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Can information drive demand for safer food? Impact of brand-specific recommendations and test results on product choice

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Abstract

As an unobservable attribute, food safety is likely to be under-provided by markets where regulatory enforcement is weak. In such settings, stimulating consumer demand for safer food can potentially encourage market actors to invest in food safety. Through a randomized trial in Kenya, we test the impact of informing consumers about which maize flour brands are most likely to comply with the regulatory standard for aflatoxin, a carcinogenic fungal byproduct. Providing information on safer brands alone does not significantly affect consumption behavior. However, when the same information is combined with a test performed on the maize flour stocked by the household, the likelihood that a safer brand is consumed 2 months later is 76% higher than in the comparison group. Our findings suggest that providing information on the relative riskiness of substitute foods could encourage consumers to make safer choices.

KEYWORDS
aflatoxin, consumer behavior, D12, D82, food safety, I12, information, LMIC

JEL CLASSIFICATION
D12, I12, D82

1 | INTRODUCTION

While foodborne illness is a major health problem globally (WHO, 2015), consumer demand for food safety is typically weak in low-income settings, resulting in low prioritization of this issue by both the market and governments (Jaffee et al., 2018). Stimulating consumer demand for safer food has the potential to catalyze action within the food industry and by policymakers. In this article, we study the impact of providing consumers in a mid-sized Kenyan city with information about relatively safe brands within a product class, and about their personal hazard exposure, on subsequent product choice.

Since food safety is a mostly unobservable attribute that is not easily evaluated by consumers, it tends to be undersupplied in poorly regulated markets. Previous research conducted in the same region of Kenya as the present study found high rates of contamination with the carcinogenic fungal byproduct aflatoxin in formally marketed maize flour (Hoffmann & Moser, 2017) . The rate of non-compliance varied dramatically across brands, from 5% to 85%, and negatively with price, suggesting that

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quality differentiation can lead to heterogeneity in terms of food safety. Despite this variation, firms with better food safety track records do not use this information to market their products, citing challenges in achieving 100% compliance, and the risk that food safety claims could result in heightened regulatory scrutiny. A recent experimental study showed no lasting impact on sales of a maize flour marketing campaign focused on food safety, indicating a little upside of making food safety claims (Hoffmann et al., 2021). On the other hand, media exposés of contamination and government food safety recalls are met with widespread concern and, according to news reports, dampened consumer demand (BBC News, 2019; Ngotho, 2019), suggesting that information from a credible third party, or negative information, may have a stronger effect than positive food safety claims made by firms.

Providing consumers with information on relative aflatoxin levels in this setting has the potential to both enable consumers to make safer choices, and increase the pressure on firms to invest in the safety of their products. Previous experimental studies of the impact of food safety information provided by a third party on consumer food choice have previously been limited to survey or laboratory contexts. Such studies are prone to experimenter demand effects, as subjects are aware they are being observed. Further, outcomes are generally measured immediately after a prompt to consider food safety, artificially inflating the salience of this attribute. The effect of informing consumers about the relative food safety of alternative products on purchase behavior thus remains largely unknown.

We test the impact of providing information about aflatoxin safety on consumer choice of maize flour through a randomized trial conducted in Eastern Kenya, a global aflatoxin hotspot. A comparison group was read a general statement about aflatoxin and the health effects of consuming contaminated food. One treatment group (T1) was in addition informed about the relationship between aflatoxin contamination and maize flour price and given the names of two brands previously found to be most likely to comply with the regulatory aflatoxin standard. A second treatment group (T2) was given the same information as T1 households, and in addition was offered the opportunity to have the maize flour in their home tested for aflatoxin.

Results show positive effects of both treatments on consumer awareness about the heterogeneity in aflatoxin contamination across maize flour brands, and on the likelihood that a respondent recalled the names of the safer brands. However, only those who had received information plus a test result (T2) were more likely than those in the comparison group to be consuming one of the safer brands mentioned 9 weeks later. Testing maize flour increased the likelihood that aflatoxin safety was a factor in consumers' choice of maize flour, relative to those who only received information on safer brands alone. Thus, while independent information on safer brands increased risk awareness, we conclude that specific information on hazard exposure was necessary to translate awareness into action.

In the following section, we review related literature on the impact of information on health risk avoidance and demand for safe food in low and middle-income countries. The following sections describe the study context, design, empirical strategy, and findings, respectively, and the final section concludes.

2 | RELATED LITERATURE

Our study relates to extensive literatures on the role of information in the avoidance of health risks and food choice. Experimental studies conducted in low-income countries, summarized by Dupas and Miguel (2017), demonstrate that information can lead to health-improving changes in behavior, including the selection of safer water sources, treatment of drinking water, and reduced sexual risk-taking. Specific information on relative risk tends to be more effective than general recommendations (Dupas, 2011). A systematic review of the effectiveness of risk communication interventions in health care settings likewise found that providing individualized risk estimates was generally more effective than general risk information (Edwards et al., 2000). Nutrition interventions informing consumers about the absence of unhealthy nutrients, rather than or in addition to the presence of healthy nutrients, were more likely to be effective (Riet, 2013), suggesting the potential effectiveness of information about food safety hazards.

Several articles have used a methodology similar to ours to measure the impact of information on water source selection or treatment behavior. Five experiments in which participants were given the results of fecal contamination tests conducted on their drinking water found that this intervention increased treatment behavior compared to either no information or general recommendations about water treatment (Brown et al., 2017; Hamoudi et al., 2012; Jalan & Somanathan, 2008; Luoto et al., 2011; Trent et al., 2018). The three of these articles that reported the impact of providing test results to households whose water was safe did not find a significant change in water treatment behavior for this sub-group, indicating no downside to providing this information.

We contribute directly to a smaller body of research on consumer demand for safe food. A review by Hoffmann et al. (2019) finds that while studies eliciting willingness to pay (WTP) for certified safe food (including aflatoxin-safe maize) often show that consumers are willing to pay a large premium for safety, WTP is almost always measured immediately after focusing participants' attention on this attribute.

The present article makes several unique contributions. First, in contrast to a recent study by (Hoffmann et al., 2021), which evaluated the effect of a firm's use of food safety claim in its marketing strategy, we consider the impact of information from a third party on the relative safety of particular brands. Second, this article is the first to our knowledge that tests the impact of consumer-specific information on exposure to a food safety hazard: the results of a rapid aflatoxin test conducted on the maize flour currently stocked by the household. Finally, our design varies information at the individual consumer level. The larger number of independent units randomized under this design (503 consumers included in the follow-up sample) allows for more precise estimation of treatment effects, compared to the study by Hoffmann, Moser, and Herrman, in which the marketing campaign was randomiezd across 73 shops.

3 | STUDY CONTEXT

3.1 | Aflatoxin in Kenya

The food safety hazard on which we provided information is the fungal byproduct aflatoxin. Aflatoxin contaminates many agricultural products and is most prevalent in maize and groundnut. Consumption of foods with very high levels of aflatoxin can result in acute and sometimes fatal poisoning, multiple outbreaks of which have occurred in the study region (Lewis et al., 2005). Chronic exposure is known to cause liver cancer (Wu et al., 2013) and is suspected of inhibiting immune system function (Wild & Gong, 2009). Further, exposure to aflatoxin in utero and during early childhood has been associated with low birth weight (Shuaib et al., 2010) and childhood stunting (Hoffmann et al., 2018; Shirima et al., 2015; Turner et al., 2007).

The Government of Kenya has set a regulatory limit for aflatoxin of 10 parts per billion (ppb) in grains, but this is imperfectly enforced. A study based on data collected in 2013 found that 26% of branded maize flour samples collected in Eastern Kenya had aflatoxin levels higher than this limit (Hoffmann & Moser, 2017).

3.2 | The Kenyan maize flour market

Maize is the primary staple food in Kenya, accounting for 42% of dietary energy intake (Kilimo Trust, 2017), and is consumed either as grain or flour. Flour is of two types: more refined sifted flour processed in larger-scale roller mills, and less refined or whole-grain flour processed from whole grain in micro-scale hammer mills. There are over 100 large-scale roller millers in Kenya; relatively few of these dominate the Nairobi market, and as of 2011, four firms accounted for 80% of sifted flour sales there (Kirimi et al., 2011). However, market concentration tends to be lower in rural areas, where regional millers offering maize at relatively lower price points command significant market share. Prices vary widely across brands: in 2013, the difference between the highest and the lowest priced brand in various towns of Central and Eastern Kenya was 27 KES per kg, slightly more than half the price of the lowest priced brand (Hoffmann & Moser, 2017).

Hammer mills ("posho mills") produce two types of flour, semi-refined (de-hulled) flour, and whole-grain (non-refined) flour. Most of these mills only provide the milling service and therefore do not purchase any grain. Consumers take maize they have produced or purchased as grain from the informal grain market to be milled. This flour is unbranded, and the source of maize may not be easy to trace, except in the case of self-produced maize. Posho flour is typically cheaper than sifted flour and is popular among rural consumers and the urban poor (Muyanga et al., 2005).

The proportion of consumers in Kenya who rely on formally processed maize flour is increasing. Based on nationally representative data from 2006, Fiedler et al. (2014) report that 33% of households had purchased sifted flour in the previous week; by 2015–2016 this figure was 39% nationally, and 57% among those in urban and peri-urban areas (Hoffmann et al., 2021). As formal sector millers often require that the grain they use meets quality standards, these firms typically pay more for maize than the informal market price (Hoffmann et al., 2018). As the same farmers and traders often supply both the formal and informal segments of market, boosting demand for aflatoxin-compliant maize within the formal sector has the potential to create incentives for better growing and handling practices, and in this way improve the quality of informally marketed and processed maize.

4 | STUDY DESIGN

4.1 | Population and sample

We reasoned that information about aflatoxin contamination of commercially marketed maize flour would be most relevant to households that normally rely on purchased maize, rather than maize they have grown on their own farms. An urban study site was therefore selected to ensure that (1) most participating households fit this description, and (2) that the relatively safer brands consumers were told about, both of which are distributed nationally, would be readily available (this was subsequently confirmed).

The study was carried out in Meru town, a county capital located in eastern Kenya, a global hotspot of aflatoxin contamination. A list of all villages (administrative units equivalent to neighborhoods) within or adjacent to Meru town which were classified as either urban or peri-urban was generated with the help of an officer from the Kenya National Bureau of Statistics based in Meru County. In total, 64 villages were identified. Villages were divided into clusters of houses or apartment buildings, from which a maximum of one household was randomly selected. In this way, a total of 1000 households were selected to form the study sample. One respondent (either the head or spouse) was recruited per household.

4.2 | Experimental design

Study participants were recruited during household visits conducted in August and September 2018. No compensation was paid to participating households. Assignment to one of three possible treatment groups, general information (C), safer brands (T1), or safer brands plus testing (T2), was determined prior to recruitment.

The probability of assignment to T2 was higher than for the other two groups, based on the expectation that most consumers' flour would be compliant with the aflatoxin regulation,[1] and the assumption that the effect of testing consumers' maize on their subsequent maize flour choice would be stronger when the test result was positive. In line with the prior evidence on the impact of testing households' water for microbial contamination (Brown et al., 2017; Hamoudi et al., 2012; Jalan & Somanathan, 2008; Luoto et al., 2011; Trent et al., 2018), a negative aflatoxin test was expected to have no impact on consumer behavior beyond the safer brands message. A test showing contamination above the regulatory limit, on the other hand, was expected to increase the effect of the safer brands message, as this would demonstrate to consumers the riskiness of their current maize type.

The proportion of the sample assigned to T2 was set such that the expected number of consumers in this group whose maize tested positive (T2P), assuming a 25% rate of non-compliance, would be equal to the number assigned to C and T1. To make efficient use of study resources, all consumers assigned to C and T1, and all T2P consumers, were followed up. The same number would be randomly sampled from T2N for follow-up. Through this approach, enough independent observations in T2N would be included in the statistical analysis, during which the observations would be weighted by the inverse probability of sampling to maintain the representativeness of the sample. The sample sizes per treatment group were thus set to 167 (C), 167 (T1), and 666 (T2). This implied, based on the 25% positive test rate assumption and the 9% baseline rate of safer maize flour consumption, a 10.7% minimum detectable effect for all cross-group comparisons of the proportion of households consuming one of the safer brands, without accounting for the correlation of baseline controls with the outcome.[2]

To ensure that, if indicated by treatment assignment, it would be possible to test households' flour, only those with maize flour in the home at the time of the baseline interview are included in the sample analyzed below. This led to a reduction in the sample sizes, but the resulting loss in power is offset by the inclusion of baseline controls in the estimation of treatment effects.

The baseline interview was conducted during the recruitment visit, and covered household characteristics, maize flour consumption, and aflatoxin knowledge and risk awareness. After the survey was completed, a script containing general information about aflatoxin and the negative health consequences of dietary exposure was read to all participants. In addition to this general information, households assigned to the safer brands information treatment (T1) were told about two brands previously found to be relatively unlikely to exceed the Kenyan limit for allowable aflatoxin contamination, and about the negative correlation between price and contamination (Hoffmann & Moser, 2017). This second piece of information was intended to provide consumers with options for choosing a safer brand in the case they felt both of the specifically named brands were out of reach.[3] Scripts for both treatments are included in Appendix 1. To avoid affecting consent or survey responses, recruitment and survey protocols were identical across groups until the end of the interview.

For those households further assigned to be offered aflatoxin testing of any maize flour they had in their home

[1] Hoffmann and Moser report that 26% of sifted maize flour samples collected from shops in the study region exceeded the regulatory aflatoxin limit (Hoffmann & Moser, 2017).

[2] The MDE was calculated using Stata's power command for two proportions, with power of .8 and significance level of 5%.

[3] While the negative relationship between likelihood of aflatoxin contamination and price holds throughout the range of maize flour prices in this region of Kenya (see fig. 1 in Hoffmann & Moser, 2017), brands priced slightly above the minimum still have a relatively high rate of contamination. We acknowledge that information on this correlation may have been difficult for consumers to interpret and could have given some of them more confidence than is warranted about the safety of maize flour offered at low, but non-minimum, prices.

(T2), a binary test, the Romer AgraStrip Total Aflatoxin Test, was used to test for aflatoxin. This test takes 10–15 min, and the results can easily be read visually. Study participants were invited to observe as the test was conducted, and its result and interpretation were shared immediately upon completion.[4] While waiting for the test results, T2 participants were advised to dispose of contaminated maize should it test above the regulatory limit, and not to feed it to domestic animals (dogs are highly susceptible to aflatoxin poisoning). To mitigate the potential for this guidance, which was deemed ethically necessary, to affect behavior, T2 participants were reminded of information provided to all groups: that exposure to aflatoxin at the levels typically observed in Kenya does not constitute an immediate health threat, and that acute aflatoxin poisoning generally only occurs when people eat maize that they know is not good.

Follow-up data were collected in November 2018, 9 weeks after baseline data collection and the information intervention. The primary outcomes analyzed are the consumption of one of the safer brands mentioned in the scripts read to participants assigned to T1 and T2, and the price of maize flour consumed. The impact of the interventions on the price paid for maize flour sheds light on the premium consumers in this population are willing to pay for food safety, and relatedly, on which consumers are affected by the information intervention. For example, if information on safer brands increases the proportion of consumers who buy these brands but has no impact on the average price paid for maize flour, this would imply that the effect of information is limited to those who already buy similarly-priced, but less safe, maize flour. If, on the other hand, food safety information increases the price paid on average, this would imply that consumers are willing to pay a premium for safer food.

4.3 | Data

Of 1000 households approached to participate in the study, 21 declined, and of the remaining 979, 819 currently had maize flour in their homes which could be tested. We restrict our analysis to this group, for whom testing was feasible in case this was required based on the experimental treatment assignment. Of the 819 households in the sample, 132 were randomly assigned to the comparison group, 137 to T1 (safer brands information) and 550 to T2 (safer brands plus testing information).

All the households assigned to the comparison and safe brands information treatment group (T1) were included in the sample for follow-up, as were all of those assigned to the safer brands plus testing group (T2) whose maize flour had tested above the regulatory threshold for aflatoxin contamination (54 households)[5]. A randomly selected subsample of 215 (44%) of the 484 households whose flour had tested below this threshold were targeted for follow-up. Other households with a negative test result were randomly excluded from the follow-up sample due to budgetary constraints, and because adding households with a negative test result did not offer significant benefits in terms of power. To account for this sampling design, we weight observations by the inverse probability of assignment to being followed up in the analysis below (1/.44 for T2 households with a negative test result and 1 for all other households). Twelve households who refused to have their flour tested at baseline were not followed up for a second interview. We test for the robustness of our results to any bias arising from this oversight through a Manski bounds approach (Horowitz & Manski, 2000). Observations by treatment group and test result at baseline, targeted for follow-up, and in the analysis sample are shown in Table 1.

4.4 | Descriptive statistics and balance checks

In this section, we briefly describe key features of the choice environment and sample, and test for balance on baseline characteristics across treatment groups.

Table 2 presents descriptive statistics on the proportion of study households consuming each type of flour at baseline, median prices per kg, and the proportion of samples of each type found to contain aflatoxin above the regulatory limit of 10 ppb. As shown in Column 1 of the table, most households (83%) were consuming sifted (packaged) flour at baseline. Of these, 9% were consuming either of the two safer brands. Six percent consumed brand one, for which the median price of 52 KSh per kg was close to the overall median price of other sifted brands (51 KSh) (Column 3), while 3% consumed brand 2, a premium brand with a median price of 73 KSh.

[4] An alternative design, in which aflatoxin test results would be shared with only a subset of randomly selected households for whom tests were conducted, would have yielded clearer results on the impact of positive versus negative results. However, as this would have denied some households actionable knowledge about personal exposure to a known health hazard, and as previous research on water treatment behavior has addressed the question of the differential effect of positive versus negative information, such a design was not deemed to be ethically acceptable.

[5] The proportion of samples that tested above the limit (positive result) was less than the 25% expected based on the level reported by Hoffmann and Moser. This discrepancy reflects the fact that aflatoxin contamination varies dramatically from year to year.

TABLE 1 Study sample

Approached at baseline	**1000**		
Declined to participate	**21**		
No maize flour	**160**		
Baseline sample	**819**		
	Baseline sample	**Targeted for follow-up**	**Reached at follow-up (main analysis sample)**
C: comparison	**132**	**132**	**123**
T1: safer brands info	**137**	**137**	**126**
T2: safer brands + test	**550**	**269**	**257**
Negative result	484	215	206
Positive result	54	54	51
Refused test	12	0	
Total	**819**	**538**	**506**

TABLE 2 Baseline consumption, median price, and aflatoxin contamination, by flour type

	1	**2**	**3**	**4**	**5**
Type of flour	**Proportion of initial sample observed to consume flour type**	***N***	**Median price per flour type/brand (KES/kg)**	**Number of samples tested**	**Proportion with aflatoxin level higher than 10 ppb**
Safer brand 1	.06	52	52	27	.00
Safer brand 2	.03	26	73	17	.00
Other sifted brands	.74	604	51	394	.07
Self-produced grain, posho-milled	.15	125	n/a	71	.28
Purchased, posho-milled	.04	34	31	29	.28
Total		841		538	.10

Notes: Some households had more than one brand hence the total value in column two exceeds the number of households (819). The price of self-produced maize is omitted since we do not have sufficient data to calculate the value of self-produced maize.

Nineteen percent of study households were consuming flour processed by small-scale hammer ("posho") mills. This included maize the consumers had produced themselves (15%) or purchased as whole grains and brought to the mill (3.8%), and that which had been pre-milled at the posho mill and then purchased (.4%). Posho-milled flour made from purchased grain was less expensive than sifted flour, at a median price of 31 KSh per kg including the cost of milling. We do not report prices for self-produced maize since we do not have data on maize sales prices or production costs.

Column 5 of Table 2 shows the proportion of samples of each type of flour tested that were found to contain aflatoxin above the 10 ppb Kenyan regulatory limit. None of the samples of either safer brands had aflatoxin levels higher than 10 ppb, and 7% of other packaged brands had levels higher than 10 ppb. Among flour samples that had been ground at a posho mill, 28% tested above the aflatoxin standard, with the rate equal between home-produced and purchased maize. The higher level of contamination in posho flour may be due to the fact that the study was conducted in one of the highest aflatoxin risk counties in Kenya, whereas much of commercially milled maize is grown elsewhere in the country where maize yields are higher and aflatoxin is lower. Further, as aflatoxin tends to be concentrated in the hull of the grain, sifted flour is partially decontaminated through the removal of the maize hull.

Table 3 presents descriptive statistics for the households and respondents in the analysis sample. Awareness of aflatoxin was high at baseline: 72% of participants said they had previously heard of aflatoxin, 60% were able to define it correctly, and 78%, including those who initially said they had not heard of the toxin, could name at least one

TABLE 3 Pre-intervention household and respondent characteristics (analysis sample)

	Mean	SD
Age of the respondent (complete years)	43.7	15.8
Education level of the respondent (complete years)	10.0	4.2
Respondent is male	.20	.43
Respondent is household head	.48	.54
Ever heard of aflatoxin	.72	.48
Able to explain what aflatoxin is	.60	.53
Knows at least one health effect of exposure to aflatoxins	.78	.45
Any flour in the shop must be safe	.39	.52
Some brands have higher levels of aflatoxin than others	.55	.54
General trust level (scale of zero to two)	.31	.71
Institutional trust level (scale of zero to four)	1.65	1.62
Impatience level	5.68	3.96
Qualitative interview	.08	.30

Notes: Means for T2 are weighted by the probability of inclusion in the sample.

health effect of exposure.[6] Participants' awareness about variation in aflatoxin safety across brands were assessed through true or false responses to two statements: (a) any packaged maize flour available at the shop must be safe (false), and (b) some brands of packaged flour have higher levels of aflatoxin contamination than others (true). Thirty-nine percent of participants believed that any packaged maize flour is safe, while just over half (55%) believed some brands are safer than others. Fourteen percent of respondents identified one of the two brands mentioned in the script as relatively low in aflatoxin. Descriptions of the variables measuring trust, indices of household wealth, and aflatoxin knowledge used as controls in the analysis are provided in Appendix 2.

We also show in Table 3 the proportion of households that were randomly selected to be administered an additional qualitative interview that assessed quality and safety perceptions of maize flour, for which we control in the analysis.

Treatment group means for the analysis sample, and *p*-values for tests of equality between these for the variables described in Table 3 or related indices, and for the type and price paid for maize consumed at baseline, are presented in Appendix Table 1. Four out of 45 tests (three comparisons for each of 15 respondent and household characteristics) based on linear regression of baseline covariates on treatment indicators show a difference significant at $p < .05$. Similar results are obtained for the baseline sample and the sample for which follow-up was attempted, as shown in Appendix Tables 2 and 3, respectively. In addition to the tests of balance conducted for each baseline covariate, we test for the joint significance of differences across groups for all the covariates. We follow a non-parametric approach described in (Hansen & Bowers, 2008), which assesses balance on all the covariates jointly including all linear combinations of the covariates. The result is a single test statistic with a chi-square distribution. The comparison between each of the treatment groups (T1 and T2) with the comparison group, and with each other, yield *p*-values of .263, .143, and .175, respectively, indicating that randomization was successful in achieving statistical balance across groups.

Households assigned to T2 can further be divided into two groups depending on the test result. While the test result is clearly not random, and we do not expect balance on baseline variables for these two subgroups, we find it interesting to compare each of these groups with one another and with the comparison group. Results, shown in the Appendix Table 4, indicate that households with a negative test result were on average wealthier, more educated, had higher levels of aflatoxin knowledge, and were less likely to be represented in the survey by the household head, compared to those whose maize was found to be contaminated. Relative to comparison group households, those with maize above the allowable aflatoxin level differed in terms of the type of maize consumed, while heads of households with negative test results were less likely to have been interviewed.

4.5 | Attrition

The overall attrition rate between enrollment and follow-up 2 months later (for those included in the follow-up sample) was 7%. This is driven primarily by the survey

[6] Respondents who had not heard of aflatoxin were read the following statement before being asked to describe the health effects of exposure: "Aflatoxin is a poison that is produced by mold on maize and other crops".

team failing to find respondents in their homes during the follow-up survey. Attrition was lowest in the safer brands plus test information group at 6.4%, and highest in the safer brands information only group (T1), at 8.0%. As shown in Appendix Table 5, differences in attrition rates across treatment groups are not statistically significant based on ordinary least squares regression of an indicator of attrition on treatment status. However, the exclusion of the 12 respondents who refused to have their maize tested at baseline from follow-up data collection implies that attrition within T2 was non-random. Further, attritors differ from non-attritors on other observables characteristics, namely age, aflatoxin knowledge, and beliefs regarding the heterogeneity of aflatoxin contamination in branded flour. We include in the appendix bounding specifications in which the 12 observations that were not followed up are assigned the maximum and minimum values of the dependent variable, following (Horowitz & Manski, 2000). In these bounding specifications, we address other aspects of non-random attrition by weighting observations by the inverse probability of being observed at follow-up according to their baseline characteristics and treatment assignment.

5 | EMPIRICAL STRATEGY

5.1 | Main outcomes

Data collected during the follow-up survey were used to generate the two primary outcome variables: consumption of one of the two safer brands mentioned in the information script at follow-up and the price of flour consumed at follow-up. The type of flour consumed at follow-up is based on direct observation, if possible, but if there was no flour in the house, as was the case for 23% of households, respondents were asked about the type of flour they had purchased most recently. We include in the tables below a specification in which the sample is restricted to those who had flour in their homes at follow-up, and whose flour choice was thus directly observed.

For the price of flour consumed at follow-up, we use the median price per kilogram of that brand or type as reported by households in the follow-up sample due to significant measurement error observed in the price data.[7] Since we do not have sufficient data to calculate the value of self-produced maize, we assign the median price per kg of posho mill flour to households that were consuming self-produced maize that is milled at the posho mill. As a robustness check, we also present a specification that omits these households.

To estimate treatment effects on each outcome of interest, we estimate the following equation by ordinary least squares (OLS):

$$y_{i1} = \alpha_1 + \beta_2 \cdot T1_i + \beta_3 \cdot T2_i + \beta_4 \cdot y_{i0} + \beta_5 \cdot Q_i + \beta_6 \cdot X_i + \varepsilon_{1i} \qquad (1)$$

where y_{i1} is the outcome variable for household *i* at follow-up, $T1_i$ is an indicator of assignment to the safer brands information treatment, $T2_i$ is an indicator of assignment to the safer brands information plus test treatment, y_{i0} is the outcome variable at baseline,[8] Q_i indicates that the respondent was selected to participate in the qualitative interview, X_i is the set of baseline controls for household *i* as described in Table 4, and ε_{1i} is the error term. Heteroskedasticity-robust standard errors are clustered at the village level to account for potential spatial correlation in outcomes. We also present, as robustness checks, results from (a) a specification of the version of Equation (1) that omits baseline respondent and household characteristics, X_i, and (b) a logistic regression of the binary outcome (consumption of a safer brand) on treatment indicators and baseline controls.

Additionally, we provide descriptive results on how outcomes differ depending on the result of the aflatoxin test result. These differences are estimated based on OLS estimation of Equation (2)

$$y_i = \alpha_2 + \beta_7 \cdot T1_i + \beta_8 \cdot T2P_i + \beta_9 \cdot T2N_i + \beta_{10} \cdot y_{i0} + \beta_{11} \cdot Q_i + \beta_{12} \cdot X_i + \varepsilon_{2i} \qquad (2)$$

in which *T2Pi* indicates that the household's flour tested above the Kenyan aflatoxin standard, *T2Ni* indicates a test result showing contamination below this threshold, and other variables are as defined above.

It is not possible, under our experimental design, to estimate the causal impact of a negative or positive test on the study outcomes, as baseline test results are endogenous to consumer maize choices and thus likely to be correlated with respondent characteristics. This is a limitation of the design, which was based on the ethical imperative of providing test results to all participants whose maize was tested. Indeed, as noted above, households that received a positive test result

[7] Price data on branded maize flour collected from markets for a separate study by one of the authors found a within-brand intraclass correlation (ICC) of .90 [95% CI: .79–1.00]. In contrast, the within-brand ICC of branded maize flour in the household data collected for this study was .14 [95% CI: .00–.32]. The baseline price shown in balance tests and used as a control variable is constructed in the same way.

[8] Observations for which baseline flour price is missing due to consumption of self-produced maize are included in the regression and assigned a dummy variable indicating this.

TABLE 4 Maize flour type at follow-up among comparison and T2 households, by baseline flour type and test result

	Posho at baseline		Packaged flour at baseline	
Follow-up flour type	**Comparison**	**T2, positive test**	**Comparison**	**T2, positive test**
Safer brand	.00	.25	.09	.26
Other brand	.52	.39	.88	.61
Posho flour	.57	.36	.08	.13
Observations	21	28	91	23

differed significantly at baseline both from control households and from those who received a negative test result. For this reason, we only estimate Equation (2) with the full set of baseline controls included, and caution that β_8 and β_9 capture the influence of any unobserved differences across sub-groups in addition to the impact of receiving a positive or negative test result, respectively.

5.2 | Mechanisms

The information interventions tested through this experiment are expected to affect consumer behavior through two mechanisms: awareness of aflatoxin risk and how to avoid it, and perceived importance of this risk. The brand-specific information on aflatoxin contamination provided through both T1 and T2 is expected to increase consumer awareness that aflatoxin contamination varies systematically across brands; it further provides actionable information about how to avoid this risk. However, a consumer who believes that the maize flour their family normally consumes is unlikely to be contaminated may not assign much importance to this information. By providing information on personal exposure, T2 is expected to increase the weight given to aflatoxin safety in consumers' flour purchase decisions, particularly among those whose flour is found to be contaminated. In addition, witnessing an aflatoxin test could potentially increase the salience of information about the relative aflatoxin safety of brands provided to both treatment groups. This salience could in turn increase the retention of the safer brands information by participants in T2 relative to those assigned to T1.[9]

To assess the extent to which the information treatments affected consumer behavior through the two channels of awareness and importance, we estimate Equations (1) and (2) using three intermediate outcomes: an index indicating awareness of variation in aflatoxin safety across brands, a dummy variable indicating whether the respondent is able to identify either of the two safer brands mentioned in the information script, and an indicator of whether aflatoxin safety is considered in the choice of flour consumed at follow-up. We include results from logistic regressions of these outcomes on treatment indicators and baseline controls as a robustness check.

The risk awareness index is constructed from respondents' reactions to the following three statements: (a) any packaged maize flour available at the shop must be safe (false), (b) some brands of packaged flour have higher levels of aflatoxin contamination than others (true), and (c) more expensive brands have a lower chance of being contaminated with aflatoxin compared to cheaper brands (true). Each answer is assigned a value ranging from 0 to 4, based on a five-point Likert response ranging from strongly agree to strongly disagree. A 'strongly agree' response to an accurate statement is assigned a value of 4, while a 'strongly agree' response in an incorrect statement is assigned a value of 0. The index therefore ranges from 0 to 12, where 12 indicates the highest awareness level and 0 indicates lowest awareness level.

6 | RESULTS

6.1 | Type of flour consumed at follow-up

We begin the presentation of results with a brief description of the consumption patterns at follow-up relative to the flour type consumed at baseline. As shown in Table 4, the type of maize flour consumed over time by a given consumer was far from constant. In the comparison group, 57% of those who had been consuming posho at baseline were also doing so at the time of the follow-up survey, while 52% were consuming packaged flour (some consumed both posho and packaged flour; none were consuming either of the safer brands). Of baseline posho consumers whose flour tested above the regulatory limit for aflatoxin, 25% were consuming one of the safer brands at follow-up, 39% consumed a different brand, and 36% were still consuming posho flour.

Among the consumers of packaged flour brands not identified as safer at baseline, 9% of those assigned to

[9] Information provided through the study could have prompted participants to obtain additional information about aflatoxin from other sources during the period between baseline and follow-up, potentially strengthening the effect of the interventions. Effects of the experimentally varied interventions presented below are inclusive of any such intermediate impacts.

TABLE 5 Impact of information treatment on the consumption of a safer brand and the price per kg of maize flour

	1 Consumes a safer brand	2 Consumes a safer brand	3 Price per kg of flour consumed	4 Price per kg of flour consumed
Panel A				
Safer brands information only (T1)	.044	.044	.623	1.162
	(.035)	(.042)	(.906)	(.868)
Safer brands info plus testing (T2)	.074**	.086**	.994	1.221*
	(.032)	(.040)	(.696)	(.648)
T1 = T2: *p*-value	.356	.323	.592	.933
Observations[a]	503	389	503	432
Panel B				
Negative test result group (T2N)	.057*	.072*	.773	1.138*
	(.033)	(.042)	(.712)	(.652)
Positive test result group (T2P)	.216***	.220**	2.855**	2.019
	(.065)	(.090)	(1.269)	(1.447)
T1 = T2N: *p*-value	.713	.541	.837	.976
T1 = T2P: *p*-value	.005	.037	.052	.521
T2N = T2P: *p*-value	.015	.113	.096	.523
Observations[†]	503	389	503	432
Additional sample restrictions		Had flour at follow-up		Excludes those consuming own maize
Comparison group mean	.098	.117	46.43	48.24

Notes: all columns show OLS estimates with heteroskedasticity-robust standard errors clustered at the village level in parentheses. Panel A shows results from a regression of each of the outcome variables on indicators of assignment to the two experimental treatments. In Panel B, T2 is divided into two groups based on the test result, a negative test result group whose flour tested below 10 ppb and a positive test result group for the households whose flour tested above 10 ppb. Observations are weighted by the inverse probability of randomly determined inclusion in the follow-up sample. All specifications include an indicator for whether the baseline respondent participated in a qualitative interview and the respondent and household characteristics described in Table 3. Coefficients for the controls used in the models are shown in Appendix Table 9. Panel B also includes T1 treatment indicator. The specification in column 2 excludes households who did not have any flour at follow-up while column 4 excludes those consuming flour from own produced maize.

[†]Three respondents could not recall the name of the most recently consumed flour and are thus excluded from this analysis.

*$p < .10$.

**$p < .05$.

***$p < .01$.

the control group had switched to one of the two safer brands at follow-up, while 88% were consuming one of the other packaged brands and 8% were consuming posho flour. For sifted flour consumers whose maize had tested above the aflatoxin limit, the proportion who had switched to a safer brand at follow-up, at 26%, was similar to the switching rate of posho consumers with a positive test.

6.2 | Impact of information on product choice

Turning to the formal analysis of treatment effects on flour choice, Table 5 shows the impact of information on the two primary outcomes: consumption of a safer brand and the price of the brand consumed at follow-up. In Panel A, we show treatment effects as estimated through Equation (1). Panel B shows results of Equation (2), in which outcomes for T2 households are split by the test result.

The effect of the safer brands information only treatment (T1) on the likelihood of consuming a safer brand at follow-up is not statistically distinguishable from zero (Columns 1). Households whose flour was tested (T2), on the other hand, were 7.4 percentage points more likely than comparison group households to consume a safer brand at follow-up compared to those in the comparison group, a 76% increase compared to the control group mean of 9.8%. Restricting the sample to households whose flour could be directly observed yields similar estimated treatment effects (Column 2). Results from models that exclude controls (Appendix Table 6), and from a logistic regression of the binary outcome (consumption of a safer brand) on treatment indicators (Appendix Table 7) are similar.

Given that posho flour was over three times as likely to be contaminated with aflatoxin as sifted brands,

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TABLE 6 Impact of information on risk awareness and stated reasons for the preferred flour type at follow-up

	1 Risk awareness	2 Correctly names a safer brand	3 Aflatoxin safety considered in flour choice
Panel A			
Safer brands information only (T1)	.553**	.210***	.022
	(.264)	(.054)	(.026)
Safer brands info plus testing (T2)	.566***	.269***	.084***
	(.185)	(.044)	(.024)
T1 = T2: *p*-value	.944	.254	.053
Observations	506	506	506
Panel B			
Negative test result group (T2N)	.495**	.244***	.067***
	(.188)	(.045)	(.024)
Positive test result group (T2P)	1.181***	.488***	.224***
	(.329)	(.088)	(.058)
T1 = T2N: *p*-value	.759	.513	.155
T1 = T2P: *p*-value	.058	.004	.001
T2N = T2P: *p*-value	.024	.006	.009
Observations	506	506	506
Mean of the comparison group	7.374	.171	.024

Notes: all columns show OLS estimates, with heteroskedasticity-robust standard errors clustered at the village level in parentheses. Panel A shows results from a regression of each of the intermediate outcome variables on indicators of assignment to the two experimental treatments. In Panel B, T2 is divided into two groups based on the test result, a negative test result group whose flour tested below 10 ppb and a positive test result group for the households whose flour tested above 10 ppb. Observations are weighted by the inverse probability of randomly determined inclusion in the follow-up sample. All specifications include an indicator for whether the baseline respondent participated in a qualitative interview and respondent and household characteristics described in Table 3. Coefficients for the controls used in the models are shown in Appendix Table 11. Panel B also includes T1 treatment indicator.

*$p < .10$.

**$p < .05$.

***$p < .01$.

understanding the reaction of the 19% of the sample who consumed posho flour at baseline is of particular interest. While the study is not powered to test for heterogeneous effects by baseline flour type, we find that point estimates of both treatment effects on the primary outcomes are higher for baseline posho flour consumers than for those who consumed sifted flour (Appendix Table 8).

Households that received a positive test result were especially likely to be consuming a safer brand at follow-up, at 22 percentage points, or over three times, above comparison households (Columns 1 and 2, Table 6, panel B). Consumption of safer flour at follow-up among these households is also significantly higher than both those assigned to T1, and those who received a negative test result. While these differences cannot be interpreted as causal effects, it is worth noting that at baseline, households with positive test results were far less likely to be consuming one of the safer brands. Consumption of a safer flour brand is also slightly higher than comparison households (at $p < .1$) among those who received a negative test result, though this could reflect pre-existing differences across groups.

Treatment effects on the unit value of flour consumed at follow-up are shown in Panel A of Columns 3 and 4 in Table 6. Results shown in Column 3 are based on the full sample, including those consuming self-produced maize at follow up, with the value of this maize imputed as the median price of posho mill flour. Column 4 shows results from a specification that omits households consuming self-produced maize at follow up. For households given safer brands information alone (T1), the treatment effect on the price paid for maize is positive but not statistically different from zero. The effect of information plus testing (T2) is positive and weakly statistically significant ($p = .064$) in the specification that excludes those consuming own maize. Treatment effects on the outcome are not statistically distinguishable between T1 and T2.

Disaggregating T2 by test result, the greatest difference in expenditure on maize flour per kg is between comparison households and those with a positive test result, though this is imprecisely estimated due to the smaller number of households in this group, and thus is only significant for the specification in Column 3, which includes more observations. The difference against comparison households is smaller, and significant at $p < .1$, for households whose flour tested below the aflatoxin standard at baseline. Similar to the difference in consumption of safer flour discussed above, this could be a result of pre-existing preferences for higher-priced flour among those whose flour tested negative.

6.3 | Mechanisms

To shed light on the mechanisms behind the treatment effects on product choice described in the previous section, we turn to the intermediate outcomes of aflatoxin risk awareness, knowledge of safer brands, and the importance of aflatoxin safety in maize flour choice.

Results presented in Columns 1 and 2 of Table 6 show that both information treatments positively affected awareness of heterogeneity in aflatoxin safety across maize flour brands and the ability to name at least one of the safer brands. The effects of T1 and T2 on these outcomes are similar and statistically indistinguishable, suggesting that conducting an aflatoxin test on participants' flour did not meaningfully affect retention of the standard information provided across treatment groups.

Results in Panel B show that risk awareness and recall of safer brands were both higher among households that received a positive test result (T2P) relative to those in the comparison group, those who had received information on safer brands without a test (T1), and those who had received a negative test result (T2N). While these results cannot be interpreted as causal, it stands to reason that information about the aflatoxin safety would be more salient to households who are at the same time told the flour they are consuming is contaminated.

Turning to the reported importance of aflatoxin safety in purchase decisions, we see no impact of safer brands information alone (T1) on the likelihood that consumers mentioned aflatoxin safety as a reason for selecting a given flour type or brand. The testing treatment, however, had a significant impact on this outcome, and the effect is statistically distinguishable from that of T1 at $p = .053$. This result appears to be driven by the effect on those who received a positive test result, who were more likely than those in the comparison group, T1, or T2N, to cite aflatoxin safety as a reason for their choice of flour.

Results from a logistic regression of the binary intermediate outcomes (correctly names a safer brand and aflatoxin safety considered in flour choice) on treatment indicators (Appendix Table 10) are similar.

Overall, these results indicate that while information alone is effective at increasing awareness about food safety risks and increasing knowledge of safer options, providing specific information on hazard exposure is critical for translating awareness and knowledge into action. Guidance provided to participants on the disposal of contaminated maize could have made this information particularly salient.

7 | DISCUSSION AND CONCLUSION

We tested the role of information in stimulating demand for safer maize flour. Maize consumers in a county capital in Eastern Kenya were visited in their homes and given general information about aflatoxin, and the names of the two brands with the highest probability of meeting the Kenyan regulatory limit for this contaminant. A rapid test of maize flour stored in the home during this visit was conducted for a subset of households.

Providing information about differences in aflatoxin safety across brands, and about which brands are safest, affected consumers' risk awareness and ability to identify safer brands 9 weeks later. However, the likelihood of consuming one of these brands did not change for consumers provided with this information only. Participants who were in addition provided with the result of an aflatoxin test conducted on their own maize flour at baseline were more likely to be consuming a safer brand at follow-up. We interpret these results as arising due to the greater significance of information about how to avoid a food safety hazard when one's exposure to the hazard is known.

A caveat to this interpretation is that guidance regarding safe disposal of contaminated maize, which was provided to the group whose maize was tested, could have amplified the perceived health risk of consuming contaminated flour for this group. A second limitation is that it is not clear how consumers interpreted information provided in T1 about the relationship between maize price and the likelihood of contamination. This information, which was intended to provide consumers with options for safer choices if the two brands mentioned were out of reach financially, may have given some consumers false confidence in the safety of brands offered at prices above the minimum. If so, this could have reduced the impact of information provided in both treatments on the purchase of either of the two safer brands identified.

Our results suggest that simply providing consumers information about which foods are safest is insufficient to substantially shift demand in the study setting of Eastern Kenya, and that awareness of one's current exposure to food safety hazards can increase responsiveness to such information. Communicating hazard exposure through

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individualized test results, as was done in this study, is clearly not a scalable policy. However, it would be feasible to make information available about the relative levels of contamination present in substitute food products, based on surveillance data. Whether the effect on consumer food choice of such information would be as strong as that of sharing individual test results is an open question that warrants further attention. Previous evidence on the effect of providing household versus source-level information on water quality suggests provision of more general information could be effective (Luoto et al., 2011).

We find that at the time of the study, the rate of noncompliance with food safety regulations was far higher in the unregulated, informally marketed flour available in Meru town than in the sifted flour produced by small-scale formal millers there. Similar results have been shown for processed versus informally marketed raw milk in Kenya (Wanjala et al., 2017). We caution that relative rates of aflatoxin contamination in the formal and informal sector are likely to vary both spatially and over time, based on the source and time since harvest of maize used within each sector. More comprehensive data would be required to develop actionable recommendations for consumers on the relative safety of these products.

To the extent that the patterns, we observe hold in data that are representative over both space and time, calling consumers' attention to differences in the safety of formally versus informally marketed maize in this setting would have the potential to shift consumption toward the safer formal sector. This would be expected to encourage formalization of the processing sector, facilitating adoption of aflatoxin control measures by a larger share of the industry, and ultimately leading to a safer food supply.

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SUPPORTING INFORMATION

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