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ORIGINAL PAPER

Food choice responses to changes in the price of a staple crop: a discrete choice experiment of maize in rural Malawi

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Abstract

Price and affordability are important drivers of food choice, particularly for rural smallholder farming households in Malawi, experiencing extreme poverty, food insecurity, and lack of dietary diversity. Lowering the cost of staple crops such as maize targeted by agricultural input subsidy programmes (AISPs) may potentially increase consumption of the staple crop, but it might also lead to consumption of a more diverse range of foods. Using a discrete choice experiment, this study investigated food choice responses to changes in maize price in rural Malawi. Study participants (n = 400) were given a series of choice tasks for which they were asked to choose between food baskets with varying cost, reflecting local prices and with maize at both high and low price. Baskets contained different types of foods including maize, rice, cabbage, small-dried fish, and/or a soft drink. The data were analysed using mixed logit models including investigation of heterogenous effects based on socio-demographic characteristics, food security and actual market purchases. Individuals revealed a preference, as expected, for lower cost food baskets. Small-dried fish and cabbage were the highest valued food products. At a low cost of maize, the expected utility from a basket with maize was greater than a basket with other items, particularly among households with high- and low-food purchases, low socioeconomic status, living in Phalombe District, and experiencing food insecurity, indicating that among such populations a low price of maize will not necessarily lead to increases in dietary diversity. In contrast, among households living in Lilongwe District, with high SES and food secure, a lower maize price will not lead to a loss in dietary diversity as they prefer a basket containing non-maize products over maize. The findings suggest that achieving food security and dietary diversity may require a range of policy approaches addressing different pathways of impact as opposed to relying on subsidizing inputs for staple crop production.

Keywords Choice experiment · Dietary diversity · Input subsidies · Food choices · Staple prices

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1 Introduction

Malnutrition is a significant public health issue in many countries globally, including in Malawi, where it contributes to a heavy burden of poor health, as well as limiting social and economic development (Walls et al. 2023; National Statistics Office (NSO), 2017b). In many countries where livelihoods depend on agriculture (approximately 85% of the population of Malawi, for example), agricultural input subsidy programmes (AISP) are commonly used to address low agricultural productivity, as well as food and nutrition insecurity (NSO, 2017a; Walls et al., 2023). Thus, successful AISP outcomes may include wider availability of food and lower prices of agricultural produce. A concern with AISP from a nutrition perspective, however, is that they often target staple crops and therefore may only affect production and consumption of the staple crop. This may lead to improvements in food security but is less likely to impact dietary diversity. Yet, dietary diversity is an important aspect of good nutrition, and is also recognised as such by people in poor village communities of rural Malawi (Walls et al., 2023; Aberman & Roopnaraine, 2020) whose diets typically lack diversity; being made up of mainly maize and just a small number of other food products (Snapp & Fisher, 2015; Verduzco-Gallo et al., 2014). Malawi has a long history of implementing AISP in response to food shortages and food insecurity including during the food crises of 2001/02 and 2004/05 (Chinsinga, 2007; Chinsinga & Poulton, 2014). A particularly prominent AISP in Malawi has been the Farm Input Subsidy Programme (FISP), which operated between 2005 and 2020. The FISP enabled eligible households to purchase fertiliser and improved seeds for maize and legumes through a voucher system at reduced prices (Walls et al., 2023). In 2020, the FISP was replaced with the Affordable Inputs Programme (AIP),[1] which targets more farmers but no longer subsidizes legume seeds (Logistics Unit, 2021).

Food price and affordability are critical drivers of food choice in Malawi, with large proportions of the population experiencing extreme poverty and recurrent food insecurity (NSO, 2021; Government of Malawi (GoM), 2015, 2017, 2019). Potential higher agricultural production resulting from the FISP could lower maize prices and benefit both households participating in the FISP as well as non-participating households that are net buyers of maize, although detrimentally affect households that are net sellers aiming to realise income from crop sales (Chirwa & Dorward, 2013). Previous studies have shown only weak effects of input subsides on grain prices in Malawi, Zambia, and Nigeria (Ricker-Gilbert et al., 2013; Takeshima & Liverpool-Tasie, 2015), but if the cost of maize was lowered, this could lead to increased consumption of the staple crop, but could also increase access and consumption to a greater diversity of foods (Chirwa & Dorward, 2013). Even then, wider seasonal variation has a considerable effect on food purchases and consumption in Malawi (Chirwa et al., 2012), a country where farming relies on only a single rainy season. The lean season spanning between November and March is characterised by low food stocks; and households are cash constrained with the additional pressure of needing at this time to invest in farming activities including purchase of farm inputs (Chirwa et al., 2012). By contrast, income from crop sales is markedly higher during the post-harvest season, at which time households also have relatively higher food stock from own production. Many studies of low-income country settings including of Malawi have shown that dietary diversity varies by season (Abizari et al., 2017; Hirvonen et al., 2015; Sibhatu & Qaim, 2017; Zanello et al., 2019). However, no prior study of which we are aware has examined how the consumption of subsidized staple crops like maize and wider dietary diversity is affected by changes in the price of the staple crop. Therefore, this study aimed to investigate food choice responses in rural Malawi to changes in maize price informed by different food price scenarios.

Previous literature has noted the importance of understanding how preferences for different food attributes drive food choices. This has commonly been explored using DCE methodology, which offers a flexible and robust approach for investigating food choices and trade-offs in attributes. For instance, Kershaw et al. (2019) assessed meal choices among women in Chicago and found that whilst healthfulness and taste were important attributes across the board, price was only an important consideration among those of low socio-economic status. Another study by Marchi et al. (2016) found that time preferences influenced consumers' choice of healthy and environmentally friendly food products. DCE applications in Malawi have investigated cropping system choices among rural households. Silberg et al. (2020) analysed preferences among maize farmers for intercropping systems to reduce striga infestation in Malawi and reported strong preference for practices that allow for more food security over improvements in land productivity and reduced labour requirements. Ortega et al. (2016) investigated farmers' valuation of legume-maize cropping system characteristics and found that farmers discounted legume yields in preference of maize yields largely due to labour and market access constraints for legume production in Malawi. Similarly, Waldman et al. (2017) found that maize yield was valued twice as much as pigeon pea yield in maize-legume intercrops in Malawi. In Zambia, Meenakshi et al. (2012)

[1] In the 2020/2021 farming season, the AIP targeted 3.8 million farmers. The inputs included inorganic fertiliser and a choice of seeds for maize or sorghum or rice. Beneficiaries redeem their inputs using biometric information linked to the National Identity System.

estimated demand for nutritious foods finding that provision of nutrition messages supports greater willingness to pay for orange maize relative to white maize, a finding consistent with that of Kimenju et al. (2005) in Kenya. Another study in Kenya considered people's choices among a range of insect-based food products (Alemu & Olsen, 2019). Thus, DCEs have widely been applied to address a range of policy questions in agriculture, food, and nutrition research.

2 Methods

2.1 Study area, sampling, and data

The data collection for the DCE was conducted in tandem with a larger work programme, investigating the impact of Malawi's FISP on dietary diversity (Walls et al., 2023; Matita et al., 2021b). Survey data collection was conducted in Lilongwe District and Phalombe District in central and southern regions of Malawi, respectively. The two districts are different in their biophysical, agro-ecological, and socio-economic characteristics. For instance, market access within Lilongwe District is closely linked to Lilongwe, Malawi's capital city. Households in Lilongwe District tend to have higher incomes relative to all other areas in Malawi (GoM, 2005) although across the whole of Malawi low crop earnings together with increasing cost of farm inputs contribute to reducing households' disposable incomes. In 2017, 44% of the households of Lilongwe District and 75% of the households in Phalombe District were categorized as living in poverty (NSO, 2017a). More recent statistics, however, show the poverty prevalence stands at 64% in both districts (NSO, 2020). Farm production is relatively undiversified in Lilongwe District where maize is primarily cultivated as a food crop and tobacco as a cash crop (Fatch et al., 2021; Gumma et al., 2019). Farming systems in Phalombe District are, in contrast, more diversified. This is partly due to small land holding sizes which are common in this densely populated area (NSO, 2019). National surveys show that, on average, households in Phalombe District cultivated 1.2 acres of land in the 2016/17 farming season which is below the national average of 1.5 acres and lower than the 1.7 acres reported for Lilongwe District (NSO, 2017a).

The study sample included 400 randomly selected households (200 in each district), from two enumeration areas (the geographic area canvassed by one census representative, consisting of approximately 300 households) in one traditional authority[2] of each district (Malawi is divided into 28 districts and into approximately 250 traditional authorities). In each household surveyed, we interviewed 'the person who makes the decisions about food preparation for the household'. These people were mostly women (98%) and may not necessarily represent the person with control or the greatest influence over income or food purchases in the household.

Data were collected in May 2017 and February 2018, reflecting post-harvest and lean seasons when maize prices are low and high, respectively. The DCE survey was completed once, in February 2018. The larger study further included a market survey and a household survey. The household survey collected information about dietary diversity, food purchasing, and socio-demographic characteristics, as described elsewhere (Walls et al., 2023). In the household survey, respondents were asked, amongst other questions, to list foods, and their respective quantities, purchased from local markets by the household in the previous seven-day period. Food quantities were elicited using standardised measures such as kilograms, as well as non-standardised measures. In the case of non-standardised measures (e.g., a 'bucket' of maize, or 'pile' of fish), the study used two standardised cups to understand the quantity being described. The 'large cup' held 1500 mL; the 'small cup' held 600 mL. Each field worker had the cups with them physically and showed the respondents, to help with understanding real-life quantity.

The market survey collected the market prices of the food products commonly consumed in the study districts, and this informed the DCE design. The administration of the DCE preceded the other survey questions of interest in the wider study.

At the end of the DCE survey questions, we also asked each participant: "How much do you usually spend when you go to the market to shop for your household? For how many days?" and "What did you buy last time you went to the market, and in what quantity?". We also specifically asked if they had bought any of the five items in this experiment, and if so in what quantity.

2.2 Ethical approval

Informed consent was obtained at the beginning of each interview. Participants were given the opportunity to read the study information and had it explained to them by the research assistants. Ethical approval to undertake the study was provided by the London School of Hygiene

[2] In Malawi several villages are grouped together under one traditional authority. The chief heading the traditional authority acts as custodian of the cultural and traditional values of the community. They have the control of customary land and settle associated disputes. They also act as chairperson of Area Development Committees (ADCs) and lead development initiatives including mobilizing people's participation. see https://www.fao.org/gender-landrights-database/country-profiles/countries-list/customary-law/traditional-authorities-and-customary-institutions/en/?country_iso3=MWI

and Tropical Medicine and the National Committee on Research Ethics on Social Sciences and Humanities (Malawi).

2.3 The discrete choice experiment

The DCE method involves simulating the context in which participants would normally make choices among a set of competing alternatives – in this case alternative food baskets. This is achieved by designing an experiment in which attributes describing the alternatives are systematically varied to produce multiple choice tasks. Participants are then asked to indicate their preferred alternative (food basket, in our case) in each task. The information collected from such choice experiments is referred to as stated preferences. Identifying relevant attributes and levels is key to designing any such stated-preference study. In this study the attributes – basket components and their prices – were derived from both household and market surveys described above.

The reported diets of study participants were simple, largely consisting of maize in the form of meal porridge commonly called *nsima*, and 'relish'. As described by Aberman and Roopnaraine (2020), 'relish' is any food item which accompanies *nsima*. This was commonly green vegetables like pumpkin leaves. Other foods (e.g., beans, big fish) were less commonly consumed with *nsima*. Dietary diversity in this context was low and limited to an estimated four food groups (Matita et al., 2021a; Koppmair et al., 2017; Walls et al., 2023). Maize was the most common food purchased, with 22% and 73% of the households reporting maize purchases in the four weeks prior to the survey during the postharvest and lean season, respectively. Furthermore, about 70% of study respondents reported that they had not consumed any meat in the week prior to the survey. There were no significant differences in meat consumption between the lean and post-harvest season.

2.4 DCE design

We used an unlabelled design with four alternatives – three baskets of food and an opt-out (i.e., the respondents could decide not to choose any of the baskets). The three baskets contained maize at different quantities and a combination of four other foods. These other foods were rice, cabbage, small-dried fish commonly called *bonya*, and a soft drink ('Frozy'). Rice was included as a possible substitute for maize but since it is more expensive than maize it is not commonly consumed. Small-dried fish was chosen to represent a high-protein food that is more prevalent in this setting where an alternate food like meat is rarely consumed. Cabbage was chosen to represent a less frequently consumed vegetable. The soft drink Frozy is an example of a new product gaining traction in low-income rural regions. This is connected to shifts away from traditional diets to meals typically much higher in animal sourced and ultra-processed foods, vegetable oils and sweeteners often referred to as the nutrition transition (Walls et al., 2018). The food categories were chosen to represent different dietary food groups while also being suitable for rural Malawians' diets. The five products chosen are in no way meant to represent a 'healthy diet', but rather are chosen for their markedly different nutritional characteristics, to help understand the types of products that may become more or less desirable under different maize price scenarios. To set prices for the products, we drew on the market survey data mentioned earlier. Table 1 shows the different levels of cost for each of the five foods and their respective quantities.

Table 1 DCE attributes and levels

Attribute	Levels	
	Cost (MK[c])	*Equivalent quantity/volume (some given in 'cups'[a])*
Maize (expensive price scenarios)	400, 800	1 or 2 large cups (1 large cup = 1500 mL)
Maize (cheaper price scenarios)	150, 300, 450, 600	1, 2, 3 or 4 large cups (1 large cup = 1500 mL)
Cabbage	0, 150	0 or 1 medium sized head
Rice	0, 250	0 or 1 small cups (1 small cup = 600 mL)
Small-dried fish	0, 250	0 or 1 small cups (1 small cup = 600 mL)
Frozy	0, 200	0 or 1 bottle
Cost of a basket[b]	900, 950, 1000, 1050, 1100	

[a]The choice sets were created using the costs of the above food items as attributes with two or four different levels of cost. To make choices cognitively easier for respondents, instead of displaying the cost of each individual food, the choice cards showed pictures of equivalent quantity of the foods in standard cups (see Figs. 1 and 2). For example, if the attribute level for maize was MK800 then a picture of two cups was shown on the choice set for that basket. If the attribute level was MK0 (cabbage, rice, small-dried fish or frozy) then no item was included in the basket

[b]The cost of the whole basket is calculated once the design was found, as the sum of the items in the basket. The design however, had restricted the cost of the basket to be between 900 and 1100 MK to match the average expenditure based on the market survey

[c]MK = Malawi Kwacha. The 2018 annual average exchange rate was 1 USD = MK732 according to the Reserve Bank of Malawi[3]

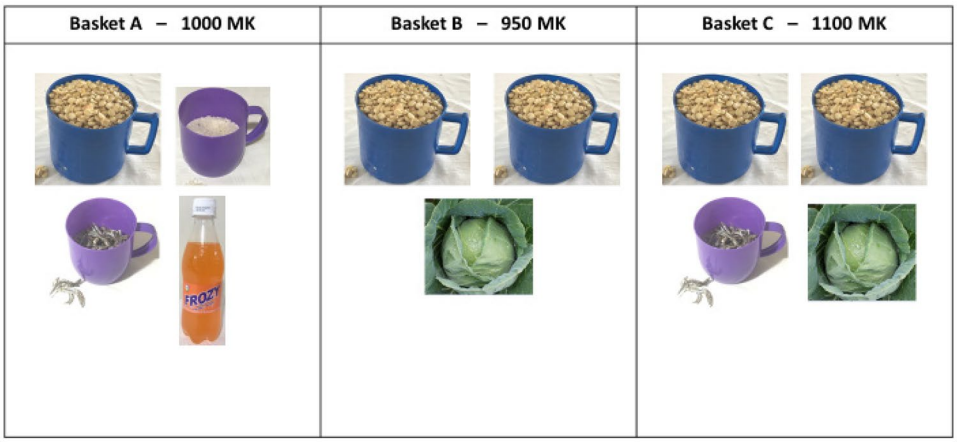


Fig. 1 An example of the choice tasks presented to respondents – a high maize price scenario

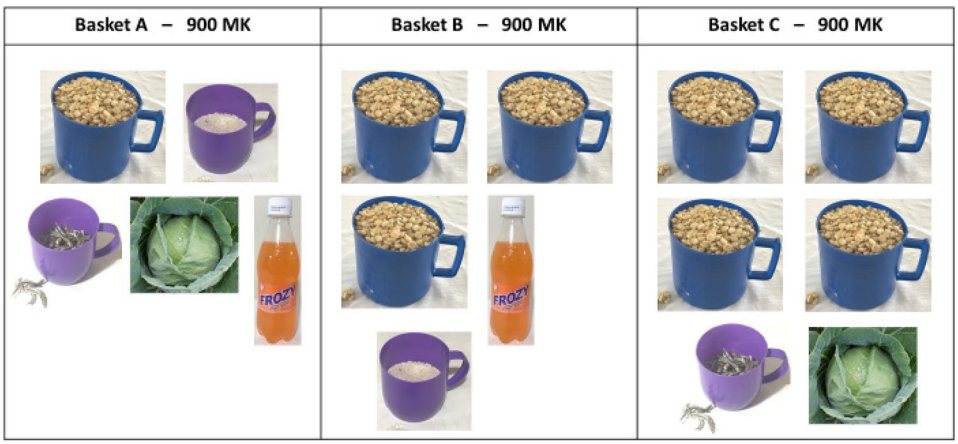


Fig. 2 An example of the choice tasks presented to respondents – a low maize price scenario

We used NGENE software to create two sets of five choice tasks applying a d-error-minimising efficient design with a modified Federov algorithm (Kershaw et al., 2019; Silberg et al., 2020). The first set was used to simulate conditions of high maize price (400 MK/kg during lean season) and the second set for low maize price (150 MK/kg in post-harvest season). The attributes that described each of the baskets were the cost of each of the five foods. Maize was always assumed to be present, and its cost had four (low price scenario) or two (high price scenario) levels. The remaining four foods all had two levels – zero or a positive value, with zero indicating that this particular food was not included in the basket. As our earlier study estimated that, on average, a household consumed food products valued at MK1000 (US$1.40) each 2–3 days, we restricted each basket to cost between MK900 and MK1100. This helped to ensure that baskets could contain a variety of items at realistic prices as opposed to few or single items. Cost was operationalised in the design as a restriction on the three alternative baskets. Once the choice tasks were created, the cost of each food was summed for each basket based on the quantities of different foods present and this total basket cost was displayed on the choice cards as an additional attribute. However, instead of using the cost of each of the food items on choice cards, we used corresponding quantities to make the choices cognitively easier for the respondents (see Figs. 1 and 2). The choice tasks corresponding to low and high maize price scenario were combined so that each respondent was asked to make ten choices between the four alternatives (three baskets and opt-out). If the participant chose opt-out a forced choice task from the three baskets was asked immediately afterwards to assess differences between conditional and unconditional demand. The choice tasks were presented to respondents in random order to avoid ordering bias.

The task set to the participants to make the choice was: "If you were shopping at the market for your household for the next 2–3 days, [and had about MK1000 to spend], which of these baskets would you choose?" (Note, 732 MK was equivalent to US$1 at the time of the study).[3] We asked the participants to consider that they had about MK1000 to spend to understand choices regardless of their actual ability

[3] Reserve Bank of Malawi annual average exchange rate sourced at https://www.rbm.mw/statistics/majorrates.

to pay. Fieldworkers explained to participants that all the items were of good quality. The participants were then shown the choice tasks one at a time (ten in total).

We considered as a research team, including discussion with fieldworkers, how best to represent the foods in the baskets. We initially considered drawing by hand each of the foods and the baskets but decided that photographs would be clearer and more easily/widely understood. Thus, we bought the foods of interest in local markets and took several rounds of photographs, before settling on a style that we felt was clear and easily interpretable. With the fieldworkers, we discussed which type of soft drink would be best to represent soft drinks in general. We decided on Frozy, a Mozambican produced drink and one of the more commonly consumed soft drinks in rural Malawi. We also had discussions about how to represent products such as maize, rice and small dried fish often bought in a loose form – and the quantities of these in the food baskets. We decided to photograph these products in the two cup sizes that fieldworkers later also used to assist participants with explaining the quantity of items in the baskets. We trained the fieldworkers to spend time explaining several of the initial choice tasks to the respondents, and familiarising respondents with the two cup sizes, ahead of the experiment to ensure understanding of the quantity of products represented in the pictures.

We piloted the DCE three times: first, with data collectors amongst themselves (14 people); second, with selected residents of the city of Zomba where the fieldworkers were trained; and third, with selected residents of a poorer region of rural Zomba about 30–40 min' drive from Zomba city – a region for which the demographics more closely approximated those of the people in the actual study. This piloting allowed assessment of the clarity of the questions presented, the overall participants´ understanding of the survey format and the salience of the attributes to the research question. Based on these tests, we adjusted the instrument as needed.

2.5 Empirical strategy

Our empirical analysis uses the random utility theoretical framework. An individual is assumed to choose a food basket that gives the maximum utility. The utility function according to Hauber et al. (2016) can be expressed as:

$$U_i = V(\beta, X_i) + \varepsilon_i$$

where V is a function defined by attribute levels for alternatives i; X_i is a vector of attributes levels defining alternative; ε_i is an error term and β is a vector of estimated coefficients. We use maximum likelihood simulations to determine the probability of choosing alternatives consistent with prior studies (Kershaw et al., 2019; Silberg et al., 2020). We assumed the coefficients associated with each attribute are normally distributed and estimated mixed logit models (also known as random parameter logit models). The advantage with these models is that they allow for preference heterogeneity among respondents. A parsimonious model of choice was estimated – a dummy variable equals one for the chosen alternative or zero otherwise against a set of independent variables here in the cost of a basket and the food types of maize, cabbage, small-dried fish, or Frozy. Except for maize, all other food items have one unit in the food baskets and entered the model as dummy variable equal to 1 if the food basket included a particular food item, zero otherwise. The soft drink, Frozy, is the reference category. The maize variable took values one to four representing the number of cups of maize in the basket as depicted in the choice tasks (Figs. 1 and 2).

Further analysis assessed any district, food security and socio-economic (SES) status heterogeneous effects in the stated preference by including interaction terms in the mixed logit models. The SES variable is an index generated by principal component analysis (PCA) including housing characteristics and durable assets owned by a household. Food insecurity is defined as a dummy variable equal to one if the respondent worried in the past month prior to the survey that their household would not have enough food, zero otherwise. We checked for the presence of multicollinearity between the variables used in the models and found that no predictors were highly correlated based on the Variance Inflation Factor (VIF) (Table A1).

Finally, we combined the stated preferences data from the DCE with revealed preference data from the survey on what individuals purchased the last time they visited the market. Households were categorised into high/low purchasing households as assessed through the number of food purchases made the last time they visited the market, to understand if actual level of purchase was associated with preferences stated in the experiment. Only a third of households were 'high' purchasing households, purchasing between three to six food groups from the market at their last visit. The 'low' purchasing households sourced between zero and two food groups from the market at their last visit. The binary variable describing the level of purchases was included in the model and interacted with variables describing attributes of the basket.

3 Results

3.1 Characteristics of respondents

Table 2 describes the study sample. Most of the respondents were women (98%). Forty percent of the households were reported to be female-headed[4]; a proportion higher

[4] The head of the household is the person considered by household members as the person primarily responsible for the household; they could be of any sex and may be responsible in the household for decision making about income spending or crop cultivation.

Table 2 Sample characteristics (n = 400)

Variable	Mean	Median	SD[a]	Min.[b]	Max.[c]
Female respondent (1/0)	0.98	1	0.14	0	1
Female headed household (1/0)	0.40	0	0.49	0	1
Education of the respondent (1/0)					
No education	0.30	0	0.46	0	1
Lower primary education	0.27	0	0.44	0	1
Upper primary education	0.35	1	0.48	0	1
Secondary education	0.08	0	0.27	0	1
Years of schooling	3.88	4	3.52	0	18
Ever attended school (1/0)	0.71	1	0.45	0	1
Household size (# of people)	4.74	5	1.93	1	11
Sold some crops to local market (1/0)[d]	0.14	0	0.34	0	1
Bought some crops from local market (1/0)[d]	0.85	1	0.36	0	1
Ever FISP beneficiary in the past (1/0)	0.68	1	0.47	0	1
Low SES (0/1)	0.62	1	0.49	0	1

Table 2 shows descriptive statistics of the sample. [a]Standard deviation, [b] Minimum, [c]Maximum. SES = socio-economic status. Dummy variables are indicated with 1/0 in brackets. [d]Those who sold some crops at their local market could also have bought some crop at the local market at some point, i.e., these are independent and not mutually exclusive of each other

than the 29% estimated from national surveys about the study districts (NSO, 2020). Such findings are important, given that gender influences food choices. In Malawi, male headed households are associated with positive nutrition outcomes (Snapp & Fisher, 2015). Based on the SES index, 60% of the households were considered to have low SES, i.e., in the three lowest quantiles of the SES index distribution. The associated standard deviation is also low suggesting minor differences in the socio-economic status of the respondents. Most of the respondents (71%) had attended school but the highest level of education attained for the majority (62%) was primary education. The average of four years of schooling in this localised study is below the six years estimated for Lilongwe District and Phalombe District from national surveys (NSO, 2020) which may affect food and nutrition information assimilation. The households that were interviewed had on average 4.7 household members, but some had up to 11 members which could raise their food needs and affect intrahousehold food allocation (Harris-Fry et al., 2017).

About 14% of the households (9% in Phalombe District and 19% in Lilongwe District[5]) had sold some crops at their local markets in the four weeks prior to the survey. More specifically 7% and 8% of the households sold legume and maize crops, respectively. Estimates from a national survey show that 60% of households in the study districts sold some of their harvested crops during the 2018/19 farming season. The different recall period used in the surveys could explain the differences including that the DCE survey was conducted during the lean period when people did not have much to sell. The income from crop sales supports diverse food choices and market experience (Nandi et al., 2021). Regarding market purchases, 85% of the households (97% in Phalombe District and 73% in Lilongwe District) had bought some crops at their respective local markets in the past four weeks. A greater proportion of households reported purchasing maize (73%) in comparison to legume crops (54%). Lastly, 68% of the households (73% in Phalombe District

Table 3 Top purchased food groups at the market (proportion reporting)

Food item	All households	Lilongwe	Phalombe
Fish & other seafoods	54.8	50.5	59.0*
Spices, condiments & beverages	51.3	53.0	49.0
Cereals	29.0	14.5	43.5***
Fats and oils	21.0	23.0	19.0
Vegetables	17.0	8.0	26.0***
Legumes, nuts & seeds	11.3	9.5	13.0
White roots and tubers	9.0	0.0	18.0***
Fruits	6.8	4.5	9.0*
Sweets	3.7	3.0	4.5
Meat, poultry & offal	3.0	2.0	4.0
Milk & milk products	0.3	0.5	0
Eggs	0	0	0
Mean expenditure last time visited food market (MK)	864	639	1090***

Table 3 shows food purchased the last time the respondent visited the market and the average expenditure. Test of mean difference was conducted for the two districts. * $p < 0.10$; ** $p < 0.05$; *** $p < 0.01$

[5] The results in brackets show differences by district otherwise the rest were not substantially different.

Table 4 Mixed logit estimates of food basket choices

	Model I		Model II		
Dependent variable: choice	Coeff.	SE	Coeff.	SE	WTP (MK)
Attribute (Mean)					
Units of maize	0.087***	(0.031)	0.085***	(0.030)	102.74
Basket contained cabbage (1/0)	0.136***	(0.046)	0.138***	(0.046)	165.50
Basket contained rice (1/0)	0.099*	(0.054)	0.099*	(0.054)	118.59
Basket contained small-dried fish (1/0)	0.160***	(0.039)	0.161***	(0.039)	193.69
Cost of a basket	-0.084**	(0.039)	-0.083**	(0.039)	-
Standard Deviation					
Units of maize	0.075	(0.079)	-	-	-
Basket contained cabbage (1/0)	0.334***	(0.067)	0.335***	(0.067)	-
Basket contained rice (1/0)	-0.005	(0.126)	-	-	-
Basket contained small-dried fish (1/0)	-0.001	(0.143)	-	-	-
Cost of a basket	0.247***	(0.088)	0.245***	(0.088)	-
Log Likelihood	-4353.284		-4353.441		
Likelihood-ratio Chi-squared	11.278**		10.963***		
Number of observations	11,940		11,940		

Table 4 shows mixed logit/random parameter logit model estimates of respondent's choice of food baskets. The price variable is rescaled for easier interpretation. Model I include all attributes as random variables whilst Model II keeps only those attributes with heterogeneity as random; the other attributes are included as fixed variables. (1/0) indicates dichotomous variables for the stated category equal to 1, otherwise equal to 0 for the base category. The willingness to pay (WTP) was generated by STATA command *wtp* from model II. Standard errors in parentheses

* $p<0.10$; ** $p<0.05$; *** $p<0.01$

and 64% in Lilongwe District) had ever received a FISP subsidy coupon.

3.2 Food purchases among experiment participants

Table 3 presents food items purchased by the households at 'the last time they visited the market' – in categories consistent with food groups used in measures of dietary diversity scores (Swindale & Bilinsky, 2006). Only 3% of the sample reported no market purchases. On average, the diversity of foods purchased was two food groups with a minimum of one and a maximum of six items. Approximately 39% of the households purchased one item at the market; two or three items were purchased by 20% of the respondents. Fish and other sea food was the most purchased food group, with the product purchased being almost solely small-dried fish – and a significantly higher proportion of households purchased small-dried fish in Phalombe District (59%) than in Lilongwe District (51%). Half of the respondents had purchased from the spices, condiments, and beverages[6] category, with no statistically significant differences between the two districts. Cereal purchases consisted largely of maize, with a significantly higher proportion of households purchasing maize in Phalombe District (43%) than Lilongwe District (15%). This is unsurprising given the dominance of maize cultivation in Lilongwe District compared to mixed farming practiced in Phalombe District. Significant differences in the purchase of vegetables were also found with a greater proportion of households reporting purchasing vegetables in Phalombe District (26%) than in Lilongwe District (8%). The purchase of other food items such as from the categories 'milk and milk products', 'sweets' and 'meat, poultry and offal' were reported by less than five percent of the sample and none reported purchasing eggs. Despite being low, the overall, food purchase diversity was significantly higher in Phalombe District (2.45) than Lilongwe District (1.69) ($p<0.01$). Additionally, respondents in Phalombe District spent significantly more money at the market (MK1,090) than those from Lilongwe District (MK639); the overall average expenditure was MK864 ($p<0.01$).

3.3 Food choices and preferences (regression results)

Table 4 reports estimates of preferences for food baskets from mixed logit estimation. The obtained likelihood-ratio Chi-squared statistic suggests the model is significant ($p<0.05$) and therefore all parameters are different from zero. The model estimations were to be based on 12,000

[6] In this study spices and condiments included ingredients used in small quantities for flavour, such as chillies, spices, herbs, fish powder, tomato paste, and flavour cubes.

observations (400 respondents performing ten choice tasks each), with three options per choice task. We dropped two respondents in the analysis due to an incomplete answer in one choice task; thus 11,940 observations were evaluated. All attributes were significantly associated with the choice of a food basket (Table 4). A positive parameter estimate indicated an individual obtained positive utility from choosing the concerned food basket, whilst a negative estimate implies disutility or that the decision to choose the food basket was discouraged by the attribute. The results were interpretated relative to the base category of soft drink (frozy). As expected, respondents preferred lower cost baskets indicated by negative coefficient for the cost variable ($p < 0.05$). Each food product had a positive coefficient meaning that additional maize, cabbage, and small-dried fish were all preferred relative to the base category of soft drink ($p < 0.01$). The inclusion of rice was only weakly significant in the choice of food baskets ($p < 0.1$). The significance of the standard deviation estimates shows heterogeneity in preferences around presence of cabbage in the basket and the cost of a basket ($p < 0.05$). Model II in Table 4 thus includes only these two attributes as random variables. For these two attributes the standard deviation also exceeded the mean implying switches in the direction of the preference across the sample. This indicates that some respondents valued presence of cabbage in the basket while others disliked it, for example. The finding on the cost having a positive sign for some respondents is not intuitive as demand curves are

Table 5 Sensitivity of food choice by district and socio-economic status

Dependent variable: choice	Model III (by district)		Model IV (by SES)	
	Coeff.	SE	Coeff.	SE
Attribute (Mean)				
Units of maize	0.133***	(0.043)	0.093*	(0.049)
Basket contained cabbage (1/0)	0.239***	(0.064)	0.239***	(0.073)
Basket contained rice (1/0)	0.199***	(0.077)	0.150*	(0.087)
Basket contained fish (1/0)	0.201***	(0.055)	0.157**	(0.063)
Cost of a basket	-0.056	(0.055)	-0.073	(0.062)
Units of maize*Lilongwe	-0.094	(0.061)	-	-
Basket contained cabbage*Lilongwe (1/0)	-0.204**	(0.091)	-	-
Basket contained rice*Lilongwe (1/0)	-0.200*	(0.109)	-	-
Basket contained fish*Lilongwe (1/0)	-0.079	(0.078)	-	-
Cost of basket*Lilongwe	-0.054	(0.078)	-	-
Units of maize* low SES	-	-	-0.012	(0.062)
Basket contained cabbage* low SES (1/0)	-	-	-0.166*	(0.093)
Basket contained rice* low SES (1/0)	-	-	-0.083	(0.112)
Basket contained fish* low SES (1/0)	-	-	0.007	(0.080)
Cost of basket* low SES	-	-	-0.017	(0.080)
Standard Deviation				
Basket contained cabbage (1/0)	0.301***	(0.102)	0.284**	(0.120)
Cost of a basket	0.242***	(0.089)	0.202	(0.158)
Basket contained cabbage*Lilongwe (1/0)	-0.189	(0.234)	-	-
Cost of basket*Lilongwe	0.006	(0.168)	-	-
Basket contained cabbage* low SES (1/0)	-	-	0.208	(0.211)
Cost of basket* low SES	-	-	0.183	(0.237)
Log Likelihood	-4349.564		-4351.083	
Likelihood-ratio Chi-squared	10.566**		10.794**	
Number of observations	11,940		11,940	

Table 5 shows heterogeneous effects on food choice with respect to location of residence and socioeconomic status (SES) based on mixed logit/random parameter logit model. The price variable is rescaled for easier interpretation. (1/0) indicates dichotomous variables for the stated category equal to 1, otherwise equal to 0 for the base category. Lilongwe is a location dummy variable equal to one if the respondent resided in Lilongwe District, zero otherwise. In the sample 50% of the respondents were from Lilongwe District. Low SES is a dummy variable equal to one for households in the three lowest quantiles of the SES index distribution, zero otherwise. In the sample, 60% of the respondents had low SES. Standard errors in parentheses. * $p < 0.10$; ** $p < 0.05$; *** $p < 0.01$

typically downward sloping (i.e., people consistently dislike higher cost). Our finding likely reflects the limited range in the cost of a basket used which was set around the average observed expenditure (MK900-MK1100) which could be due to the range being too low and respondents placing relatively more value on other attributes.

3.4 Heterogeneous effects on food choices and preferences

3.4.1 Sensitivity of food choice by district and SES

Table 5 presents models with interaction terms between the attributes and district (model III) and socio-economic status (model IV). Some differences are apparent. Respondents from Lilongwe District (model III) had lower utility from a food basket including cabbage ($p < 0.05$) and rice ($p < 0.10$) compared to respondents from Phalombe District. It appears that alternative foods like rice and cabbage may be less preferred in Lilongwe District, where maize cultivation is more dominant, than in Phalombe District, with a greater prevalence of mixed cropping patterns. The coefficient for the cost of a basket, of small-dried fish and additional maize did not vary by location. Model IV examining differences by SES found that the only difference between lower and higher SES group was that of lower utility ($p < 0.10$) from a basket including cabbage for respondents in the lower SES group.

3.4.2 Sensitivity of food choice by food purchases at the market and food security situation

Model V in Table 6 looks at whether preferences differ based on actual food purchases. The results indicate that households that purchased fewer items (0–2) at the market were less likely to choose food baskets with additional maize in comparison to those that purchased more items (> 2) from the market ($p < 0.10$). Further, we find in Table 6 model VI that none of the food attributes significantly influenced food choices for those who had indicated no food security concerns. Those who had reported concerns about food security

Table 6 Food choice sensitivity by purchases at the market and food security situation

Dependent var: choice	Model V (by market purchases)		Model VI (by food security)	
	Coeff.	SE	Coeff.	SE
Attribute (Mean)				
Units of maize	0.168***	(0.053)	-0.099	(0.084)
Basket contained cabbage (1/0)	0.150*	(0.078)	-0.017	(0.123)
Basket contained rice (1/0)	0.224**	(0.094)	0.046	(0.147)
Basket contained fish (1/0)	0.152**	(0.067)	-0.079	(0.106)
Cost of a basket	-0.120*	(0.069)	0.091	(0.104)
Units of maize *low purchases	-0.122*	(0.065)	-	-
Basket contained cabbage * low purchases (1/0)	-0.019	(0.095)	-	-
Basket contained rice * low purchases (1/0)	-0.187	(0.115)	-	-
Basket contained fish * low purchases (1/0)	0.015	(0.082)	-	-
Cost of a basket * low purchase (1/0)	0.054	(0.084)	-	-
Units of maize * food insecurity (1/0)	-	-	0.212**	(0.090)
Basket contained cabbage * food insecurity (1/0)	-	-	0.178	(0.132)
Basket contained rice * food insecurity (1/0)	-	-	0.060	(0.158)
Basket contained fish * food insecurity (1/0)	-	-	0.277**	(0.114)
Cost of a basket * food insecurity	-	-	-0.201*	(0.112)
Standard Deviation				
Basket contained cabbage (1/0)	0.333***	(0.067)	0.334***	(0.067)
Cost of a basket	0.246***	(0.089)	0.129	(0.315)
Basket contained cabbage * low purchases (1/0)	0.003	(0.156)	-	-
Cost of a basket * low purchase (1/0)	0.013	(0.267)	-	-
Basket contained cabbage * food insecurity (1/0)	-	-	0.002	(0.166)
Cost of a basket * food insecurity	-	-	0.224	(0.208)
Log Likelihood	-4350.479		-4345.883	
Likelihood-ratio Chi-squared	10.800**		10.929**	
Number of observations	11,940		11,940	

showed greater preference to additional units of maize, fish and had a negative and significant cost parameter.

3.5 Maize and non-maize products demand simulation

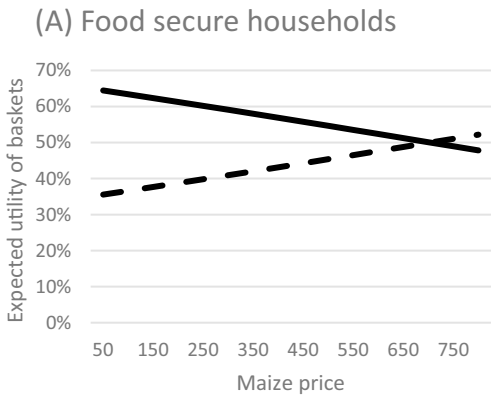
We undertook simulations by subgroups for better understanding of the changes in demand for maize and non-maize products as the price of maize varied. This was done using fixed variable coefficients obtained from the mixed logit models reported in Tables 5 and 6. Figure 3 shows the expected utility from the basket with 1 cup of maize in comparison to a basket with one unit of each of the other items (but no maize) at different price of maize for households with different characteristics. At the point of intersection, a basket with one unit of maize provides the same utility as a basket with one unit of each of the other foods, at a certain maize price. The utility of food baskets with maize is above the utility of baskets with non-maize products for several types of households: among households with high and low food purchases from the market, although for low food purchases the disparity is small; among food insecure households; among households in Phalombe district; and among households with low SES (Graphs B, C, D, F & H). Thus, in this experimental setting, we find that below a certain maize price for these households with high- and low-food purchases, living in Phalombe District, facing food insecurity and low SES, a lower price of maize will not lead to increased dietary diversity – in fact it would lead to further declines in dietary diversity as preference for maize increases. In contrast, among households living in Lilongwe District, with high SES and food secure, a lower maize price will not lead to a loss in dietary diversity as they prefer a basket containing non-maize products over maize (Graphs A, E & G).

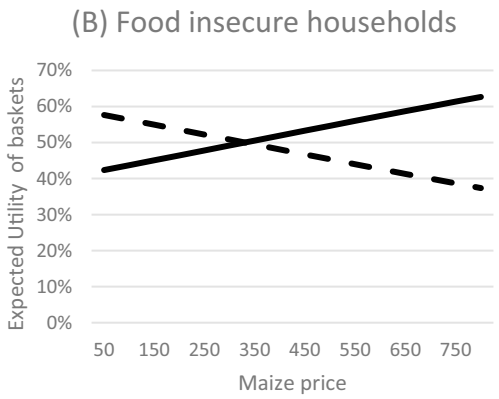
4 Discussion

Participants in our DCE study revealed their food choice response to different food price scenarios, an important investigation in this setting of rural Malawi where maize dominates diets, and food insecurity and poverty are widespread. The DCE results consistently indicated preference for additional maize in a food basket among participants relative to a soft drink. This finding was obtained in overall effects as well as interaction effects with the food security situation. This speaks to the importance of maize relative to other energy-giving food and beverage products in the diets of Malawians, as described in other studies (Aberman & Roopnaraine, 2020; Kershaw et al., 2019; Verduzco-Gallo et al., 2014), and to the high level of food insecurity faced by this population. Nonetheless, we also found that the inclusion of small-dried fish or cabbage in a food basket had greater value to respondents than additional maize. Such preferences accord with earlier observations (Aberman & Roopnaraine, 2020; Gelli et al., 2020) that although diets are dominated by maize in rural Malawi, households desire and often consume a range of other nutritious foods including vegetables and small-dried fish.

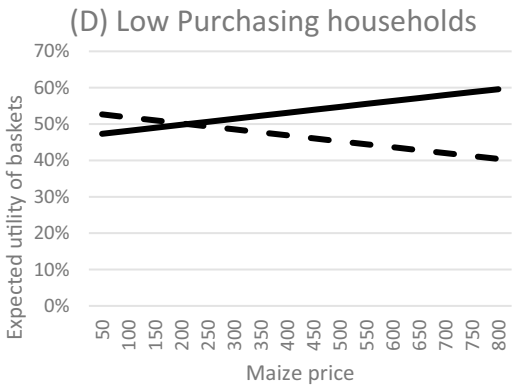
Our finding that on average people preferred lower cost food baskets is consistent with economic theory and findings in Malawi (Ecker & Qaim, 2011) and other low-income settings (Kershaw et al., 2019). However, there was significant heterogeneity, with some respondents being indifferent or having a positive association between cost and choice. The results of focus group discussions with respondents from these same districts (Walls et al., 2023) also highlighted price and affordability as key drivers of food choice.

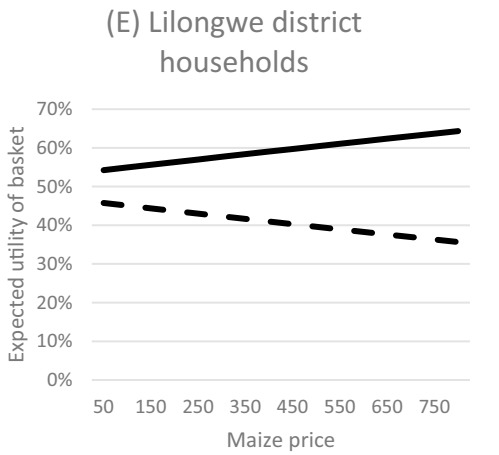
Overall, the experiment suggests that a lower price of maize will not necessarily lead to increases in dietary diversity in rural Malawi, with a maize price decline associated with greater utility from food baskets with maize for certain populations, such as those with low SES and facing food insecurity. This finding supports observations that poor households in rural Malawi respond to increases in income by increasing maize consumption (Ecker & Qaim, 2011). Others also demonstrate that households prioritise food security in terms of having adequate maize over considerations of dietary diversity and growing of nutrient-rich crops like legumes (Matita et al., 2022; Ortega et al., 2016; Silberg et al., 2020; Waldman et al., 2017). This is perhaps because as estimated by the report *The State of Food Security and Nutrition in the World 2020* (FAO et al., 2020) the cost of a healthy diet is in many settings considerably higher than the cost of a diet that only meets energy needs through starchy staples. Even so other literature indicates that greater food market purchases is associated with higher dietary diversity (Matita et al., 2021a; Nandi et al., 2021). In this study, however, there was the suggestion that individuals with higher food purchases were from the more food insecure households, as maize was among the top three foods purchased. It is possible that those individuals that purchase less from the market do so mainly for products that cannot be produced on-farm. In this context with high levels of poverty, having access to land to grow own food for consumption may be associated with fewer food purchases. Thus, whilst in many contexts participation in food markets may be associated with greater dietary diversity, perhaps what is more relevant in understanding diets is the types of foods being purchased. Greater food market purchases may not simply translate into the achievement of more nutritious diets. Furthermore, we found that among households with low SES, high food purchases, residing in Phalombe District and experiencing food insecurity, the expected utility from food baskets with non-maize products declined as maize price falls. This was despite the revealed positive preference for non-maize food attributes such as small-dried fish and cabbage. The results suggest that to improve dietary diversity, recognition must

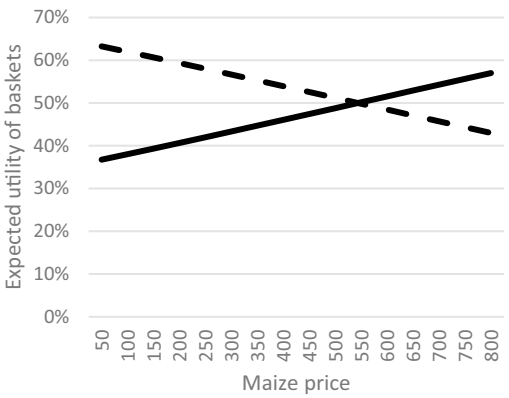

(A) Food secure households
Expected utility of baskets
70%
60%
50%
40%
30%
20%
10%
0%
50 150 250 350 450 550 650 750
Maize price

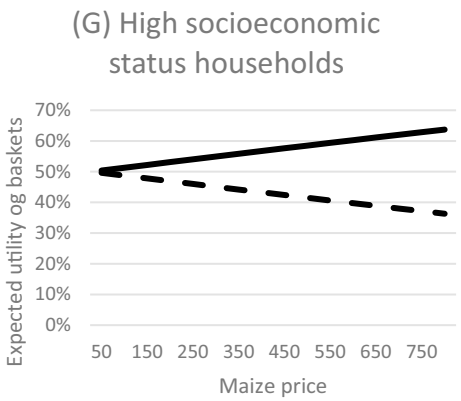

(B) Food insecure households
Expected Utility of baskets
70%
60%
50%
40%
30%
20%
10%
0%
50 150 250 350 450 550 650 750
Maize price

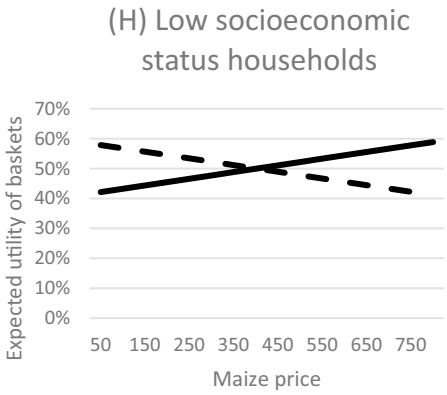

(C) High food purchasing households
Expected utility of baskets
70%
60%
50%
40%
30%
20%
10%
0%
50 100 150 200 250 300 350 400 450 500 550 600 650 700 750 800
Maize price


(D) Low Purchasing households
Expected utility of baskets
70%
60%
50%
40%
30%
20%
10%
0%
50 100 150 200 250 300 350 400 450 500 550 600 650 700 750 800
Maize price


(E) Lilongwe district households
Expected utility of basket
70%
60%
50%
40%
30%
20%
10%
0%
50 150 250 350 450 550 650 750
Maize price


(F) Phalombe district households
Expected utility of baskets
70%
60%
50%
40%
30%
20%
10%
0%
50 100 150 200 250 300 350 400 450 500 550 600 650 700 750 800
Maize price


(G) High socioeconomic status households
Expected utility og baskets
70%
60%
50%
40%
30%
20%
10%
0%
50 150 250 350 450 550 650 750
Maize price


(H) Low socioeconomic status households
Expected utility of baskets
70%
60%
50%
40%
30%
20%
10%
0%
50 150 250 350 450 550 650 750
Maize price

◂**Fig. 3** Changes in demand for maize and non-maize products. Notes: In the graphs, the dashed line (---) represents the utility of a basket with maize while the solid line represent the utility of a basket with other products (non-maize)

be made of the influence of location factors, food security status as well as SES on the utility obtained from a basket with maize. Additionally, the preference for alternatives to maize – illustrated by our inclusion of rice as a substitute – seemed mixed or at times lacking altogether. This is likely explained by the far higher cost of rice compared to maize, which has also been reported elsewhere (Tiba, 2010). It follows that whilst the participants prefer baskets with fish and cabbage over baskets with the other attributes, the demand for non-maize items in response to a decline in maize prices is weak especially in a context of food (maize) insecurity.

The models in this study report absence of heterogeneous effects related to SES except for inclusion of a cabbage in a food basket. This is contrary to many studies showing that food choices and diets vary by SES (Bell et al., 2021). Studies in high-income countries where disparities in SES groups are often large have found food choices to vary with SES, with the poor likely to be more responsive to price changes than the non-poor (de Bekker-Grob, et al., 2012). A discernible pattern of the effects of SES is, however, only seen in the simulations. It could be that in this low-income study context, individuals' food choices were weakly sensitive to the measure of SES used, likely because of only small differences in SES among the poor farming communities in this study. Besides in this setting food purchases are limited, with many farmers producing much of their own food for consumption. The average of two food groups being purchased the last time the respondent visited the market reported as part of the DCE is below the four food groups purchased in the past week reported in Matita et al. (2021a), a finding that was based on a new metric of food purchase diversity from survey data with the same study participants as in this DCE study. The variation likely reflects the difference in time period, with the participants of the DCE reporting purchases from food markets more frequently than weekly. To a large extent reported purchases from food markets are of those items that households cannot produce at home and/or are meant to supplement food stocks especially in the lean season (Zanello et al., 2019). In this DCE, the food groups with most frequent purchases were 'fish and other sea foods', 'spices, condiments and beverages' and 'cereals', consistent with other studies (Ecker & Qaim, 2011). Similarly, among different animal-sourced foods, small-dried fish is the most purchased, although its affordability likely remains a challenge for most rural Malawian households.

This study is not without limitations. The experiment is undertaken in two regions of Malawi and therefore the results may not be generalisable to the whole of Malawi. Further, the results should be interpreted with caution given the small sample from two enumeration areas in each district. There is also limited variation in some characteristics of the respondents such as food security and socio-economic status. Additionally, the cost of the basket was limited to around average spending in a food market over a two-to-three-day period and asking respondents to consider in their choices that they had money worth about an average basket to spend, could have affected price sensitivity. We suggest that simulations should also be used cautiously as hypothesis generating findings because not all variables in the models were statistically significant at conventional levels. Future research could consider subgroup effects in greater depth, for example, through latent class models. The DCE, whilst insightful about stated preferences, may also align less than perfectly with actual observed behaviours (Kershaw et al., 2019). That notwithstanding, this study makes a unique contribution to ideas and policy dialogues about food security and nutrition in Malawi, a country implementing production input subsidies for the staple crop – maize – but with huge challenges in dietary diversification with consequences for different types of malnutrition. Our findings have important implications for interventions designed to promote dietary diversification among populations with diets dominated by staple foods like maize. Specifically, using food price policies and agricultural production input subsides on maize may not support – or be enough to support – diverse food consumption. Policies that increase household incomes may do better in this context where the cost of food and its affordability is among the key determinant of food choices. The persistent preference for maize may also need to be addressed with consistent nutrition information and education about the importance of diversifying diets away from such a strong reliance on staple crops.

5 Conclusion

Based on information derived from household and market surveys in two districts of rural Malawi, we designed a DCE to assess the impact of maize price changes on food choice and dietary diversity. We find that a lower price of maize will likely not lead to greater dietary diversity particularly because of consistent preference for a basket with additional maize among certain population sub-groups. This points to the importance of income/affordability pathways among smallholder farmers to achieving food and nutrition security and suggests a role for economic policy directly improving the incomes of smallholder farmers as opposed to subsidizing inputs for staple crop production.

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Availability of data and material Available upon request.

Declarations

Ethics approval Ethical approval was provided by Malawi's National Committee on Research Ethics on Social Sciences and Humanities and the London School of Hygiene and Tropical Medicine.

Conflict of interest Authors declare no conflict of interest.

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