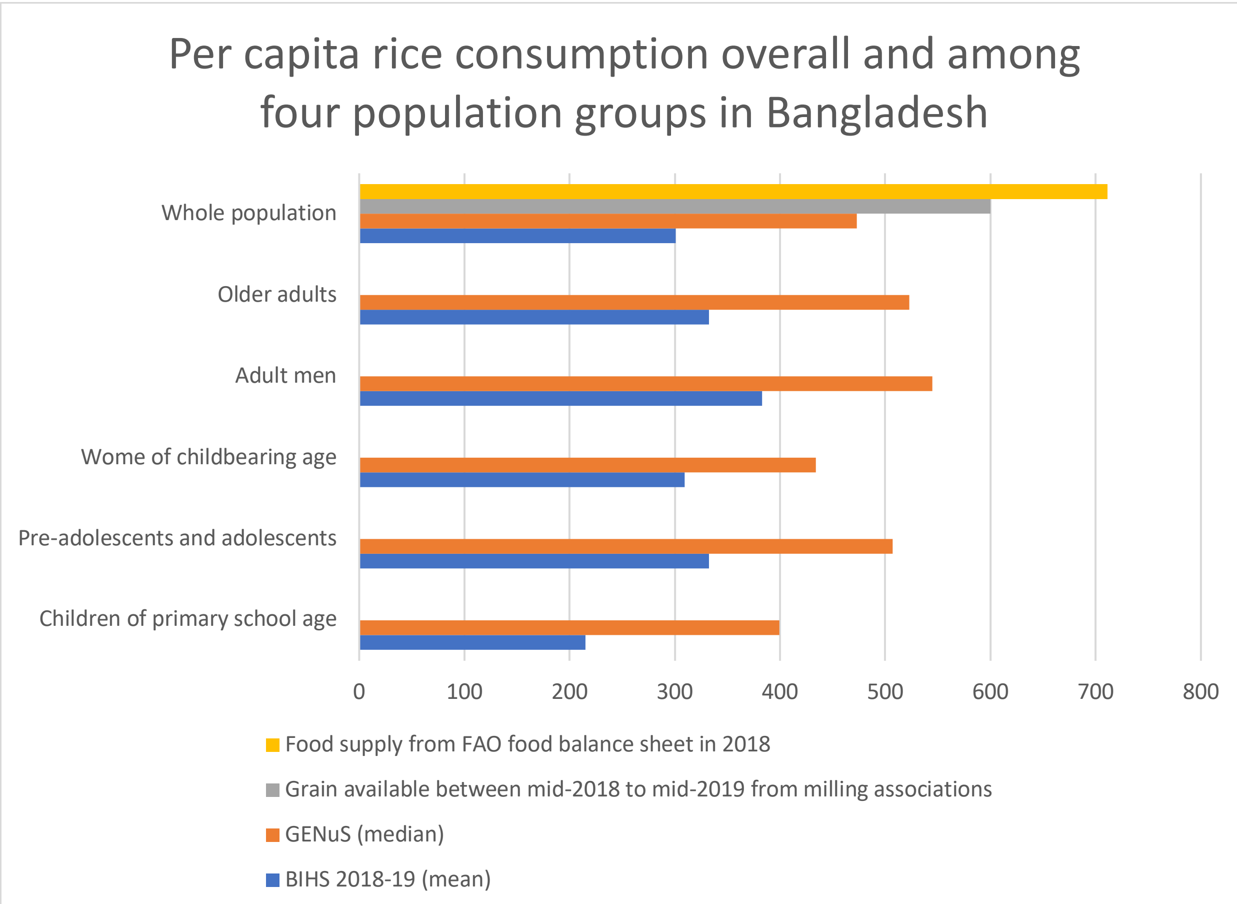


Figure 6. Per capita rice consumption overall and among four population groups (school-age children, women of childbearing age, adult men and older adults) from two databases (Bangladesh Integrated Household Survey 2018-19, GENuS) milling associations and FAO food balance sheets in Bangladesh. BIHS excluded the observations where foods containing rice were purchased outside of the home.



Approach 2. Contacting milling associations for the estimated amount of cereal grains available for human consumption.

The per capita available among the total population varied per grain and country. In 2018, the available wheat flour was 116.8 grams/capita/day, the available maize flour was 245.7 grams/capita/day and the available rice was 58 grams/capita/day in Kenya. In 2019, the available wheat flour was 150 grams/capita/day, the available maize flour was 218.3 grams/capita/day and the available rice was 40.5 grams/capita/day in Kenya (**Table 11**).

Maize flour is available the most among the cereal grains. From 2018 to 2019, wheat flour available increased from 116.8 grams/capita/day to 150 grams/capita/day.

Table 11. Per capita cereal grain available in Kenya in 2018 and 2019.

Year	**Cereal grain**	**Available for human consumption(MT/year) [1][a]**	**PopulationsSize (n) [2][b]**	**Per capita production (grams/capita/day) [3] [c]**
2018 (Jan-Dec)	Wheat Flour	2,172,000	50,951,000	116.8
	Maize Flour	4,570,000	50,951,000	245.7
	Rice	1,078,000	50,951,000	58
2019 (Jan-Dec)	Wheat Flour	2,857.200	52,215,000	150
	Maize Flour	4,161,000	52,215,000	218.3
	Rice	772,584	52,215,000	40.5

Abbreviation: metric tons (MT). 1 MT=10^6 grams.

[a] The cereal grains available for human consumption (MT/year) was provided by Mary Kihara (email communication: March 2021).

[b] The population size used was the total population in Kenya from 2018 and 2019.[44]

[c] Calculation: [3] = ([1] *10^6) / ([2] * 365)

In Bangladesh from July 2018 to June 2019, the available wheat flour was 109 grams/capita/day and rice was 599.83 grams/capita/day (**Table 12**); the available maize flour was not reported. Rice is the most available among the three cereal grains (**Table 12)**.

Table 12. Per capita cereal grain available for human consumption in Bangladesh.

Year	Cereal Grain	Amount of available for human consumption (MT/year) [1]	Population Size (2018-19) (n) [2]	Per capita production (grams/capita/day) [3]
2018-19 (July 2018-June 2019)	Wheat Flour	6,650,000	167,217,000[b]	109
	Maize Flour	NA		NA
	Rice	36,610,000		599.8

Abbreviation: NA, not applicable. Metric tons (MT). 1 MT=10^6 grams.
[a] The cereal grains available for human consumption (MT/year) was provided by Guljer Ahmmed (email communication: March 2021).
[b] Population size in Bangladesh was 166,368,00 in 2018 and 168,066,00 in 2019.[45] The average population size between 2018 and 2019 was 167,217,000.
[c] Calculation: [3] = ([1] *10^6) / ([2] * 365)

Approach 3. FAO food balance sheet data.

From 2014 to 2018 in Kenya, the food supply quantity of wheat and products was 103, 96, 97.3, 101.6, and 110 grams/capita/day, respectively (**Table 13**). During the same period, the food supply quantity of rice and rice products was 66, 51.8, 58.7, 53.2, and 60 grams/capita/day, respectively. The food supply quantity of maize and products was 210.3, 230.8, 216.6, 205.7, and 206.5 grams/capita/day from 2014 to 2018, respectively. Overall, the food supply quantity of wheat and products gradually increased from 2014 to 2018, while the food supply quantity of maize and maize products and rice and rice products decreased during this period.

From 2014 to 2018 in Bangladesh, the food supply quantity of wheat and products was 50, 50, 52.7, 52.3 and 51.2 grams/capita/day, respectively (**Table 13**). The food supply quantity of rice and rice products was 708, 708.9, 701.7, 713.5 and 711.5 grams/capita/day, respectively. The food supply quantity of maize and maize products was 1.8, 1.8, 1.8, 1.8, and 1.9 grams/capita/day, respectively.

Table 13. Per capita cereal grains supply in Bangladesh and Kenya based on FAO new food balance sheet.

Year	**Food Supply Quantity (grams/capita/ day) in Kenya**[a]	**Food Supply Quantity (grams/capita/ day) in Bangladesh**[b]
2014	Wheat and Products[c]: 103 Rice and Products[d]: 66 Maize and Products[e]: 210.3	Wheat and Products[c]: 50 Rice and Products[d]: 708 Maize and Products[e]: 1.8
2015	Wheat and Products: 96 Rice and Products: 51.8 Maize and Products: 230.8	Wheat and Products: 50 Rice and Products: 708.9 Maize and Products: 1.8
2016	Wheat and Products: 97.3 Rice and Products: 58.7 Maize and Products: 216.6	Wheat and Products: 52.7 Rice and Products: 701.7 Maize and Products: 1.8
2017	Wheat and Products: 101.6 Rice and Products: 53.2 Maize and Products: 205.7	Wheat and Products: 52.3 Rice and Products: 713.5 Maize and Products: 1.8
2018	Wheat and Products: 110 Rice and Products: 60 Maize and Products: 206.5	Wheat and Products: 51.2 Rice and Products: 711.5 Maize and Products: 1.9

[a] Food Supply quantity in Kenya included wheat and products, rice and products, and maize and products.[47]
[b] Food Supply quantity in Bangladesh included wheat and products, rice and products, and maize and products.[48]
[c] Wheat and Products included: Wheat; Flour, wheat; Bran, wheat; Macaroni; Germ, wheat; Bread; Bulgur; Pastry; Starch, wheat; Gluten, wheat; Cereals, breakfast; Wafers; Mixes and doughs; Food preparations, flour, malt extract.[46]
[d] Rice and Products included: Rice, paddy; Rice, husked; Rice, milled/husked; Rice, milled; Rice, broken; Gluten, rice; Starch, rice; Bran, rice; Flour, rice.[46]
[e] Maize and Products included: Maize; Germ, maize; Flour, maize; Bran, maize; Gluten, maize; Starch, maize; Feed and meal, gluten.[46]

Discussion

To assess per capita cereal grain consumption in Kenya and Bangladesh, we followed several approaches and compared the results. We found that regardless of grain or country, dietary databases (or proxies thereof) provided the lowest overall estimates of wheat flour, maize flour and rice consumption by the total population through Approach 1, with the exception of KHSNP 2016. The rice consumption was larger than rice available and supply quantity for both Approach 2 and Approach 3 in KHSNP 2016. In comparison, the estimates derived from cereal grain available for the country (Approach 2) and FAO food balance sheets (Approach 3) generated higher per capita consumption values. Grain consumption for the four target population groups (school age children, women of childbearing age, adult men, older adults) were only estimable from analysis of datasets (Approach 1); neither available values nor food balance sheets information provide this disaggregated information. Adult men consume the most amount of cereal grains and children of primary school age consume the least amount of cereal grains among all population groups.

Among the total population, the cereal grain consumption from Approach 1 is smaller than the cereal grain consumption from Approaches 2 & 3, except for rice consumption in from the KHSNP 2016 survey in Kenya for Approach 1. There may be several reasons for this general trend. First, Approach 1 did not include rice flour in rice consumption. However, Approach 2 & 3 included all rice and rice products. Second, KHSNP 2016 and BIHS 2018-19 (but not KNMS 2011) had a pre-identified food list, so if people consume a grain in a food that is not onn the food list, they may not report it, leading to an intake underestimation. Third, KNMS 2011 only included women of childbearing age and pre-adolescents and adolescents. The cereal grain consumption among the whole Kenyan population is underestimated, because adult men and older women and men were excluded from the survey. Finally, in BIHS 2018-19 we excluded some cereal grain–containing food, because these foods were purchased and the quantity consumed was not reported in the dataset.

Comparison of Results

For Kenya, maize is the major staple food and people consume 88 kg of maize and maize products per year per person in 2009, which is about 241.1 grams/person/day and 65% calories intake of all staple food.[22,49] Wheat flour is the second major staple food with 17% calories intake of all staple food.[49] This showed that the two major staple foods are maize and wheat in Kenya. People who live in Kenya consume most maize and then wheat, which is similar with the results from all three approaches. The maize consumption which is 241.1 grams/person/day is higher than maize flour consumption from Approach 1, but similar with Approach 2 and Approach 3.[22,49] One of the reasons is that KNMS 2011 only had pre-adolescents and adolescents and children of childbearing age, so the using these two population groups to estimate the overall population underestimate the total amount of maize consumption. The other reason is that KHSNP 2016 had a fixed food list, which people may not report the food that does not in the fixed food list. This process can also underestimate the maize consumption. The other study conducted in Nairobi County in Kenya, which estimated the mean maize flour consumption was 632.4 grams/person/day.[50] The mean consumption of maize flour is much larger than our results from all three approaches. The reason is that this study is not a national representative survey and only focus on one county in Kenya, so the consumption amount of maize flour can be different from national representative data we used for all three approaches.

Bangladesh Household and Income Expenditure surveys conducts every five years and estimated per capita rice and wheat consumption per day.[23] The results showed that rice consumption was 458.5 g/p/d in 2000, 439.6 g/p/d in 2005, 416 g/p/d in 2010, 367.2 g/p/d in 2016.[23] This shows that the rice consumption is decreasing from 2000 to 2016, which is similar with our results on rice trending from Approach 3. However, the rice consumption from HIES survey series is smaller than the rice available and supply quantity from Approach 2 and Approach 3, but close to the rice consumption from Approach 1. The reason is that the actual consumption is different from availability and supply quantity. For BIHS 2018-19 in Approach 1, the mean rice consumption is about 300 g/c/d, which is 67.2 grams less than HIES in 2016 for rice consumption. There are two possible explanations. First, the rice consumption decreases since decades ago, so the actual rice consumption in 2018-19 is lower than rice consumption in 2016. Second, foods which consumed outside of households did not included in the data analysis for rice consumption in BIHS 2018-19, so the rice consumption is underestimated in BIHS 2018-19.

Strengths and Limitations

There are several strengths and limitations in this study. One strength is that all databases analyzed are nationally representative for Approaches 1, 2 and 3, so we can use these data to estimate national cereal grain consumption. For Approach 1, the datasets analyzed are publicly available, so others can replicate, expand or improve these analyses. Three of the datasets in Approach 1 (BIHS 2018-19 in Bangladesh and KNMS 2011 and KHSNP 2016 in Kenya) have sample weights, so both adjusted and unadjusted result could be calculated.

One of the limitations in this investigation is that some of the databases in Approach 1 date from 2011 (KNMS 2011 and GENuS 2011); if food-consumption patterns have changed since then, the estimates generated by these databases are not up-to-date. Another limitation for Approach 1 is that people self-reported food consumption, purchases and/or home production and as such may suffer from reporting bias.[51]

Different surveys used different dietary assessment methods—each with their own strengths and limitations. For KNMS 2011 in Approach 1, the survey method is a 24-hour dietary recall applied to individuals. For BIHS 2018-19 and KHSNP 2016, people reported their food expenditures weekly with a pre-identified food list; we assumed that all foods purchased were consumed but that may not always be the case. Also, in KHSNP 2016, some household members may eat out, so their intake would be underestimated if the survey respondent did not have this information on hand.

For the Approach 2, cereal grain consumption available for human consumption included domestic produced, imported and exported. For Approach 3, the supply quantity was provided. The limitation for Approach 2 and Approach 3 was that they only provide data among overall population instead of population groups (like Approach 1). The other limitation for Approach 2 and Approach 3 was that household waste was not included in the data analysis.

Implications for Food Fortification Programs

In Kenya and Bangladesh, estimated cereal grain consumption was generally lower than the food supply quantity in FAO food balance sheets. If this pattern is accurate, using FAO food balance data to plan food fortification programs may lead to lower fortification effectiveness. This is possible if nutrient levels in fortification standards are established assuming a higher intake of the cereal grain. Similarly, if FAO food balance sheets estimates are used to monitor the potential nutrient contribution of fortified grains year after year, they may misrepresent nutrient intake.

Conclusion

When we compare cereal grain consumption across Approaches 1, 2 and 3 in Kenya and Bangladesh, estimates from dietary or proxy surveys were lower than those estimated from milling association availability figures and FAO food balance sheet information, with the exception of rice in Kenya's KHSNP 2016. These data suggest that depending on the source of grain-intake information, the potential coverage, reach, and impact of fortified grains can vary.

Acknowledgments

We wish to thank colleagues from Nutrition International who filled data gaps in Approach 1 and gathered the data for Approach 2: Jacqueline Kung'u, Joy Kiruntimi, Mandana Arabi, Manpreet Chadha, Martha Nyagaya, Mary Kihara and Manoj Kumar Raut. We also appreciate the support from Matthew R. Smith in understanding the GENuS database, Becky Tsang in sharing datasets, and Alexandra Doyle for answering our questions on the Kenya Hunger Safety Programme Phase 2 2016 dataset.

Chapter 3 Public Health Implications and Future Directions

Public Health Implications

We compared three approaches to estimate cereal grain consumption in Kenya and Bangladesh. One reason to do this was to assess how closely FAO food balance sheet data approximate dietary (or proxy) intake for the same foods. This study also focused on the different amount of cereal grains consumed within four different population groups to better estimate intake among groups vulnerable to micronutrient deficiencies such as women of childbearing age and children. FAO food balance sheets consistently overreport intake compared with dietary or proxy data. This is problematic if FAO data are used to plan fortification programs with wheat flour, maize flour and rice. Generally, for higher intake levels, lower nutrient levels are added through fortification (and vice versa: for lower intake levels, higher nutrient levels are added). Therefore, if grain intake is assumed to be higher than it actually is, the amount of nutrients added through fortification may not be high enough to optimally reduce deficiencies of the nutrient in the target population.

Additionally, fixed food lists may consistently lead to underestimates in cereal grain consumption compared with open-ended inquiries of what people eat. For example, in the Kenya National Micronutrient Survey 2011, the cereal grain consumption is higher than calculated in the Kenya Hunger Safety Net Programme Survey 2016 for pre-adolescents and adolescents and women of childbearing age among wheat flour and maize flour. The only exception is that KHSNP 2016 has larger amount of rice consumption than KNMS 2011. KNMS 2011 used a 24-hour dietary recall to survey what people ate (with no pre-defined food lists). However, it is important to note that KHSNP 2016 asked about household-level consumption and KNMS 2011 inquired about individuals' intake.

Adult men always eat the most amount of cereal grains among all population groups. Then, older adults, women of childbearing age and pre-adolescent and adolescents eat similar amounts of cereal grains. In comparison, children of primary school age eat the least amount of cereal grains. Women of childbearing age are often the target of food fortification programs. Their cereal grain intake was consistently lower than FAO food balance sheet estimates for all grains in both countries. Therefore, if fortification programs are planned to use the higher intakes, it is possible women are not getting the recommended levels of nutrients through fortification.

According to FAO food balance sheet information in 2014 to 2018, the wheat flour supply is increasing in both Kenya and Bangladesh while in Kenya the maize flour supply is decreasing. These data suggest that eating patterns may be changing in as short as a four-year period. It is therefore important to monitor whether these changes impact the amount of nutrients being provided through fortified versions of these foods. And if fortification standards need to be reviewed and revised.

Future Directions

Two illustrative countries were selected for this exercise. However, it would be interesting to expand this analysis to other countries, in the same and different geographic regions, to determine if the trends observed here are replicated elsewhere.

With respect to the datasets obtained for the analyses for Bangladesh and Kenya, there are many additional research activities that can be completed. For example, we were unable to analyze the Bangladesh Household Income and Expenditure Survey 2010 because it lacked information on the age and sex distribution of all household members. Therefore, we were not able to apply the adult male equivalent methodology to estimate individuals' apparent grain intake. BHIES 2010 has more than double the households than the BIHS 2018-19 datasets we were able to analyze. Not only would the BHIES 2010 provide a robust dataset to analyze, it would also provide an earlier time point to assess trends over time in grain consumption in Bangladesh. Therefore, we recommend collaborating with the BHIES 2010 survey implementers to be able to get the age and sex information of household members to be able to mirror the analysis completed for BIHS 2018-19.

Another limitation of the BIHS 2018-19 survey is that for foods purchased outside of the household, quantities consumed were not provided in the dataset. However, the amount spent (in the local currency) to purchase the food is included. Therefore, we recommend collaborating with BIHS 2018-19 implementers to devise a strategy to convert food costs into food grams and thus complement the analysis completed of foods consumed inside the household.

The newest KNMS and GENuS surveys will be published later this year. Therefore, the most recent version of KNMS and GENuS can be used to obtain contemporaneous estimates of cereal grain consumption and to compare trends over time.

Appendices

Appendix 1. Rice- and wheat flour-containing food excluded in data analysis for Bangladesh Integrated Household Survey 2018-19.[39]

Food	**Number of records**	**Include (rice, wheat flour or maize flour)**	**What percentage of the food is made up of the grain?**
Biscuit	4846	Wheat flour	90
Bonroti/paoroti	1480	Wheat flour	95
Burger	9	Wheat flour	60
Cake	2237	Wheat flour	90
Chanachu	3298	Wheat flour	30
Khichuri	195	Rice	90
Mowa (Puffed rice ball coat)	167	Rice	95
Murali	58	Rice	95
Paes/firni/cooked firni	135	Rice	90
Pitha	977	Rice	90
Polao/Biryani/Tehari	258	Wheat flour	85
Puri	977	Wheat flour	80
Rice/Jao	1849	Wheat flour	100
Singara	1784	Wheat flour	50

Appendix 2. Per capita wheat flour consumption among the overall population and four population groups (school-age children, women of childbearing age, adult men and older adults) from three databases in Kenya.

Populations	Unadjusted wheat flour consumption in Kenya (grams/capita/day)	Adjusted wheat flour consumption in Kenya (grams/capita/day)
School age children 1.Children of primary school age: 5 years to <10 years	Database KNMS 2011 (n=2224)[b]: Mean: NA Median: NA Database KHSNP 2016 (n=64,213): Mean: 30.7 SD: 164.1 Median: 0 25% IQR: 0 75% IQR: 46.3 Database GENuS (32 datasets)[c]: Mean: NA Median: 60.6	Database KNMS 2011 (n=2224): Mean: NA Median: NA Database KHSNP 2016 (n=64,213): Mean: 31.1 SD: 805.9 Median: 0 25% IQR: 0 75% IQR: 49.7
School age children 2.Pre-adolescents and adolescents: 10 years to <19 years	Database KNMS 2011 (n=2224): Mean: 75.2 SD: 105 Median: 30.6 25% IQR: 0 75% IQR: 108 Database KHSNP 2016 (n=64,213): Mean: 44.3 SD: 196.2 Median: 0 25% IQR: 0 75% IQR: 68	Database KNMS 2011 (n=2224): Mean: 64.8 SD: 98.1 Median: 30.6 25% IQR: 0 75% IQR: 99 Database KHSNP 2016 (n=64,213): Mean: 40.1 SD: 978.8 Median:0 25% IQR: 0 75% IQR: 62.4

	Database GENuS (32 datasets): Mean: NA Median: 76.4	
Women of childbearing age 15-<50 years	Database KNMS 2011 (n=2224): Mean: 71.4 SD: 103 Median: 17 25% IQR: 0 75% IQR: 108 Database KHSNP 2016 (n=64,213): Mean: 44.4 SD: 213.6 Median: 0 25% IQR: 0 75% IQR: 68.2 Database GENuS (32 datasets): Mean: NA Median: 86.4	Database KNMS 2011 (n=2224): Mean: 74 SD: 115.1 Median: 0 25% IQR: 0 75% IQR: 108 Database KHSNP 2016 (n=64,213): Mean: 47.4 SD: 1095.6 Median: 0 25% IQR: 0 75% IQR: 76.5
Adult men 15-<50 years	Database KNMS 2011 (n=2224): Mean: NA Median: NA Database KHSNP 2016 (n=64,213): Mean: 55.5 SD: 295.2 Median: 0 25% IQR: 0 75% IQR: 83.7	Database KNMS 2011 (n=2224): Mean: NA Median: NA Database KHSNP 2016 (n=64,213): Mean: 55.6 SD: 1451.5 Median: 0 25% IQR: 0 75% IQR: 89.4

	Database GENuS (32 datasets): Mean: NA Median: 85.2	
Older adults 50 years and older	Database KNMS 2011 (n=2224): Mean: NA Median: NA Database KHSNP 2016 (n=64,213): Mean: 39.1 SD: 60.6 Median: 0 25% IQR: 0 75% IQR: 66.4 Database GENuS (32 datasets): Mean: NA Median: 80.6	Database KNMS 2011 (n=2224): Mean: NA Median: NA Database KHSNP 2016 (n=64,213): Mean: 37.4 SD: 471.9 Median: 0 25% IQR: 0 75% IQR: 60.7
Whole population (all ages and all sexes)[a]	Database KNMS 2011 (n=2224): Mean: 56.7 SD: 91.4 Median:0 25% IQR: 0 75% IQR: 90 Database KHSNP 2016 (n=64,213): Mean: 40.1 SD: 195.4 Median: 0 25% IQR: 0 75% IQR: 58	Database KNMS 2011 (n=2224): Mean: 56.9 SD: 99.6 Median: 0 25% IQR: 0 75% IQR: 81 Database KHSNP 2016 (n=64,213): Mean: 40.1 SD: 985.8 Median: 0 25% IQR: 0 75% IQR: 60.8

	Databases GENuS (32 datasets) Mean: NA Median: 73.4	

Abbreviation: NA, not applicable. No data were available for calculation.
[a] Whole population with all ages and all sexes included children between 0-5 years old.
[b] KNMS 2011 only included two population groups: pre-adolescents and adolescents and women of childbearing age.
[c] GENuS 2011 does not provide Mean, SD, and IQR in the dataset.

Appendix 3. Per capita maize flour consumption among the overall population and four population groups (school-age children, women of childbearing age, adult men and older adults) from three databases in Kenya.

Populations	**Unadjusted maize flour consumption in Kenya (grams/capita/day)**	**Adjusted maize flour consumption in Kenya (grams/capita/day)**
School age children 1.Children of primary school age: 5 years to <10 years	Database KNMS 2011[d] (n=2224): Mean: NA Median: NA Database KHSNP 2016[a](n=64,213): Mean: 51.1 SD: 64.2 Median: 38.4 25% IQR: 12.4 75% IQR: 68.2 Database KHSNP 2016[b](n=64,213): Mean: 41.3 SD: 65 Median: 25.5 25% IQR: 0 75% IQR: 60 Database GENuS[e] (32 datasets): Mean: NA Median: 137.6	Database KNMS 2011 (n=2224): Mean: NA Median: NA Database KHSNP 2016[a] (n=64,213): Mean: 55.5 SD: 580.4 Median: 41.6 25% IQR: 15.5 75% IQR: 71.5 Database KHSNP 2016[b] (n=64,213): Mean: 44.8 SD: 592.9 Median: 26.7 25% IQR: 0 75% IQR: 61.1
School age children 2.Pre-adolescents and adolescents: 10 years to <19 years	Database KNMS 2011 (n=2224): Mean: 219.7 SD: 152.4 Median: 200.2 25% IQR: 94 75% IQR: 347.5	Database KNMS 2011 (n=2224): Mean: 24 SD: 126.3 Median: 200.2 25% IQR: 138.4 75% IQR: 347.5

	Database KHSNP 2016[a](n=64,213): Mean: 82.1 SD: 333.7 Median: 56.5 25% IQR: 18.7 75% IQR: 100.1 Database KHSNP 2016[b](n=64,213): Mean: 67.9 SD: 334.4 Median: 38 25% IQR: 0 75% IQR: 87.6 Database GENuS (32 datasets): Mean: NA Median: 172.7	Database KHSNP 2016[a] (n=64,213): Mean: 88.1 SD: 2679.5 Median: 61.6 25% IQR: 22.5 75% IQR: 105.1 Database KHSNP 2016[b] (n=64,213): Mean: 74.2 SD: 2686.4 Median: 43.6 25% IQR: 0 75% IQR: 91.9
Women of childbearing age 15-<50 years	Database KNMS 2011 (n=2224): Mean: 180 SD: 175.9 Median: 209.2 25% IQR: 85 75% IQR: 290 Database KHSNP 2016[a] (n=64,213): Mean: 77.3 SD: 206 Median: 54.4 25% IQR: 17.5 75% IQR: 100.5 Database KHSNP 2016[b](n=64,213):	Database KNMS 2011 (n=2224): Mean: 212.5 SD: 194.8 Median: 182.7 25% IQR: 68 75% IQR: 297.3 Database KHSNP 2016[a] (n=64,213): Mean: 82.3 SD: 1785.8 Median: 59.2 25% IQR: 20.6 75% IQR: 104.7 Database KHSNP 2016[b] (n=64,213):

	Mean: 62.5 SD: 206.7 Median: 35 25% IQR: 0 75% IQR: 85.2 Database GENuS (32 datasets): Mean: NA Median: 150.3	Mean: 66 SD: 1794.3 Median: 36.2 25% IQR: 0 75% IQR: 88.1
Adult men 15-<50 years	Database KNMS 2011 (n=2224): Mean: NA Median: NA Database KHSNP 2016[a] (n=64,213): Mean: 99.1 SD: 381.8 Median: 67.6 25% IQR: 20.7 75% IQR: 122.5 Database KHSNP 2016[b](n=64,213): Mean: 80.6 SD: 382.6 Median: 43.5 25% IQR: 0 75% IQR: 104.4 Database GENuS (32 datasets): Mean: NA Median:192.7	Database KNMS 2011 (n=2224): Mean: NA Median: NA Database KHSNP 2016[a] (n=64,213): Mean: 106.8 SD: 2977.8 Median: 76.1 25% IQR: 29.7 75% IQR: 130.1 Database KHSNP 2016[b] (n=64,213): Mean: 86.2 SD: 2987.8 Median: 49.4 25% IQR: 0 75% IQR: 107.5
Older adults 50 years and older	Database KNMS 2011 (n=2224): Mean: NA	Database KNMS 2011 (n=2224): Mean: NA

	Median: NA Database KHSNP 2016[a] (n=64,213): Mean: 84.3 SD: 320.7 Median: 55 25% IQR: 13.9 75% IQR: 99.5 Database KHSNP 2016[b](n=64,213): Mean: 70.1 SD: 321.3 Median: 35.3 25% IQR: 0 75% IQR: 87.2 Database GENuS (32 datasets): Mean: NA Median: 182.3	Median: NA Database KHSNP 2016[a] (n=64,213): Mean: 91.9 SD: 2459.3 Median: 58.8 25% IQR: 15.8 75% IQR: 108.7 Database KHSNP 2016[b] (n=64,213): Mean: 78.8 SD: 2466.7 Median: 42.6 25% IQR: 0 75% IQR: 94.1
Whole population (all ages and all sexes)[c]	Database KNMS 2011 (n=2224): Mean: 167.6 SD: 163 Median: 128 25% IQR: 43 75% IQR: 246.8 Database KHSNP 2016 (n=64,213): Mean: 72.4 SD: 263.9 Median: 48 25% IQR: 13.1 75% IQR: 90.8 Database KHSNP 2016 (n=64,213):	Database KNMS 2011 (n=2224): Mean: 171 SD: 175.3 Median: 128 25% IQR: 21 75% IQR: 196 Database KHSNP 2016 (n=64,213): Mean: 77.5 SD: 2109.2 Median: 51.5 25% IQR: 16.2 75% IQR: 94.9 Database KHSNP 2016 (n=64,213):

	Mean: 59.2 SD: 264.3 Median: 28.3 25% IQR: 0 75% IQR: 77 Databases GENuS (32 datasets) Mean: NA Median: 153.2	Mean: 63.6 SD: 2114.5 Median: 30.9 25% IQR: 0 75% IQR: 80.5

Abbreviation: NA, not applicable. No data were available for calculation.

[a] Maize flour included consumption of both maize flour (pre-packed) and maize flour (posho).

[b] Maize flour only included consumption of maize flour (posho).

[c] Whole population with all ages and all sexes included children between 0-5 years old.

[d] KNMS 2011 only included two population groups: pre-adolescents and adolescents and women of childbearing age.

[e] GENuS 2011 does not provide Mean, SD, and IQR in the dataset.

Appendix 4. Per capita rice consumption among the overall population and four population groups (school-age children, women of childbearing age, adult men and older adults) from two databases in Kenya.

Populations	**Unadjusted rice consumption in Kenya (grams/capita/day)**	**Adjusted rice consumption in Kenya (grams/capita/day)**
School age children 1.Children of primary school age: 5 years to <10 years	Database KNMS 2011[b] (n=2224): Mean: NA Median: NA Database KHSNP 2016 (n=64,213): Mean: 49.7 SD: 69.1 Median: 40.8 25% IQR: 7.2 75% IQR: 75.1 Database GENuS[c] (32 datasets): Mean: NA Median: 19.8	Database KNMS 2011 (n=2224): Mean: NA Median: NA Database KHSNP 2016 (n=64,213): Mean: 47.1 SD: 645.5 Median: 37.8 25% IQR: 6.3 75% IQR: 69.6
School age children 2.Pre-adolescents and adolescents: 10 years to <19 years	Database KNMS 2011 (n=2224): Mean: 23.2 SD: 93.2 Median: 0 25% IQR: 0 75% IQR: 0 Database KHSNP 2016 (n=64,213): Mean: 74 SD: 125.7 Median: 59.7 25% IQR: 0.06 75% IQR: 111.8	Database KNMS 2011 (n=2224): Mean: 17.7 SD: 80.5 Median: 0 25% IQR: 0 75% IQR: 0 Database KHSNP 2016 (n=64,213): Mean: 66.8 SD: 1211.1 Median: 49.8 25% IQR: 0 75% IQR: 100.5

	Database GENuS (32 datasets): Mean: NA Median: 24.8	
Women of childbearing age 15-<50 years	Database KNMS 2011 (n=2224): Mean: 26.6 SD: 66.4 Median: 0 25% IQR: 0 75% IQR: 23.2 Database KHSNP 2016 (n=64,213): Mean: 71 SD: 106.4 Median: 57.6 25% IQR: 0 75% IQR: 108 Database GENuS (32 datasets): Mean: NA Median: 21.5	Database KNMS 2011 (n=2224): Mean: 26.2 SD: 67 Median: 0 25% IQR: 0 75% IQR: 24.5 Database KHSNP 2016 (n=64,213): Mean: 69.8 SD: 1020.1 Median: 54.2 25% IQR: 7 75% IQR: 105
Adult men 15-<50 years	Database KNMS 2011 (n=2224): Mean: NA Median: NA Database KHSNP 2016 (n=64,213): Mean: 87.6 SD: 142.6 Median: 70.4 25% IQR: 0 75% IQR: 111.8	Database KNMS 2011 (n=2224): Mean: NA Median: NA Database KHSNP 2016 (n=64,213): Mean: 85.3 SD: 1390.3 Median: 65 25% IQR: 0 75% IQR: 130.1

	Database GENuS (32 datasets): Mean: NA Median: 27.6	
Older adults 50 years and older	Database KNMS 2011 (n=2224): Mean: NA Median: NA Database KHSNP 2016 (n=64,213): Mean: 72.6 SD: 72.6 Median: 60.2 25% IQR: 0 75% IQR: 112 Database GENuS (32 datasets): Mean: NA Median: 26.1	Database KNMS 2011 (n=2224): Mean: NA Median: NA Database KHSNP 2016 (n=64,213): Mean: 65.9 SD: 515.7 Median: 52.2 25% IQR: 0 75% IQR: 104.6
Whole population (all ages and all sexes)[a]	Database KNMS 2011 (n=2224): Mean: 21.9 SD: 63.5 Median: 0 25% IQR: 0 75% IQR: 0 Database KHSNP 2016 (n=64,213): Mean: 65.8 SD: 49.8 Median: 104.8 25% IQR: 0 75% IQR: 97.9	Database KNMS 2011 (n=2224): Mean: 21.1 SD: 62.4 Median: 0 25% IQR: 0 75% IQR: 0 Database KHSNP 2016 (n=64,213): Mean: 62.3 SD: 992.2 Median: 45.2 25% IQR: 0 75% IQR: 91

	Databases GENuS (32 datasets) Mean: NA Median: 28.2	

Abbreviation: NA, not applicable. No data were available for calculation.

[a] Whole population with all ages and all sexes included children between 0-5 years old.

[b] KNMS 2011 only included two population groups: pre-adolescents and adolescents and women of childbearing age.

[c] GENuS 2011 does not provide Mean, SD, and IQR in the dataset.

Appendix 5. Per capita wheat flour consumption among the overall population and four population groups (school-age children, women of childbearing age, adult men and older adults) from two databases in Bangladesh.

Populations	**Unadjusted wheat flour consumption in Bangladesh (grams/capita/day)**	**Adjusted wheat flour consumption in Bangladesh (grams/capita/day)**
School age children 1.Children of primary school age: 5 years to <10 years	Database BIHS 2018-19 (n=11,711): Mean: 20.1 SD: 30.1 Median: 3.7 25% IQR: 0 75% IQR: 31.6 Database GENuS[b] (32 datasets): Mean: NA Median: 29.3	Database BIHS 2018-19 (n=11,711): Mean: 19 SD: 4585.2 Median: 3.4 25% IQR: 0 75% IQR: 29.7
School age children 2.Pre-adolescents and adolescents: 10 years to <19 years	Database BIHS 2018-19 (n=11,711): Mean: 30.9 SD: 47.4 Median: 4.8 25% IQR: 0 75% IQR: 48.9 Database GENuS (32 datasets): Mean: NA Median: 37.2	Database BIHS 2018-19 (n=11,711): Mean: 29 SD: 6933.6 Median: 4 25% IQR: 0 75% IQR: 45.8
Women of childbearing age 15-<50 years	Database BIHS 2018-19 (n=11,711): Mean: 30.5 SD: 45.4 Median: 5.7 25% IQR: 0 75% IQR: 48	Database BIHS 2018-19 (n=11,711): Mean: 28.1 SD: 6375.8 Median: 5 25% IQR: 0 75% IQR: 44.5

	Database GENuS (32 datasets): Mean: NA Median: 29.6	
Adult men 15-<50 years	Database BIHS 2018-19 (n=11,711): Mean: 33.3 SD: 51.1 Median: 5.1 25% IQR: 0 75% IQR: 51.4 Database GENuS (32 datasets): Mean: NA Median: 40.0	Database BIHS 2018-19 (n=11,711): Mean: 31.5 SD: 7636.7 Median: 4.6 25% IQR: 0 75% IQR: 48
Older adults 50 years and older	Database BIHS 2018-19 (n=11,711): Mean: 32.5 SD: 51.4 Median: 4.2 25% IQR: 0 75% IQR: 49.7 Database GENuS (32 datasets): Mean: NA Median: 38.4	Database BIHS 2018-19 (n=11,711): Mean: 30.2 SD: 7031.4 Median: 5.2 25% IQR: 0 75% IQR: 45.4
Whole population (all ages and all sexes)[a]	Database BIHS 2018-19 (n=11,711): Mean: 28.2 SD: 44.8 Median: 4.4 25% IQR: 0 75% IQR: 42.2	Database BIHS 2018-19 (n=11,711): Mean: 26.1 SD: 6460.2 Median: 4 25% IQR: 0 75% IQR: 38.8

	Databases GENuS (32 datasets) Mean: NA Median: 35.7	

Abbreviation: NA, not applicable. No data were available for calculation.

[a] Whole population with all ages and all sexes included children between 0-5 years old.

[b] GENuS 2011 does not provide Mean, SD, and IQR in the dataset.

Appendix 6. Per capita maize flour consumption among the overall population and four population groups (school-age children, women of childbearing age, adult men and older adults) from two databases in Bangladesh.

Populations	**Unadjusted maize flour consumption in Bangladesh (grams/capita/day)**	**Adjusted maize flour consumption in Bangladesh (grams/capita/day)**
School age children 1.Children of primary school age: 5 years to <10 years	Database BIHS 2018-19 (n=11,711): Mean: 0.2 SD: 3.1 Median:0 25% IQR: 0 75% IQR: 0 Database GENuS[b] (n=): Mean: NA Median: 1.1	Database BIHS 2018-19 (n=11,711): Mean: 0.2 SD: 497.1 Median: 0 25% IQR: 0 75% IQR: 0
School age children 2.Pre-adolescents and adolescents: 10 years to <19 years	Database BIHS 2018-19 (n=11,711): Mean: 0.2 SD: 3.4 Median: 0 25% IQR: 0 75% IQR: 0 Database GENuS (n=): Mean: NA Median:1.4	Database BIHS 2018-19 (n=11,711): Mean: 0.3 SD: 581.5 Median:0 25% IQR: 0 75% IQR: 0
Women of childbearing age 15-<50 years	Database BIHS 2018-19 (n=11,711): Mean: 0.2 SD: 3. Median: 0 25% IQR: 0 75% IQR: 0 Database GENuS (32 datasets):	Database BIHS 2018-19 (n=11,711): Mean: 0.3 SD: 564.5 Median: 0 25% IQR: 0 75% IQR: 0

	Mean: NA Median: 1.1	
Adult men 15-<50 years	Database BIHS 2018-19 (n=11,711): Mean: 0.3 SD: 4.7 Median:0 25% IQR: 0 75% IQR: 0 Database GENuS (32 datasets): Mean: NA Median:1.5	Database BIHS 2018-19 (n=11,711): Mean: 0.4 SD: 767.9 Median:0 25% IQR: 0 75% IQR: 0
Older adults 50 years and older	Database BIHS 2018-19 (n=11,711): Mean: 0.2 SD: 3.6 Median: 0 25% IQR: 0 75% IQR: 0 Database GENuS (32 datasets): Mean: NA Median: 1.4	Database BIHS 2018-19 (n=11,711): Mean: 0.3 SD: 524.1 Median: 0 25% IQR: 0 75% IQR: 0
Whole population (all ages and all sexes)[a]	Database BIHS 2018-19 (n=11,711): Mean: 0.2 SD: 3.6 Median: 0 25% IQR: 0 75% IQR: 0 Databases GENuS (32 datasets)	Database BIHS 2018-19 (n=11,711): Mean: 0.3 SD: 574.4 Median: 0 25% IQR: 0 75% IQR: 0

	Mean: NA Median: 0.84	

Abbreviation: NA, not applicable. No data were available for calculation.

[a] Whole population with all ages and all sexes included children between 0-5 years old.

[b] GENuS 2011 does not provide Mean, SD, and IQR in the dataset.

Appendix 7. Per capita rice consumption among the overall population and four population groups (school-age children, women of childbearing age, adult men and older adults) from two databases in Bangladesh.

Populations	**Unadjusted rice consumption in Bangladesh (grams/capita/day)**	**Adjusted rice consumption in Bangladesh (grams/capita/day)**
School age children 1.Children of primary school age: 5 years to <10 years	Database BIHS 2018-19 (n=11,711): Mean: 215.3 SD: 146.9 Median: 237.8 25% IQR: 36 75% IQR: 315 Database GENuS[b] (32 datasets): Mean: NA Median: 399.3	Database BIHS 2018-19 (n=11,711): Mean: 212.2 SD: 23458.6 Median: 237.3 25% IQR: 27.7 75% IQR: 311.7
School age children 2.Pre-adolescents and adolescents: 10 years to <19 years	Database BIHS 2018-19 (n=11,711): Mean: 332.7 SD: 229 Median: 367.2 25% IQR: 51.3 75% IQR: 482.6 Database GENuS (32 datasets): Mean: NA Median: 506.8	Database BIHS 2018-19 (n=11,711): Mean: 325.9 SD: 35420.1 Median: 363.1 25% IQR: 41 75% IQR: 479.8
Women of childbearing age 15-<50 years	Database BIHS 2018-19 (n=11,711): Mean: 309.5 SD: 213.8 Median: 347.1 25% IQR: 41.3 75% IQR: 454.6	Database BIHS 2018-19 (n=11,711): Mean: 302.8 SD: 31623.5 Median: 345.1 25% IQR: 36 75% IQR: 449

	Database GENuS (32 datasets): Mean: NA Median: 434.0	
Adult men 15-<50 years	Database BIHS 2018-19 (n=11,711): Mean: 383.2 SD: 256.9 Median: 438.2 25% IQR: 51.5 75% IQR: 566 Database GENuS (32 datasets): Mean: NA Median: 544.9	Database BIHS 2018-19 (n=11,711): Mean: 377.2 SD: 40102.4 Median: 434.3 25% IQR: 43.1 75% IQR: 562.2
Older adults 50 years and older	Database BIHS 2018-19 (n=11,711): Mean: 332.4 SD: 243 Median: 353.3 25% IQR: 53.4 75% IQR: 483.4 Database GENuS (32 datasets): Mean: NA Median: 522.7	Database BIHS 2018-19 (n=11,711): Mean: 318.8 SD: 34762.7 Median: 363.1 25% IQR: 38.9 75% IQR: 472
Whole population (all ages and all sexes)[a]	Database BIHS 2018-19 (n=11,711): Mean: 300.6 SD: 226.8 Median: 315.8 25% IQR: 45.2 75% IQR: 458.4	Database BIHS 2018-19 (n=11,711): Mean: 291.4 SD: 34452.3 Median: 306.9 25% IQR: 36.4 75% IQR: 451

	Databases GENuS (32 datasets) Mean: NA Median: 472.9	

Abbreviation: NA, not applicable. No data were available for calculation.

[a] Whole population with all ages and all sexes included children between 0-5 years old.

[b] GENuS 2011 does not provide Mean, SD, and IQR in the dataset.

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