AIMS Agriculture and Food

AIMS Agriculture and Food, 5(4): 578–598.
DOI: 10.3934/agrfood.2020.4.578
Received: 28 January 2020
Accepted: 09 August 2020
Published: 14 September 2020

http://www.aimspress.com/journal/agriculture

Research article

Health communication effects on food safety behaviors: A regression analysis of the determinants of food safety behaviors in health communication for life rural program districts

Gretchen H. Thompson*[,1], **Rachel Lenzi**[1], **James M. MacCarthy**[1], **Aulive Msoma**[2], **Bagrey Ngwira**[3] **and Heather Chotvacs**[4]

[1] Global Health and Population Research Department, FHI 360, Durham, NC, USA
[2] USAID Health Communication for Life Project, FHI 360, Lilongwe, Malawi
[3] Department of Environmental Health, The Polytechnic, University of Malawi, P/Bag 303, Chichiri, Blantyre, Malawi
[4] Maternal, Newborn, and Child Health Department, FHI 360, Washington, DC, USA

* **Correspondence:** Email: gthompson@fhi360.org; Tel: +19195447040.

Abstract: We investigate the relationship between the adoption of practices shown to reduce the risk of aflatoxin consumption and several hypothesized protective factors—including exposure to social and behavior change communication and beliefs about the danger and severity of consumption of potentially contaminated foodstuffs. The study utilizes cross-sectional survey data collected from rural heads of households in Malawi as baseline data for a U.S. Agency for International Development-funded social and behavior change communication project, Health Communication for Life. We hypothesized that four groups of factors would be associated with the use of practices shown to reduce the risk of aflatoxin contamination and consumption—demographic factors, geographic location, exposure to health communication about food safety and risks of aflatoxin contamination, and beliefs. The exposure model and belief model found higher scores to be associated with adopting positive food safety behaviors and in the hypothesized directions. This indicates that exposing people to information about food safety increases their reported food safety behaviors across production, storage, and purchasing activities. The effects of exposure to food safety messages and beliefs about food safety persisted in our trimmed model, net of the effects of education. This finding indicates that communication channels and exposure to social and behavior change messaging are an effective means of influencing food safety behaviors especially in environments where educational levels are low. Our findings may well extend to contexts beyond our study area into other rural, agriculturally dependent, and low-education environments in southern Africa.

Keywords: health communication; social and behavior change; food safety; food security; aflatoxin; mycotoxin; nutrition; Malawi

Abbreviations: HC4L: Health Communication for Life; USAID: United States Agency for International Development; ONSE: Organized Networks of Services for Everyone-*Athanzi*; GLM: Generalized Linear Model

1. Introduction

Food safety is an integral part of food security and a pressing global problem. The development of sustainable agriculture must entail efforts to support nutrition-sensitive agricultural programs where food safety is addressed alongside food security. Throughout Africa, and especially in Malawi, maize is a staple crop that makes up the majority of peoples' diet and is susceptible to contamination with mycotoxins—"secondary metabolites produced by microfungi that are capable of causing disease and death in humans and other animals." [1,2]. Exposure to aflatoxin, a type of mycotoxin, has been linked to stunting and is a known hepatic carcinogen [1,3,4], while fumonisins, another mycotoxin, are linked to esophageal cancer [3]. Malawi has the highest prevalence of esophageal cancer in the world (24.2 per 100,000 people), alongside widespread stunting, liver cancer, and other comorbidities associated with mycotoxin exposure [5]. Globally, experts are calling for greater attention to mycotoxins, including social science research to understand the complexity of factors contributing to risk and agricultural practices [6,7].

Published data indicate widespread mycotoxin contamination in staple foodstuffs in Malawi, such as maize and groundnuts [8–13], including aflatoxins and fumonisins. Additional risks stem from constraints on agricultural inputs available to small farmers and food insecurity at the household level, which drives the consumption of unsafe grains [14]. Malawi's economy is largely dependent on agricultural development; maize and groundnuts comprise a significant portion of the agricultural commodities produced [12]. Increased international regulation around mycotoxins has concentrated potentially contaminated food in domestic markets and among subsistence farmers as producers aim to export the highest quality grains, leaving poor quality and contaminated grains in great quantities for domestic markets [15,16]. Meanwhile, Malawi's food safety policies and regulatory infrastructure are inadequate to test and regulate food stuffs sold in markets or processed commercially [12,17]. These limitations are exacerbated by the severe impacts of climate change, particularly seasonal droughts throughout southern Africa [14], the most recent of which lasted from 2016 to 2017. This is because drought conditions are conducive to the spread of mold spores and plant stress.

There are multiple interrelated health, environmental, and economic benefits of enhancing food safety, nutrition, and livelihoods: Improved dietary diversity can reduce exposure to foodborne toxins [18], lead to greater crop diversification, improve child health, and sustain livelihoods in households with limited market access [19]. Strategies to prevent mycotoxin consumption involve social and behavior change interventions to reduce the consumption of contaminated food through increased awareness of risk and prevention, as well as implementation of pre- and post-harvest practices that are known to reduce the likelihood of fungal growth and resulting mycotoxin contamination [17,20]. Low-tech solutions that can be sustainably implemented by individuals and households are particularly relevant in countries such as Malawi, where there is limited government capacity to regulate foodstuffs and a large proportion of the population produces their own foodstuffs for household consumption [17].

In this paper we investigate the relationship between the adoption of practices shown to reduce the risk of aflatoxin consumption among rural heads of households in Malawi and several hypothesized protective factors—including exposure to social and behavior change communication and beliefs about the danger and severity of consumption of potentially contaminated foodstuffs. The study utilizes cross-sectional survey data collected as baseline data for a United States Agency for International Development (USAID)-funded social and behavior change communication project, Health Communication for Life (HC4L).[1]

2. Literature review

2.1. Previous research on household food safety behaviors

Globally, most knowledge, attitudes, and practices research has focused on food handling in institutional and commercial settings [21–25] or on professional health and agriculture stakeholders [22,26–28]. Many of these studies concentrate on groundnuts. There is little research that examines household-level trends on aflatoxins and food safety behaviors [16,22,29–31]. Studies of smallholder farmers in South Africa and Tanzania surveyed household knowledge, attitudes, and practices related to food safety and found that knowledge was relatively low and associated with socio-economic factors such as education, marital status, and income [32,33]. Household-level research in Ethiopia conducted by Beyene and colleagues (2016), in contrast, found caretakers of young children had high levels of knowledge about agricultural practices to reduce mold production and contamination, but implementation of these practices during storage and processing at the household level remained low [34]. Additionally, knowledge of the health consequences of consuming moldy foods was low. Research in India found higher awareness of aflatoxin contamination in groundnuts among traders and extension agents compared to farmers [35]. Among farmers, larger farm size, participation in extension programs, growing for commercial markets, and economic motivation had positive and significant associations with knowledge [35].

Matumba et al. (2015) conducted a survey of the general public in Malawi to examine knowledge, attitudes, and practices related to molds as an indicator of mycotoxins in their food. Although most of the 805 survey respondents knew molds can be dangerous to health (88%), only 50% knew that the mold toxins do not break down with cooking. The respondents' average knowledge score was 3.55 out of a maximum of 9, indicating low overall knowledge of molds; scores were higher among men than women. This study also identified social, financial, and economic barriers to taking action to control molds and mycotoxins in foodstuffs [16]. A more recent mixed methods

[1] HC4L implements social and behavior change activities and works with local collaborators to disseminate and implement mass media, interpersonal communication, community mobilization, and social media activities across eight health and development areas, including food safety and aflatoxin management and control.

knowledge, attitudes and practices study conducted by Anitha et al. (2019) in three districts in Malawi also found relatively limited knowledge of aflatoxins and pre- and post-harvest strategies to mitigate aflatoxins among farmers. While knowledge, grading, and storing practices improved and crop contamination levels decreased following a crop management training intervention, improvements in attitudes toward consumption of contaminated foodstuffs did not improve [31].

2.2. Social and behavior change theories

Behavioral theories such as the health belief model [36], information-motivation-behavioral skills model [37], and the theory of planned behavior [38] generally share a common underpinning in psychological research. These types of theories posit that behavior is influenced by a range of individual factors, such as perceptions of risks, susceptibility, and benefits of enacting a behavior; beliefs about social support or the consequences of a behavior; behavioral intentions; and information or knowledge about a behavior, including the necessary skills and self-efficacy to enact a behavior [39]. Common theoretical constructs across these theories include beliefs, knowledge, exposure to information, and attitudes. In the current study, food safety behaviors then ought to be influenced by knowledge, attitudes and beliefs about strategies for reducing mold consumption.

At the same time, we understand that the motivations and resources needed to enact behavior changes is predicated on many other factors, such as income levels, structural conditions, and other socio-demographic factors. In short, social and behavior change is also explained through demographic transition theories [40], particularly those theories pertaining to health and epidemiological transitions [41]. Demographic and socioeconomic factors are well established in the literature as significant drivers of social and behavioral change, including health behaviors [42]. Socioeconomic explanations for health behaviors and health status have also found that income and education drive healthy behaviors generally [43]. These theories are extended to food safety behaviors in the present analysis.

Lastly, spatial theories of social and behavior change also may explain behavior change [42,44]. Previous research has shown that the centrality or relative proximity of a given area to key locations of power or resources, such as a nation's capital, are important factors to understand when analyzing social and behavior change [42,44].

2.3. Hypotheses

Based on our review of the literature, we hypothesized that four groups of factors would be associated with the use of practices shown to reduce the risk of aflatoxin contamination and consumption—demographic factors, geographic location, exposure (having seen or heard health communication messaging on food safety and the risks of aflatoxin contamination), and beliefs. We hypothesized that demographic factors such as education and income would be positively associated with safe food practices. We also tested the association between age and food practices, as age is a core construct in demographic transition theory, although we did not have a sound theoretical explanation for a directional hypothesis regarding the nature of the association between these two variables. Additionally, theories of centrality in the adoption and diffusion of knowledge and innovations suggest that geographic locations more proximate to centers of power will have better outcomes [45]; thus we hypothesize that region may be significant in our findings. Based on theories of social and behavior change, we also examined the association between exposure and participants' beliefs as independent predictors of safe practices. According to theories of behavior change, these two constructs generally have a time-order sequence, where exposure precedes knowledge or accurate beliefs. However, our data are cross-sectional, so we test these independent variables both independently and as combined predictors in a global and trimmed (only including significant predictors) models.

3. Materials and methods

The methods chosen for this study were informed by programmatic needs and our review of the literature. Survey data on food safety behaviors were collected to inform baseline indicators for the behavior change communications project. The analysis of these data inform programmatic strategies, including messaging, target population and geographic focus for implementation. We collected household survey data to analyze levels of food safety knowledge, attitudes and practices among the program implementation area. Based on our review of the literature and hypotheses we derived from this review, we analyzed the survey data using quantitative methods described below.

3.1. Ethical review

Ethical review and approval was provided by [redacted for blind review] Protection of Human Subjects Committee (permit number 1048274), and by the Malawian National Committee on Research in the Social Sciences and Humanities (permit number P05/17/179). Data collectors obtained written informed consent from all participants.

3.2. Study setting and target population

HC4L operates across 16 districts in Malawi that are also served by a USAID-funded health system strengthening project called Organized Networks of Services for Everyone (ONSE)-*Athanzi*: Balaka, Chikwawa, Chitipa, Dowa, Karonga, Kasungu, Lilongwe, Machinga, Mangochi, Mchinji, Mulanje, Nkhatabay, Nkhotakota, Ntcheu, Salima, and Zomba. *Athanzi* is the Chichewa word for health. Male and female decisionmakers ("heads of household") were targeted for our survey based on the assumption that they would be best able to speak to the agricultural and food safety practices of the household.

3.3. Study design and sampling

Survey design was driven by a need to collect data from rural areas in the HC4L implementation districts to augment programmatic data. The cross-sectional household survey used multi-stage sampling (Figure 1). The first stage was the purposive selection of all 16 ONSE-*Athanzi* districts. The second stage involved random selection of enumeration areas predefined as rural by the National Statistical Office using probability proportional to size. This sampling frame excluded urban, peri-urban (townships), and uninhabited enumeration areas based on the National Statistical Office's definition for the 2008 Population and Housing Census. Enumeration areas with less than 100 households were also excluded for logistical reasons. A total of 6,927 enumeration areas were included; the number of enumeration areas per district ranged from 163 to 1,139 with an average of 433. Across the 16 districts, the number of enumeration areas randomly selected per district ranged from zero (Karonga) to five (Lilongwe Rural).

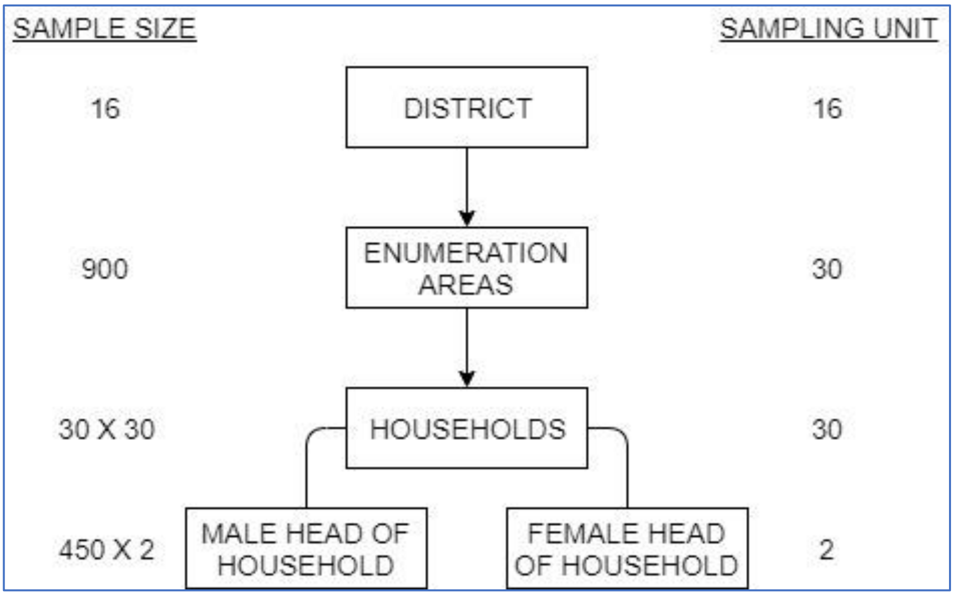

Figure 1. Multi-stage sampling design summary.

The next stage involved selection of 900 households; up to 30 households were sampled per enumeration area using systematic random sampling. Field supervisors, with assistance from the interviewers, updated the household listing for each selected enumeration area to reduce potential sampling bias. The supervisors in each site amended the enumeration area map from the 2008 census by hand to show the location of each current household, drew a route that transected each household, then sequentially numbered each household along the route. The supervisor, using a random number generator, selected a starting house and proceeded through the transect using the designated *n* skip interval (given by total number of households in an enumeration area divided by 30).

In the final stage of sampling, the interviewer selected either the male or female senior household member; respondent sex for each selected household was pre-assigned on an alternating basis, with the sex of the respondent for the first house assigned randomly in each enumeration area using a coin flip. In the event that one or more of the originally sampled houses did not contain an eligible respondent of the assigned sex, supervisors identified a new random starting point (by repeating the procedure described above) that did not include houses previously selected. If there was an eligible male/female respondent, but the respondent was not available for the interview, interviewers returned at least three times before considering that participant a non-response case. Refusals and non-response cases were not replaced, and data collection continued for the remaining selected participants as planned. Each re-visit and the reason for non-response were recorded.

3.4. Data collection

Data were collected from August 8, 2017 to September 7, 2017. The average length of the interviews was 38 minutes. Approval was sought from community "gatekeepers," including village headmen, group village heads, and district council-level staff, before initiating household listing or visiting selected households. The questionnaire, which included English, Chichewa, and Chitumbuka versions, was programmed on the KoBo collect platform using Android tablets. Surveys were administered in Chichewa or Chitumbuka. Field data collection teams had six data collectors in an enumeration area at one time. All data were stored in an electronic database with a data dictionary in English. We provide further details on the specific items included in the questionnaire in subsequent sections where we outline variables included in the analysis.

3.5. Demographic and geographic independent variables

We asked respondents about their age, gender, highest level of education achieved (no education; primary school; junior secondary school; senior secondary school; vocational or technical school; tertiary school or higher), employment (full time job outside home; mostly work as day laborer for wages; mostly work as day laborer for food or lodging; mostly work on my own property or farm; mostly stay home as homemaker; mostly unemployed; other), and source of income (farming; education; health; trade; other) to better understand demographic characteristics of the population. We also recorded respondent's residential district to measure how food safety behaviors vary by geography. Among respondents who reported being involved in growing maize and/or groundnuts in the previous growing season, we asked if they would describe their production as primarily for household consumption or primarily for sale at market.

3.6. Exposure independent variable

We assessed exposure to television and radio in the past week, exposure to messages about safe food handling and moldy crops from health workers and agricultural extension workers in the past three months, and exposure to messages about food safety in the last three months aired under the HC4L's campaign branding *Moyo ndi Mpamba* (Chichewa for "life is precious"). We then calculated overall additive exposure scores, with a total possible maximum score of 14 (0 to 1 or 0 to 3 points per item), as shown in Table 1.

3.7. Food safety belief independent variable

We asked all respondents a series of questions to assess their beliefs about the severity and consequences of consumption of contaminated foodstuffs, including whether they believed consuming moldy food prepared with high heat or animal products that came from animals fed moldy food was safe. We added responses from these questions to develop a final knowledge score that ranged from 0 to 4 possible points (0 to 1 point per item, as shown in Table 2).

Table 1. Survey items and scoring for exposure scale.

Survey item	Scoring by response option
Frequency of radio exposure in last seven days.	3-Every day 2-Most days 1-A few days 0-Not at all
Frequency of TV exposure in last seven days.	3-Every day 2-Most days 1-A few days 0-Not at all
Level of exposure to Moyo ndi Mpamba messages about moldy foodstuffs or crops in last three months.	3-More than 10 messages or adverts 2-6–10 messages or adverts 1-1–5 messages or adverts 0-Zero messages or adverts
Talked to health worker or agricultural extension worker about moldy foodstuffs or crop in last three months.	1-Yes 0-No
Level of exposure to Moyo ndi Mpamba messages about safe food handling in last three months.	3-More than 10 messages or adverts 2-6–10 messages or adverts 1-1–5 messages or adverts 0-Zero messages or adverts
Talked to health worker or agricultural extension worker about safe food handling in last three months.	1-Yes 0-No

3.8. Food safety behavior dependent variable

We also created a food safety behavior score using a series of questions about the number of food safety behaviors in which respondents engaged. To do so, we asked respondents whether they were involved with growing maize or groundnuts in the past growing season, storing or processing maize or groundnuts in the past year, and purchasing foodstuffs for their household in the last three months.[2] We then asked them whether they practiced specific food safety behaviors related to those activities. Although most respondents indicated that they were involved in all activities (up to 13 behaviors, Table 3), many reported being involved in only one or two. Because of this, not all respondents answered the same number of food safety behavior questions. To account for this difference, we calculated the food safety behavior score as the number of food safety behaviors a respondent implemented in proportion to the total number of food safety behavior questions they were asked. One point was given per behavior implemented.

[2] We also assessed behaviors related to food preparation and consumption, but ultimately did not use the items in this scale because of the large proportion of respondents who reported consuming or preparing potentially contaminated foods because they were the only foods available or because they were the only foods that the household could afford. These responses indicate food security and issues associated with poverty, which are less likely to be dependent on food safety beliefs or exposure.

Table 2. Survey items and scoring for food safety belief scale.

Survey item	Scoring by response option
Believes eating moldy foods is dangerous.	1-Yes 0-No
Believes eating moldy foodstuffs after it is prepared at high heat (i.e., boiling, frying, roasting) is harmful.	1-Yes 0-No 0-Don't know
Beliefs about relative danger of eating products (i.e., meat, milk, eggs) from animals that were fed moldy feeds.	0-It is not harmful 0-It is not as dangerous as a person directly eating moldy foods 1-It is just as harmful as directly eating moldy foods 1-It is more harmful than directly eating moldy foods 0-Don't know 0-Other
Beliefs about problems that can be caused by eating moldy foodstuffs.	1-Stomach upset, including diarrhea or vomiting 1-Stunting 1-Fever 1-Cancer 1-Affects body's natural ability to resist diseases 0-Other

3.9. Analysis weights

Due to the non-proportional allocation of the sample across districts and differential response rates, sampling weights were used in all analyses. The specific weight for a particular household to be selected was based on the following probabilities:

P_{1hi}: first − stage sampling probability of the i^{th} cluster in stratum h

P_{2hi}: second − stage sampling probability within the i^{th} cluster (households)

Thus, the overall probability of a particular household to be selected in a specific enumeration area was given by:

$$P_{hi} = P_{1hi} \times P_{2hi} \quad (1)$$

The overall weight for each household was given by the inverse of the probability of that household being selected shown below:

$$P_{hi} = \frac{1}{P_{1hi} \times P_{2hi}} \quad (2)$$

Furthermore, it was important to compute weights based on non-response rates in respective enumeration areas so that the data can be interpreted appropriately.

Table 3. Survey items and scoring for food safety behavior scale.

Survey item	Scoring by response option
Maize and groundnut production	
Practiced crop rotation during last growing season	1-Yes 0-No
Applied fertilizer or soil amendments during last growing season	1-Yes 0-No
Utilized irrigation during last growing season	1-Yes 0-No
Maize and groundnut storage	
Elevated bags off the ground where grains or groundnuts are stored in the last year, including placing on wooden pallets	1-Yes, always 1-Yes, sometimes 0-No
Used insecticides to control pests where grains or groundnuts are stored in the last year	1-Yes, always 1-Yes, sometimes 0-No
Used rodent control techniques where grains or groundnuts are stored in the last year	1-Yes, always 1-Yes, sometimes 0-No
Stored bags in a way that prevented them from touching walls where grains or groundnuts are stored in the last year	1-Yes, always 1-Yes, sometimes 0-No
Maize and groundnut processing	
Dried maize or groundnuts on mats or elevated platforms in the last year	1-Yes, always 1-Yes, sometimes 0-No
Winnowed your maize before dehulling, shelling or milling in the last year	1-Yes, always 1-Yes, sometimes 0-No
Sorted maize, groundnuts, and other foodstuffs before dehulling, shelling or milling in the last year	1-Yes, always 1-Yes, sometimes 0-No
Used the three fractions system (among those who sorted grains)	1-Yes, always 1-Yes, sometimes 0-No
Food purchasing	
Checks for molds when purchasing foodstuffs	1-Yes 0-No
Checks for insect or rodent contamination when purchasing foodstuffs	1-Yes 0-No

3.10 Statistical analysis

We analyzed the data in three steps using R statistical analysis software (version 3.6.1) [46]. The first step was a reliability analysis to validate the exposure and food safety belief scales; to test the internal consistency of the items in these two scales, we calculated Cronbach's alpha [47,48,49]. In the second step, we conducted a descriptive analysis to describe the basic characteristics of the study population. Finally, we tested our hypotheses regarding the effect of demography, geography, exposure to social and behavior change programming, and food safety beliefs on the adoption of food safety behaviors using multiple linear regression using a generalized linear model (GLM) approach. All models used a constant variance function and identity link function to model the response variable. To assess model variables for issues related to multicollinearity we used the "corrplot" and "car" statistical packages in R [50,51] to calculate bivariate correlations and the variance inflation factor for model variables. We did not find any evidence of multicollinearity given that the correlation between any two variables did not exceed 0.80 and the variance inflation factor scores all fell below 2.0.

4. Results and discussion

4.1. Descriptive analysis

We received 831 responses from the 900 selected households, a completion rate of 92%. Respondent ages ranged in value from 18 to 64, with a mean and median age of 36 and 34, respectively (Table 4). Respondents came from 15 districts with roughly 16% listing Lilongwe Rural and 10% listing Mangochi as their place of residence. Chitipa and Mchinji had the fewest respondents (3% each). The sex ratio of respondents was roughly equal, with 51% respondents reporting as female. Most respondents had completed primary school (64%), and roughly 16% of respondents had completed either junior or senior secondary school. An additional 2% of respondents reported completing vocational or tertiary school. The remaining 17% of respondents reported completing no education.

Table 4. Summary statistics for all variables included in models and additive scales (score variables)*.

Variable	Baseline Response Frequency	Mean	Median	Mode	Max	Min	SD	Var.
Sex (baseline: female)	427	NA	NA	NA	1	0	NA	NA
Age	NA	36.12	34	25&30**	64	18	12.38	153.25
Education	NA	2.15	2.00	2.00	6.00	1.00	0.92	0.85
Employment status (baseline: work on own farm)	408	NA	NA	NA	1	0	NA	NA
Primary income source (baseline: farming)	570	NA	NA	NA	1	0	NA	NA
Primary farming purpose (baseline: household)	682	NA	NA	NA	1	0	NA	NA
Exposure Score	NA	3.75	3.00	0.00	14.00	0.00	3.37	11.34
Belief Score	NA	2.76	3.00	3.00	4.00	0.00	0.91	0.82
Behavior Score	NA	0.69	0.69	1.0	1.0	0	0.23	0.51

Note: * Sample size of 831. Cronbach's alpha score for total exposure is 0.70 and for total belief is 0.88. NA = not applicable. ** Two modal categories because same number of respondents answered 25 and 30.

Roughly 49% of respondents reported working on their own property or farm as their employment status. An additional 36% of respondents said they were mostly unemployed. The remaining respondents listed either homemaker (7%), day laborer for wages (5%), full-time job outside the home (4%), day laborer for food (1%), or other (1%) as their employment status. For our analysis, we made this variable dichotomous, where respondents were either employed on their own farm (baseline category) versus all other responses. We did this because farm employment may impact food safety knowledge and behaviors. Similarly, most respondents report farming as their primary source of income (69%). Of the respondents who reported involvement with maize and/or groundnut production, many respondents indicated that they grow maize and/or groundnuts primarily for household consumption (n = 682 out of 718); a small proportion of respondents reported growing maize and/or groundnuts primarily for selling at the market.

As indicated earlier, our exposure variable was an additive scale, and here we describe the properties of each item included in this scale. Almost 3 in 5 respondents reported that they did not listen to radio at all in the previous seven days (59%). Of those who did listen to radio, 45% of respondents reported listening to the radio a few days (n = 153 of 337), 16% listening most days (n = 54 of 337), and the remaining 39% listening every day (n = 130 of 337). More than 4 in 5 respondents reported that they did not watch television at all in the previous seven days (84%). Of those who did watch television, 62% of respondents reported watching television a few days (n = 81 of 131), 20% watched most days (n = 26 of 131), and the remaining 18% watching every day (n = 24 of 131). About one-quarter of respondents reported speaking with a health worker or agricultural extension agent about moldy foodstuffs or crops (27%) or about safe food handling (28%). Although no message about moldy foodstuff and safe food handling had been aired at the time, almost half of respondents said they had heard or seen at least one *Moyo ndi Mpamba* message about moldy foodstuff in the last three months (47%). It is possible respondents conflated *Moyo ndi Mpamba* adverts about these topics with other brands, so responses for exposure were included even if they indicated *Moyo ndi Mpamba* because this measure is meant to operationalize exposure to food safety messages, not a branded campaign. Total exposure score ranged from 0 to 14, with a median of 3 (Table 4).

As with exposure, we created a food safety beliefs scale. More than 94% of respondents believed eating moldy food is dangerous (94%). Similarly, more than 9 in 10 respondents identified at least one problem caused by consuming moldy foods. In contrast, 36% of respondents believed preparing foods with mold at high heat made the food less harmful. Most respondents did not believe that eating animal products from animals fed with moldy food is harmful, with 74% of respondents saying these products were either not harmful, not as dangerous as directly eating moldy food, or they did not know and only 26% reporting such products as equally or more harmful than directly eating moldy food. Total food safety belief scores ranged from 0 to 4 with a mean of 2.76 and a median of 3 (Table 4).

We assessed behaviors related to four activities: Maize and groundnut production, maize and groundnut storage, maize and groundnut processing, and purchasing foodstuffs. About 14% of respondents did not report being involved in growing maize or groundnuts in the past growing season, while closer to one-quarter of respondents said they had not been involved in storing or processing maize or groundnuts in the last year. Nearly three-quarters of respondents said they were responsible for purchasing foodstuffs for the household over the past three months. The average proportion of positive food safety behaviors adopted was 69% across all districts. The modal score was 100% (Table 4). Respondents from Chitipa and Ntcheu adopted the highest proportion of food safety behaviors on average—78% and 77%, respectively—while respondents from Nkhota Kota adopted the lowest proportion (61%) (Figure 2).

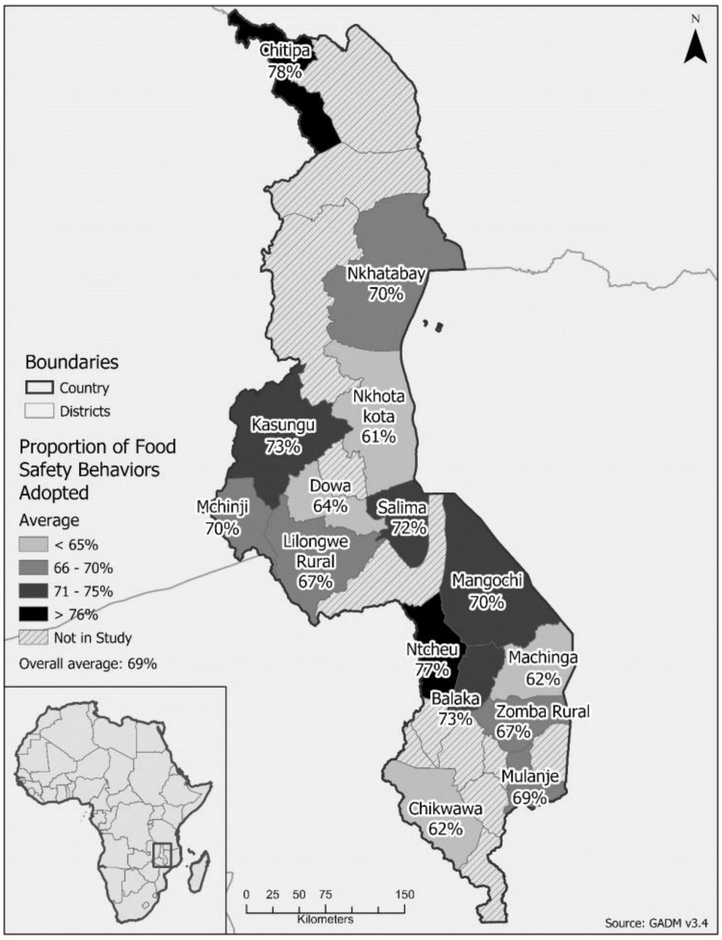

Figure 2. Overall proportion of safe food handling behaviors adopted, by district.

We also note that food safety practices to prevent mold during maize and groundnut production, harvesting, and processing were high overall. Of those who reported being involved in growing maize or groundnuts (n = 718), 90% said they used fertilizers or soil nutrient amendments (n = 643), 49% said they used crop rotation (n = 354), and 31% say they used irrigation (n = 223). Among the participants involved in storing maize or groundnuts after harvest in the last year (n = 637), 85% elevated bags off the ground (n = 541), 70% used insecticides to control pests (n = 448), 67% stored bags in a way that prevented them from touching walls (n = 428), and 42% used rodent control techniques (n = 269) at least sometimes. Of those reporting being involved in processing maize or groundnuts after harvest in the last year (n = 634), 92% winnowed their maize before dehulling, shelling, or milling (n = 583), 76% sorted grains before dehulling, shelling, or milling (n = 482), 75% dried their grains on elevated platforms (n = 476), and 60% used the three fractions system for sorting food (n = 381) at least sometimes. Finally, among participants who reported they were responsible for purchasing food for the household in the last three months (n = 607), 79% reported checking food for mold (n = 478) and 84% reported checking for insect or rodent contamination before purchasing (n = 509).

4.2. Regression analysis

Table 5 shows the regression models included in the study. Models were run according to theoretical sets of hypotheses, including the following variable groupings: demographic, geographic, exposure, belief, a combined global model, and a trimmed model. The demographic model found that greater education and an employment status other than working on own farm or property to be significantly and positively associated with adopting food safety behaviors. The geographic model found that residence in Ntcheu, Balaka, Chitipa, Kasungu, and Salima districts was significantly associated with the adoption of food safety behaviors that reduce risk of aflatoxin exposure. However, the adjusted R square for demographic and geographic models were below 1.2% and 2.1%, respectively, indicating that very little of the variability in our dependent measure—food safety behaviors—is explained by these theoretical groupings. Adding the exposure scale to the model increases the amount of variation explained ten-fold, and the belief scale also increases the model's adjusted R square by roughly 2.5%.

The exposure model and belief model both found higher scores to be associated with adopting positive food safety behaviors and in the hypothesized directions. This indicates that exposing people to information about food safety increases their reported food safety behaviors across production, storage, and purchasing activities. We also note that exposure had the largest magnitude of effect on our outcome variable, as indicated by the standardized estimate that was nearly three times larger than other estimates in the global and trimmed models.

In the full global model, exposure score and belief score remained significant, as did residence in Ntcheu and not growing maize or groundnuts in the previous year. These factors also remained significant in the final trimmed model that only included factors that were significant in the global model. Interestingly, when controlling for exposure and beliefs, the demographic controls of education and employment were no longer significant.

Table 5. Regression models predicting positive food safety behaviors.

Variable	Demographic	Geographic	Exposure	Belief	Global Model	Trimmed
Sex (male)	0.013 (0.029)	--	--	--	−0.016 (−0.036)	--
Age	−0.000 (−0.020)	--	--	--	−0.001 (−0.029)	--
Education	0.025* (0.098)*	--	--	--	0.011 (0.042)	--
Employment (not on own farm)	0.035* (0.076)*	--	--	--	0.017 (0.038)	--
Primary income source (non-farming)	−0.026 (−0.053)	--	--	--	−0.015 (−0.031)	--
Farming primarily for market[#]	0.027 (0.024)	--	--	--	0.023 (0.021)	0.018 (0.016)
Does not grow maize or groundnuts	0.038 (0.052)				0.097* (0.131)*	0.087* (0.118)*

Continued on next page

Variable	Demographic	Geographic	Exposure	Belief	Global Model	Trimmed
District	--	--	--	--	--	--
Balaka	--	0.118* (0.096)*	--	--	0.066 (0.053)	--
Chikwawa	--	0.010 (0.010)	--	--	0.008 (0.009)	--
Chitipa	--	0.170* (0.120)*	--	--	0.091 (0.064)	--
Dowa	--	0.033 (0.035)	--	--	0.006 (0.006)	--
Kasungu	--	0.122* (0.139)*	--	--	0.080 (0.090)	--
Lilongwe Rural	--	0.063 (0.103)	--	--	0.024 (0.040)	--
Machinga	--	0.011 (0.013)	--	--	0.005 (0.005)	--
Mangochi	--	0.090 (0.121)	--	--	0.032 (0.043)	--
Mchinji	--	0.084 (0.063)	--	--	0.052 (0.039)	--
Mulanje	--	0.082 (0.092)	--	--	0.077 (0.087)	--
Nkhatabay	--	0.088 (0.060)	--	--	0.034 (0.023	--
Ntcheu	--	0.154* (0.176)*	--	--	0.108* (0.123)*	0.065* (0.074)*
Salima	--	0.109* (0.125)*	--	--	0.059 (0.067)	--
Zomba Rural	--	0.057 (0.077)	--	--	0.042 (0.056)	--
Total Exposure	--	--	0.021* (0.319)*	--	0.020* (0.299)*	0.021* (0.315)*
Total Belief	--	--	--	0.041* (0.164)*	0.028* (0.028)*	0.031* (0.125)*
Intercept	0.626*	0.611*	0.605*	0.574*	0.478*	0.505*
Model Fit						
F-score	2.60	2.22	90.78	22.02	6.10	24.71
Adjusted R^2	1.20%	2.10%	10.10%	2.60%	12.8%	12.9%

Based on a sample size of 831. Variance inflation factors were computed for each model, and none of the models exceeded the 2.0 threshold. Cronbach's alpha score for total exposure is 0.70 and for total belief is 0.88. * Denotes statistically significant coefficients at a p value of 0.05 or better using a two-tailed t-test. Also, all variables were plotted to assess for distribution and were found to approximate a normal distribution. Thus, we used GLM for our analysis. # Baseline category, coded zero, was farming mainly for household consumption. Note: standardized coefficients are reported in parentheses.

5. Conclusions

Our study reveals a number of important findings regarding food safety behaviors in rural Malawi. The descriptive analysis provides an overview of characteristics of rural households and their food safety behaviors, as well as theorized determinants of food safety behaviors—including demographic, geographic, exposure, and belief variables. Most households in our sample reported growing maize and/or groundnuts primarily for household consumption, more than half of respondents reported working on their own farm or property as their employment status, and nearly 70% said farming was their primary source of income. We think these patterns indicate that it is critical for agricultural extension and other food safety education and communications efforts to target domestic subsistence producers, as well as commercial farmers or commodity producers, in order to effectively reduce risk of exposure to molds and aflatoxins. Thus, the implication is that although most growers do not produce commodities for markets, they still need adequate access to information on food safety practices and behaviors to prevent mold consumption. Although our sample did not cover all of Malawi and was designed to target rural areas in the HC4L programmatic implementation districts, we did have representation of rural areas in districts included in the program. It should also be noted that measuring employment activities and sources of income was difficult in our study because our survey design was limited to single-response answer options, thus we were not able to capture multiple streams of income or jobs or variation in seasonal employment; however, these limitations do not diminish the importance that agriculture appears to play in rural livelihoods.

Descriptive analysis also showed that exposure scores were relatively low (mean of 3 out of a maximum of 15), while belief scores were relatively high (mean of 3 out of a maximum of 4). However, when looking at individual items among the belief scores, our findings around perception of risks of eating contaminated foods prepared at high heat and risks of eating foodstuffs sourced from animals fed contaminated feed were quite low and reflected patterns found by Matumba and colleagues (2015) and Anitha and colleagues (2019). Thus, these are a specific food safety behaviors that must be addressed to reduce mold consumption and communications programs would do well to share further materials to reduce these behaviors. At the same time, we recognize that the consumption of these foods may be driven by contextual factors including food shortages meaning that other interventions to address structural barriers to safe food behaviors such as poverty and agricultural development may also be needed. As was observed by Beyene and colleagues (2016), household practices to prevent mold across maize and groundnut agricultural production, harvesting, and processing were high overall. However, there was substantial variation in proportions of respondents reporting desired behaviors across districts. This suggests that there may be other factors driving consumption beyond knowledge, including economic vulnerability and food insecurity.

Along these lines, we did not include food preparation behaviors in our scales because of the large number of people who said they had to prepare contaminated foods because it was all that was available or all they could afford. This points to socio-structural barriers to food safety such as poverty, food insecurity, and environmental crises rather than problems that can be addressed by social and behavior change communication. All the same, these factors strongly influence food safety behaviors and clearly exacerbate the consumption of contaminants, including mold. Efforts to abate mold consumption must address both knowledge, attitudes, and practices, as well as these socio-structural barriers that contribute to economic vulnerability and food insecurity.

Regression analysis reveals important associations between demographic, geographic, and social and behavior change drivers of food safety behaviors and shows that these associations are important even when controlling for other potential confounders. We did find significant differences among Ntcheu, Balaka, Chitipa, Kasungu, and Salima districts. While there is no programmatic explanation for why these districts stand out in our analysis, we do acknowledge that regional variation in agricultural production and extension practices may influence food safety behaviors at the district level. Thus, it may be useful to further explore these potential differences across regions and districts.

Although education and employment were both significant in our demographic model, these effects were absent in our global and trimmed models where other theoretical predictors are introduced. While the magnitude of effect is not as large as exposure, our belief scale had a positive and significant effect on food safety behaviors. This is an important finding, in that shifting beliefs, perceptions, and knowledge of risk is a key part of the social and behavior change process. Given recent research which has shown the role that fear can play in relation to perceived risk and food safety behaviors, this is particularly relevant finding [52]. This supports the theoretical proposition that increasing the number of Malawians who believe that aflatoxin contamination is detrimental to their health and the agricultural economy will improve the adoption of safe food behaviors.

Our standardized estimates show that exposure is by far the largest predictor of food safety behaviors among our sample—with an estimate nearly three times that of the next largest predictor. Given the need to target subsistence producers, and the effectiveness that exposure has on improving food safety behaviors, we postulate that intensified agricultural extension may be particularly effective in influencing food safety behaviors. In fact, on-farm demonstrations of good agricultural practices have demonstrated positive impacts on the adoption of food safety behaviors and may apply well in this context [52]. While gender was not significant in our models, we think this may be because food safety behaviors were aggregated into an additive scale across production, storage, and purchasing behaviors. As such, future research may wish to look at each of these stages in food production and examine the stages separately to assess the potential varying impacts of gender.

Both the magnitude and significance of the effect for exposure are important findings of our research, which support a social and behavior change communications model for improving food safety behaviors. The fact that these effects persisted in our trimmed model, net of the effects of education, indicates that communication channels and exposure to social and behavior change messaging are an effective means of influencing food safety behaviors even in environments where educational levels are low. This finding may well extend to contexts beyond our study area into other rural, agriculturally dependent, and low-education environments in southern Africa.

Acknowledgments

The authors would also like to thank the study participants, data collectors and field supervisor and acknowledge the contributions of Dr. Mario Chen, Dr. Daniela Garcia-Grandon, Dr. Christine Godwin, Tom Grey, and Dr. Dr. Lara Lorenzetti to study design, data analysis and review. This manuscript is made possible by the support of the American people through the United States Agency for International Development (USAID). The contents of this report are the sole responsibility of FHI 360 and do not necessarily reflect the views of USAID or the United States Government.

Conflict of Interest

All authors declare no conflict of interest in this paper.

References

1. Shephard GS (2008) Impact of mycotoxins on human health in developing countries. *Food Addit & Contam: Part A* 25: 146–151.
2. Bennett J, Klich M (2003) Mycotoxins. *Clin Microbiol Rev* 16: 497–516.
3. Sun G, Wang S, Hu X, et al. (2007) Fumonisin B1 contamination of home-grown corn in high-risk areas for esophageal and liver cancer in China. *Food Addit & Contam* 24: 181–185.
4. Khlangwiset P, Shephard GS, Wu F (2011) Aflatoxins and growth impairment: A review. *Crit Rev Toxicol* 41: 740–755.
5. Ferlay J, Soerjomataram I, Dikshit R, et al. (2014) Cancer incidence and mortality worldwide: Sources, methods and major patterns in GLOBOCAN 2012. *Int J Cancer* 136: E359–E386.
6. Abdallah MF, De Boevre M, Audenaert K, et al. (2018) Highlight report: Mycotoxins as food contaminants in Africa—challenges and perspectives. *Arch Toxicol* 92: 2151–2152.
7. Stepman F (2018) Scaling-up the impact of aflatoxin research in Africa. The role of social sciences. *Toxins* 10: 136.
8. Khonga E (1985) Survey of fungi and mycotoxins in malts used in brewing opaque beer in Malawi. *Luso: J Sci Technol* 6: 49–56.
9. Matumba L, Monjerezi M, Biswick T, et al. (2014) A survey of the incidence and level of aflatoxin contamination in a range of locally and imported processed foods on Malawian retail market. *Food Control* 39: 87–91.
10. Matumba L, Monjerezi M, van Poucke C, et al. (2013) Evaluation of the bright greenish yellow fluorescence test as a screening technique for aflatoxin-contaminated maize in Malawi. *World Mycotoxin J* 6: 367–373.
11. Matumba L, Sulyok M, Monjerezi M, et al. (2014) Fungal metabolites diversity in maize and associated human dietary exposures relate to micro-climatic patterns in Malawi. *World Mycotoxin J* 8: 269–282.
12. Matumba L, Van Poucke C, Monjerezi M, et al. (2015) Concentrating aflatoxins on the domestic market through groundnut export: A focus on Malawian groundnut value and supply chain. *Food Control* 51: 236–239.
13. Monyo E, Njoroge SMC, Coe R, et al. (2012) Occurrence and distribution of aflatoxin contamination in groundnuts (Arachis hypogaea L) and population density of aflatoxigenic aspergilli in Malawi. *Crop Prot* 42: 149–155.
14. Misihairabgwi JM, Ezekiel CN, Sulyok M, et al. (2019) Mycotoxin contamination of foods in Southern Africa: A 10-year review (2007–2016). *Crit Rev Food Sci Nutr* 59: 43–58.
15. Alberts JF, Lilly M, Rheeder JP, et al. (2017) Technological and community-based methods to reduce mycotoxin exposure. *Food Control* 73: 101–109.
16. Matumba L, Monjerezi M, Kankwamba H, et al. (2015) Knowledge, attitude, and practices concerning presence of molds in foods among members of the general public in Malawi. *Mycotoxin Res* 32: 27–36.

17. Strosnider H, Azziz-Baumgartner E, Banziger M, et al. (2006) Workgroup report: Public health strategies for reducing aflatoxin exposure in developing countries. *Environ Health Perspect* 114: 1898–1903.
18. Wu F, Mitchell NJ, Male D, et al. (2014) Reduced foodborne toxin exposure is a benefit of improving dietary diversity. *Toxicol Sci* 141: 329–334.
19. Lovo S, Veronesi M (2015) Crop diversification and child health: Empirical evidence from Tanzania. London: The Centre for Climate Change Economics and Policy (CCCEP); The Grantham Research Institute on Climate Change and the Environment.
20. Wu F, Khlangwiset P (2010) Evaluating the technical feasibility of aflatoxin risk reduction strategies in Africa. *Food Addit&Contam Part A, Chem, Anal, Control, Exposure&Risk Assess* 27: 658–676.
21. Ansari-Lari M, Soodbakhsh S, Lakzadeh L (2009) Knowledge, attitudes and practices of workers on food hygienic practices in meat processing plants in Fars, Iran. *Food Control* 21: 260–263.
22. Awuah RT, Agyemang KO, Fialor SC, et al. (2008) Are Ghanaians aware of the alatoxin menace? In: Leslie JF, Bandyopadhyay R, Visconti A, *Mycotoxins: Detection Methods, Management, Public Health and Agricultural Trade*. Cambridge, MA: CAB International, 327–334.
23. Bas M, Ersun AS, Gokhan K (2004) The evaluation of food hygiene knowledge, attitudes, and practices of food handlers in food businesses in Turkey. *Food Control* 17: 317–322.
24. Nee SO, Sani NA (2011) Assessment of knowledge, attitudes and practices (KAP) among food handlers at residential colleges and canteen regarding food safety. *Sains Malaysiana* 40: 403–410.
25. Soares LS, Almeida RCC, Cerqueira ES, et al. (2012) Knowledge, attitudes and practices in food safety and the presence of coagulasepositive staphylococci on hands of food handlers in the schools of Cama çari, Brazil. *Food Control* 27: 206–213.
26. Azaman NNM, Kamarulzaman NH, Shamsudin MN, et al. (2016) Stakeholders' knowledge, attitude, and practices (KAP) towards aflatoxins contamination in peanut-based products. *Food Control* 70: 249–256.
27. Ilesanmi FF, Ilesanmi OS (2011) Knowledge of aflatoxin contamination in groundnut and the risk of its ingestion among health workers in Ibadan, Nigeria. *Asian Pac J Tropical Biomed* 1: 493–495.
28. Jolly CM, Bayard B, Awuah RT, et al. (2009) Examining the structure of awareness and perceptions of groundnut aflatoxin among Ghanaian health and agricultural professionals and its influence on their actions. *J Socio-Econ* 38: 280–287.
29. Ezekiel CN, Sulyok M, Babalola DA, et al. (2013) Incidence and consumer awareness of toxigenic Aspergillus section Flavi and aflatoxin B1 in peanut cake from Nigeria. *Food Control* 30: 596–601.
30. Sanders M, De Middelseer G, Vervaet S, et al. (2014) The awareness about mycotoxin contamination of food and feed: A survey in the Flemish population. *World Mycotoxin J* 8: 375–380.
31. Anitha S, Tsusaka TW, Njoroge SM, et al. (2019) Knowledge, attitude and practice of Malawian farmers on pre- and post-harvest crop management to mitigate aflatoxin contamination in groundnut, maize and sorghum-implication for behavioral change. *Toxins* 11: 716.

32. Mboya RM, Kolanisi U (2014) Subsistence farmers' mycotoxin contamination awareness in the SADC Region: Implications on Millennium Development Goal 1, 4 and 6. *J Human Ecol* 46: 21–31.
33. Magembe KS, Mwatawala MW, Mamiro DP, et al. (2016) Assessment of awareness of mycotoxins infections in stored maize (Zea mays L.) and groundnut (arachis hypogea L.) in Kilosa District, Tanzania. *Int J Food Contam* 3: 12.
34. Beyene AA, Woldegiorgis AZ, Adish AA, et al. (2016) Assessment of mothers' knowledge and practice towards aflatoxin contamination in complementary foods in Ethiopia: From pre-harvest to household. *World Mycotoxin J* 9: 535–544.
35. Kumar GDS, Popat MN (2010) Farmers' perceptions, knowledge and management of aflatoxins in groundnuts (Arachis hypogaea L.) in India. *Crop Prot* 29: 1534–1541.
36. Hochbaum G (1958) Public Participation in Medical Screening Programs: A Socio-Psychological study. Washington, DC: US Department of Health, Education and Welfare.
37. Fisher W, Fisher J, Harman J (2003) The information-motivation-behavioral skills model: A general social psychological approach to understanding and promoting health behavior. In: Suls J, Wallston K, *Social Psychological Foundations of Health and Illness*. Malden, MA: Blackwell, 82–116.
38. Ajzen I (1991) The theory of planned behavior. *Organ Behav Human Decis Processes* 50: 179–211.
39. Glanz K, Rimer BK, Viswanath K (2008) *Health behavior and health education: Theory, research, and practice* (4th ed.), Jossey-Bass.
40. Davis K (1963) The theory of change and response in modern demographic history. *Popul Index* 29: 345–366.
41. Omran A (1971) The epidemiologic transition. A theory of the epidemiology of population change. *Milbank Q* 49: 509–538.
42. Young FW, Lyson TA (2001) Structural pluralism and all-cause mortality. *Am J Public Health* 91: 136–138.
43. Anderson NB, Armstead CA (1995) Toward understanding the association of socioeconomic status and health: A new challenge fro bio-psychological approach. *Psychomatic Med* 57: 213–225.
44. Duncan OD, Schnore LF, Rossi PH (1959) Cultural, behavioral and ecological perspectives in the study of social organization. *Am J Social O* 65: 132–153.
45. Young FW, Minai K (2002) Community ecology: A new theory and an illustrative test. *Res Human Ecol* 9: 31–40.
46. R Core Team (2019) R 3.6.1: A language and environment for statistical computing. Vienna, Austria: R Foundation for Statistical Computing. Available from: https://www.R-project.org.
47. Revelle W (2018) psych: Procedures for personality and psychological research. 1.8.12 ed. Evanston, IL: Northwestern University.
48. Cronbach LJ (1951) Coefficient alpha and the internal structure of tests. *Pschometrika* 16: 297–334.
49. Nunnaly JC (1978) Psychometric Theory. New York: McGraw-Hill.
50. Wei T, Simko V (2017) "corr plot": Visualization of a correlation matrix. 0.84 ed.
51. Fox J, Weisberg S (2019) An {R} Companion to Applied Regression, Third Edition. Thousand Oaks, CA: Sage.

52. Flavio B, Daniela C, Pasquale S (2018) Genetically modified food versus knowledge and fear: A Noumenic approach for consumer behaviour. *Food Res Int* 111: 682–688.
53. Parimi V, Kotamraju VKK, Sudini HK (2018) On-farm demonstrations with a set of good agricultural practices (GAPs) proved cost-effective in reducing pre-harvest aflatoxin contamination in groundnut. *Agronomy* 8: 10.