Consumer risk perception of vitamin A deficiency and acceptance of biofortified rice in the Morogoro region of Tanzania

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Abstract

Vitamin A deficiency is still a challenge in many African countries, including Tanzania. Survey data were gathered in Tanzania to determine consumers' risk perceptions of vitamin A deficiency (VAD) and severe visual impairment. A contingent valuation method was used and a choice experiment was conducted to measure willingness to pay (WTP) for biofortified rice, both with and without introducing genetic modification as the mechanism behind increased vitamin A content. The results indicate that the most at-risk groups, such as females and those with lower incomes, tend to underestimate the risk of VAD or do not fully understand the relationship between VAD and severe visual impairment. Furthermore, the respondents strongly preferred and were willing to pay for rice with added nutritional value.

Key words: biofortified; genetically modified; Golden Rice; vitamin A deficiency; micronutrient deficiency; willingness to pay

1. Introduction

Although the availability of nutritious food is a problem globally, residents of developing countries are more likely to be affected by malnutrition. Currently, more than 220 million people in Sub-Saharan Africa (SSA) are malnourished (Bain *et al*. 2014); it is estimated that about 40% of children below five years of age suffer from chronic malnutrition in SSA (Marx *et al*. 2014). Micronutrient malnutrition, commonly referred to as "hidden hunger", is a chronic lack of critical vitamins. Micronutrient malnutrition can occur and persist despite adequate caloric consumption if diets are not sufficiently diverse. Although deficiency in any key micronutrient can lead to health problems, the effects of vitamin A deficiency (VAD) are especially pernicious, and can include severe visual impairment (e.g. blindness and night blindness), as well as potentially fatal illnesses and disease. VAD predominantly affects women and children under the age of five (Black *et al*. 2008). Women in developing countries are particularly likely to suffer from VAD due to prolonged breastfeeding combined with diets limited in vitamin A (Miller *et al*. 2002). As a result, children become vitamin A deficient early in life from consuming breast milk and foods that are low in vitamin A. In 2010, for example, the Tanzania National Bureau of Statistics reported that approximately 33% of children under the age of five and 37% of women suffered from VAD (National Bureau of Statistics/Tanzania & ICF Macro 2011).

Inadequate availability of food with sufficient vitamin A could be addressed by increasing the supply of foods already naturally rich in vitamin A and vitamin A precursors. Additionally, vitamin A content can be addressed through the introduction of crops that are biofortified using either traditional plant-breeding methods or genetic modification (GM). However, in order for such efforts to be successful, consumers must be aware of the connection between VAD and the associated health problems. Furthermore, foods developed for increased vitamin A content must be culturally acceptable and consumers must be willing to bear the cost of purchasing them. A better understanding of demand-side issues will improve policy design and implementation, as well as provide insights into the types of innovation that are more positively received by consumers in developing countries.

To our knowledge, no existing study has specifically examined the perceived risk of VAD and the associated risk of severe visual impairment in a developing country. The perception of risk in developing countries has been the topic of previous research; however, the majority of this previous research examines risk perceptions concerning negative exogenous events (Kahan *et al*. 2011). In the context of health-related risks, previous research has examined the perceived risks of contracting particular diseases; to date, the relevant literature has examined risk perception for genetic diseases (Becker & Levine 1986; Decruyenaere *et al*. 1994; Kaptein *et al*. 2007) and communicable diseases (Marrazzo *et al*. 2005; Smith 2006), but has yet to address risk perception associated with nutritional deficiencies. It is imperative to improve understanding of risk perception for nutritional deficiencies, notably in areas where the costs of nutritional deficiencies are not trivial, in order to establish the need for and proper design of interventions designed to support decision making by consumers in the developing world.

The objective of this study was to determine the perceived risk of VAD and acceptance of biofortified rice that could decrease the risk of VAD in Tanzania. Specifically, our empirical analysis examined: 1) the perceived risk of VAD and severe visual impairment and demographic characteristics associated with perceived risks; 2) awareness of biofortification and demographic characteristics associated with awareness; and 3) willingness to pay (WTP) for rice with increased levels of vitamin A and rice that decreased the risk of severe visual impairment.

2. Background

A number of interventions have been undertaken to address VAD. Examples of interventions include nutritional education programmes, supplementation using vitamin A capsules and drops, and the biofortification of staple foods. Unfortunately, these interventions do not reach the most vulnerable groups. This is especially true in Tanzania, where public spending on nutrition is not effectively targeted to young children and pregnant women (Picanyol *et al*. 2015). Moreover, the costs associated with administering supplementation programmes are relatively high (Fiedler *et al*. 2000; Zimmermann & Qaim 2004). Even when the costs of supplementation may be economically feasible, the distribution costs may be prohibitive given limited government resources (Dawe *et al*. 2002). Biofortification has the potential to be an efficient and cost-effective strategy to address micronutrient malnutrition because it improves the nutrition profile of the staple foods that low income and rural populations commonly consume (Kimenju & De Groote 2008; Beyer 2010; Khush *et al*. 2012). Although biofortification is not a cure-all for micronutrient deficiency, it can be used to complement other existing interventions (Dawe *et al*. 2002).

Biofortification can be accomplished through both traditional breeding techniques and GM. For instance, the HarvestPlus initiative develops crops that have increased levels of micronutrients using traditional breeding techniques. Crops that have been biofortified for increased vitamin A content using traditional breeding techniques include cassava, maize and sweet potato. For some staple crops, the absence of vitamin A or its precursors makes biofortification for increased vitamin A content through plant breeding impossible; this is the case with rice, for example. Golden Rice is a rice variety biofortified using GM to add beta-carotene; the accumulation of beta-carotene gives the rice a yellow or golden colour when milled (Schaub *et al*. 2005). Given the importance of rice to the diets of households in the developing world, Golden Rice has the potential to strongly decrease the incidence of VAD and to generate large, positive welfare effects. For example, previous research has estimated that Golden Rice could decrease the disease burden of VAD by half in India (Stein *et al*. 2008), and a case study examining the potential benefits in the Philippines estimated social benefits of Golden Rice ranging between \$16 and \$88 million per year (Zimmermann & Qaim 2004).

Biofortification is a potentially cost-effective strategy for reducing the serious health issues induced by VAD among poor populations in developing countries (Dawe *et al*. 2002; Al-Babili & Beyer 2005; Anderson *et al*. 2005; Dawe & Unnevehr 2008). Unlike other interventions, biofortification has the advantage of relying on a one-time investment to introduce a modified crop. In comparison, supplementation strategies are more expensive and involve recurring costs (Dawe *et al*. 2002; De Groote & Kimenju 2008; Chow *et al*. 2010). The cost-effectiveness and sustainability of biofortified crops make biofortification a feasible approach that can reach vulnerable populations at risk of VAD who cannot afford to buy or have limited access to commercially fortified foods and supplements (Bouis *et al*. 2011).

3. Methods

3.1 Respondents and survey design

The study was conducted in the Morogoro region of Tanzania from September to October 2015. Data were collected from a random sample of 150 households in each of two districts, Morogoro and Mvomero, for a total of 300 observations. The two districts included in the study allowed examination of differences between an urban district (Morogoro) and a rural district (Mvomero). Nine villages from Mvomero and nine wards from Morogoro were selected at random, and approximately 17 households were randomly selected from each village and ward to obtain potential respondents. Respondents were household members responsible for making household food purchase decisions; as a result of this selection rule, the sample is mostly female. Summary statistics for the sample are in Table 1. Each respondent was compensated with Tanzania Shillings (Tsh) 5 000 (approximately USD 2.50 at the time of survey); however, compensation was not paid in a village until all respondents had been interviewed in an attempt not to bias responses.

Table 1: Summary statistics of respondents (n = 300)

Variable	Category	Frequency	Relative percentage
Age	18 to 29 years	80	26.7
	30 to 39 years	90	30
	40 to 49 years	57	19
	50 to 59 years	49	16.3
	60 years and above	24	8
Education	No school completed	34	11.3
	Primary school	189	63
	Secondary school	57	19
	Diploma/Certificate	15	5
	Bachelor's degree	4	1.3
	Master's degree	1	0.3
Sex	Male	114	38
	Female	186	62
Household size	0-3	94	31.3
	4-7	185	61.7
	8 and more	21	7
Income	Below 50 000	77	25.7
	50 001 to 100 000	68	22.7
	100 001 to 250 000	85	28.3
	250 001 to 500 000	59	19.7
	500 001 to 1 000 000	11	3.7
Location	Morogoro Urban	146	48.7
	Mvomero District	154	51.3

3.2 Perceived risks and demographic characteristics associated with perceived risks

The respondents indicated their perceived level of risk for suffering from VAD, becoming blind and becoming night blind on a five-point scale that included the options "No risk", "Little risk", "Medium risk", Serious risk" and "Very serious risk". An "I do not know" option was also provided for the respondents.

Individual differences that affected risk perceptions were examined by estimating separate ordered probit models for VAD, becoming blind and becoming night blind. "I do not know" responses were excluded from the ordered probit models; however, binary probit models were estimated to gain insight from those responses. Demographic characteristics were included as explanatory variables in the ordered and binary probit models to better understand the relationship between consumer characteristics and perceived risk levels.

3.3 Awareness of biofortification and demographic characteristics associated with awareness

The respondents indicated awareness of biofortified crops by answering two "Yes or No" questions. One question asked respondents if they had ever heard of biofortified crops, and the other asked if they had ever heard of GM crops. If a respondent had heard of GM crops, a second question was asked to determine if respondents thought GM crops were "Good" or "Bad", while a "I do not know" option was also provided.

To explore the role of individual consumer characteristics in explaining awareness of GM and biofortified crops, binary probit models were estimated. Demographic characteristics were included as explanatory variables in the GM/biofortification awareness models. Additionally, three dummy variables were included for respondents who answered "I do not know" when asked about perceived risk of VAD, blindness or night blindness respectively. Moreover, a continuous variable for perceived risk was included for respondents who did not respond "I do not know" when asked about a given perceived risk; perceived risk was held fixed at the sample average among respondents who answered

"I do not know". These additional variables were included to shed light on the link between perception of the risks associated with VAD and awareness of GM/biofortified crops.

3.4 Preferences for biofortified rice

Our analysis used two approaches to estimate WTP for biofortified rice: the double-bounded, dichotomous-choice (DBDC) contingent valuation method (CVM), and a choice experiment (CE). CVM and CE are techniques commonly used for non-market valuation and to estimate WTP for products that are not currently on the market (biofortified rice is not available in the study area). Previous research has examined the difference between CVM and CE and concluded that CE offers considerable benefits (Adamowicz *et al*. 1998; Stevens *et al*. 2000); most notably, CE allows for the estimation of preferences for specific attributes of a product. However, recent research examining the difficulties of collecting primary data in developing areas concluded that CVM (specifically the double-bounded dichotomous-choice approach) demanded less explanation than other preference-elicitation formats (Durand-Morat *et al*. 2015). Since it is not obvious which method is superior, both were used to gain as much insight as possible. This allowed for the provision of more comprehensive analysis by comparing and checking the sensitivity of WTP estimates.

The CVM and CE questions were administered in blocks, and the order of the blocks was randomised across respondents to minimise order effects. CVM and CE responses can both be analysed using a random utility model (McFadden 1974). Let the utility derived by person i from rice option j be represented by:

$$U_{ij} = V_{ij} + \varepsilon_{ij}, \tag{1}$$

where V_{ij} and ε_{ij} are the deterministic and stochastic portions of utility respectively. If faced with J choice options, a respondent is assumed to choose option j if $U_{ij} > U_{il}$ for all $j \neq l$. Assuming the ε_{ij} are independent and identically distributed as a type 1 extreme value random variable, then the probability of individual i choosing option j is:

$$\text{Prob(option } j \text{ is chosen)} = \frac{e^{V_{ij}}}{\sum_{k=1}^{J} e^{V_{il}}}. \tag{2}$$

3.4.1 Contingent valuation method questions and models

There were four CVM blocks that measured WTP for rice that: 1) was biofortified to increase the level of vitamin A; 2) was genetically modified to increase the level of vitamin A; 3) decreased the risk of blindness and night blindness by half; and 4) completely decreased the risk of blindness and night blindness. All blocks used the DBDC format. The DBDC format, discussed in Hanemann *et al*. (1991), is commonly used in CVM studies because it provides more efficient estimates than the single-bound format. The DBDC format differs from a single-bound dichotomous-choice format by asking a follow-up dichotomous-choice question. To illustrate the DBDC format, consider the block used to measure WTP for rice biofortified for increased vitamin A content. The respondents were asked a dichotomous-choice question that allowed them to select either a rice option that was biofortified or a rice option that was not biofortified, with the price of both options held constant at 1 800 Tsh/kg. The respondents choosing the biofortified rice option were then asked the dichotomous-choice question again; however, the price for the biofortified rice was increased to <<*Higher Price*>>. <<*Higher Price*>> varied randomly across respondents, taking on values between 2 000 Tsh/kg and 2 400 Tsh/kg, with a mean of 2 208 Tsh/kg. Conversely, respondents who did not choose the biofortified rice option were then asked the dichotomous-choice question again; however, the price for the biofortified rice was decreased to <<*Lower Price*>>. <<*Lower Price*>> varied randomly across respondents, from 1 200 Tsh/kg to 1 600 Tsh/kg, with a mean of 1 394 Tsh/kg. This process was replicated for the other sets of CVM blocks and the order of the blocks was randomised.

There were four possible outcomes for each set of DBDC questions: 1) yes to biofortified at 1 800 Tsh/kg, and yes to biofortified at <<*Higher Price*>>; 2) yes to biofortified at 1 800 Tsh/kg, and no to biofortified at <<*Higher Price*>>; 3) no to biofortified at 1 800 Tsh/kg, and yes to biofortified at <<*Lower Price*>>; and 4) no to biofortified at 1 800 Tsh/kg, and no to biofortified at <<*Lower Price*>>.

The explanatory variables included the perceived risk of VAD and the perceived risk of severe visual impairment, indicator variables for the "I do not know" responses to the perceived risk questions, and demographic characteristics. WTP for rice was calculated holding the explanatory variables constant at the means and coefficients from the estimated model. WTP at the means was calculated for the four sets of DBDC question.

3.4.2 Choice experiment and model

The CE block used conjoint analysis in which respondents made choices between alternative bundles of attributes. The attributes included vision benefits (does not decrease the risk of blindness or night blindness, decreases the risk of both blindness and night blindness by half, completely eliminates the risk of both blindness and night blindness), colour (brown, yellow, white), length (short, medium, long), and price (1 600 Tsh/kg, 1 800 Tsh/kg, 2 000 Tsh/kg). As described in Louviere *et al*. (2000), a full factorial design is a design in which every level of each attribute is combined with every level of all other attributes. For this study, which has four attributes and each attribute is varied at three levels, a full factorial design would require $3^4 = 81$ choice sets. However, it is possible to decrease the number of questions by using an orthogonal fractional factorial design. A fractional factorial design selects a particular subset of questions so that main effects can be estimated as efficiently as possible. The drawback of a fractional factorial design is that higher order effects cannot be estimated. Nevertheless, including 81 questions in the CE block was not a realistic possibility because of survey fatigue, and therefore a fractional factorial design was implemented, resulting in a total of 27 choices sets. Using the 27 choice sets, respondents made choices between three options in the CE: two rice options and a no purchase option.

For the CE analysis, the deterministic portion of the utility for option *j* for respondent *i* was estimated as:

$$V_{ij} = \beta_0 + \beta_1 D_j^1 + \beta_2 D_j^2 + \beta_3 D_j^3 + \beta_4 D_j^4 + \beta_5 D_j^5 + \beta_6 D_j^6 + \delta Price_j, \quad (3)$$

where D_j^1 is equal to one if option *j* decreases the risk of blindness and night blindness by half, and D_j^2 is equal to one if option *j* completely eliminates the risk of both blindness and night blindness. In addition, D_j^3 is an indicator equal to one if option *j* was assigned colour "brown", D_j^4 is an indicator equal to one if option *j* was assigned colour "yellow", D_j^5 is equal to one if option *j* was assigned grain size "medium", and D_j^6 is equal to one if option *j* was assigned grain size "long". Excluded categories for the set of indicator variables include "does not decrease the risk of blindness", "white colour", and "short grain size". The model was used to estimate WTP for different characteristics. For example, WTP for yellow rice relative to white rice and holding other attributes fixed is given by:

$$WTP^{Yellow} = -\frac{\beta_4}{\delta}. \quad (4)$$

4. Results

4.1 Perceived risks and demographic characteristics associated with perceived risks

The perceived risk of suffering from VAD and becoming visually impaired is shown in Figure 1. Almost half of the respondents (41.7%) chose the "I do not know" perceived risk category for being VAD. The number of "I do not know" responses was much lower for becoming blind (6.3%) and night blind (10%). The perceived risk category chosen most frequently for both becoming blind and night blind was "Medium risk"; this was also true for being VAD if you exclude the "I do not know" category. Perceived risk was greater for becoming night blind than becoming completely blind or being VAD.

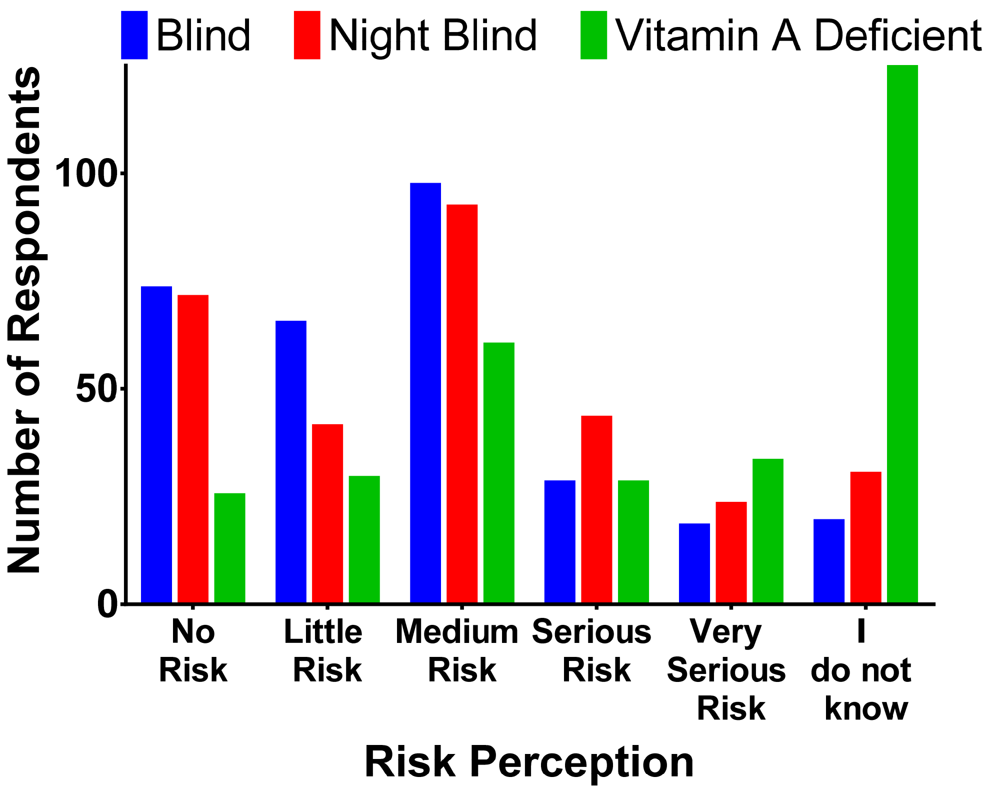

Figure 1: Perceived risk of VAD and severe visual impairment

The number of observations varies across the ordered probit models because the number of "I do not know" responses varied across the risk perception questions. Coefficient estimates from the ordered and binary probit models are shown in Table 2.

Respondents with higher levels of education and females were more likely to think that they had zero to little risk of being VAD, and also were less likely to indicate a risk level of serious to very serious. An additional level of schooling raised the probability of choosing "No risk" by 10%. Female respondents were 7.2% more likely to select the "No risk" option. The opposite was true for respondents with higher levels of income. Decreasing a respondent's income category by a single interval increased the probability of choosing "No risk" by 3.6%.

Female respondents were 14% more likely to select the "I do not know" option than males. Similarly, decreasing a respondent's income category by a single interval increased the probability of selecting the "I do not know" option by 12%. This is concerning, as the effects of VAD are more prevalent and devastating for females and those with lower incomes. Moreover, the proportion of females who are deficient in vitamin A in Tanzania is known (National Bureau of Statistics/Tanzania and ICF Macro 2011). Thus, while the proportion is known, females in Tanzania may not be aware of the statistic.

Table 2: Coefficient estimates for demographic characteristics associated with risk perception

	Dependent variables					
Independent variables	*VAD risk perception*[a]	*VAD "I do not know"*[b]	*Blindness risk perception*[a]	*Blind "I do not know"*[b]	*Night blindness risk perception*[a]	*Night blind "I do not know"*[a]
Constant	1.842***	0.811**	-0.526	0.518	-0.275	-1.15**
	(0.459)	(0.392)	(0.336)	(0.824)	(0.340)	(0.514)
Age	0.113	0.070	0.279***	0.038	0.302***	0.105
	(0.078)	(0.069)	(0.059)	(0.122)	(0.061)	(0.087)
Education	-0.546***	-0.107	-0.177**	-0.665***	-0.107	-0.088
	(0.119)	(0.106)	(0.090)	(0.249)	(0.096)	(0.133)
Female	-0.391**	0.393**	0.238*	0.660*	0.181	0.117
	(0.173)	(0.163)	(0.135)	(0.365)	(0.138)	(0.221)
Household size	0.027	-0.050	0.040	-0.233**	0.006	-0.090
	(0.046)	(0.046)	(0.038)	(0.100)	(0.038)	(0.061)
Income	0.190**	-0.338***	0.182***	-0.034	0.115*	0.105
	(0.085)	(0.075)	(0.062)	(0.141)	(0.064)	(0.097)
Rural	-0.121	-0.266	0.315**	-0.805**	0.064	-0.347
	(0.186)	(0.172)	(0.145)	(0.336)	(0.148)	(0.226)
Number of observations	175	300	281	300	270	300
Log likelihood	-250.9	-184.8	-380.8	-53.0	-412.3	-92.9

Note: [a] The dependent variable levels for the ordered probit models were "No risk", "Little risk", "Medium risk", "Serious risk" and "Very serious risk". [b] The binary probit models were estimated for the "I do not know" responses, which were excluded from the ordered probit models. Standard errors are reported in parenthesis. ***, ** and * represent 0.01, 0.05 and 0.10 levels of statistical significance.

Female respondents were 7.4% less likely to select the "No risk" option than males. Decreasing a respondent's age and income categories by a single interval increased the probability of choosing "No risk" by 8.5% and 5.6% respectively. Residents of the Mvomero District were 9.7% less likely to select the "No risk" option. The opposite was true for respondents with higher levels of education. An additional level of schooling raised the probability of choosing "No risk" by 5.4%. Notably, lower income individuals were not aware of their increased risk of visual impairment.

Female respondents were 5.3% more likely to select the "I do not know" option than males. An additional level of schooling and household size decreased the probability of choosing "I do not know" by 6.3%. and 2.2% respectively. Residents of the Mvomero District were 7.2% less likely to select the "I do not know" option.

Although many demographic characteristics significantly affected the perceived risk of becoming blind, only age and income significantly affected *Night Blindness Risk Perception*. The direction of those effects for becoming night blind was similar to becoming blind. Decreasing a respondent's age and income categories by a single interval increased the probability of choosing "No risk" by 9.5% and 3.6% respectively. None of the reported demographic characteristics influenced the respondents' selection of the "I do not know" category. Once again, lower income individuals did not appear to be aware of their increased risk of visual impairment.

4.2 Awareness of biofortification and demographic characteristics associated with awareness

Only a small portion of respondents were aware of biofortification. Eighteen percent of respondents indicated having heard of biofortified crops, and 20% indicated having heard of GM crops. Of the 20% who had heard of GM crops, 34% indicated that GM crops were good, 36% did not know if GM crops were good, and 30% indicated that GM crops were not good.

Coefficient estimates from the binary probit models for awareness of biofortified and GM crops are shown in Table 3. Only a few coefficient estimates were significant, which is not that surprising, as the proportion of the sample that was aware of either of the food technologies was low. Respondents whose VAD risk perception was "I do not know" were less likely to be aware of biofortified crops. Respondents with higher levels of education were more likely to be aware of both biofortified and GM crops. Lastly, respondents residing in the relatively rural Mvomero District were more aware of biofortified crops than respondents residing in the more urban area. This relationship may be explained by rural residents having greater involvement in agricultural production.

Table 3: Coefficient estimates for demographic characteristics associated with awareness

Independent variables	*Awareness of biofortified crops*	*Awareness of GM crops*
Constant	-2.981***	-2.244***
	(0.624)	(0.559)
VAD risk perception	0.158	0.099
	(0.116)	(0.107)
VAD "I do not know"	-0.443**	-0.157
	(0.216)	(0.193)
Blindness risk perception	0.074	0.150
	(0.141)	(0.132)
Blind "I do not know"	-0.164	-0.297
	(0.583)	(0.504)
Night blindness risk perception	-0.052	-0.148
	(0.142)	(0.131)
Night blind "I do not know"	0.331	0.191
	(0.343)	(0.323)
Age	0.124	0.061
	(0.085)	(0.079)
Education	0.386***	0.391***
	(0.134)	(0.122)
Female	-0.082	-0.037
	(0.197)	(0.182)
Household size	0.056	0.046
	(0.052)	(0.048)
Income	-0.015	0.010
	(0.091)	(0.084)
Rural	0.457**	0.121
	(0.217)	(0.193)
Log likelihood	-124.1	-134.7

Note: Standard errors are reported in parenthesis. *** and ** represent the 0.01 and 0.05 levels of statistical significance.

4.3 Preferences for biofortified rice

Figure 2 shows the responses to the CVM questions. Nearly all respondents chose the rice option that had an increased level of vitamin A or decreased the risk of severe visual impairment for the first question. Furthermore, after viewing a higher price in the follow-up question, more than half the sample continued to choose the enhanced rice options. These results suggest that consumers would be receptive to biofortified rice.

Coefficient estimates from the CVM model are shown in Table 4. *Price* and *VAD "I do not know"* were significant and negative across all models. This indicates that respondents who did not know their risk of being VAD were less likely to choose a rice option that was biofortified or decreased the risk of severe visual impairment. *Education* was significant and negative in the models that elicited WTP for rice biofortified to increase the level of vitamin A. This indicates that respondents with higher levels of education were less likely to choose a rice option that was biofortified. Interestingly, the education variable was not significant in the models that elicited WTP for rice that decreased the risk of severe visual impairment; however, the *VAD risk perception* variable was significant and positive in both. This suggests that respondents with higher levels of perceived risk of becoming VAD were more likely to choose a rice option that reduces the risk of severe visual impairment. This is important because it may indicate that there is a linkage between VAD and visual impairment, for at least some of the sample. Also, significant and negative in the *Completely eliminates risk of visual impairment* model were *Night blind "I do not know"* and *Age*. This indicates that older respondents were less likely to choose a rice option that reduces the risk of severe visual impairment, despite the fact that *Age* was significant in the ordered probit models for *Blindness risk perception* and *Night blindness risk perception* models.

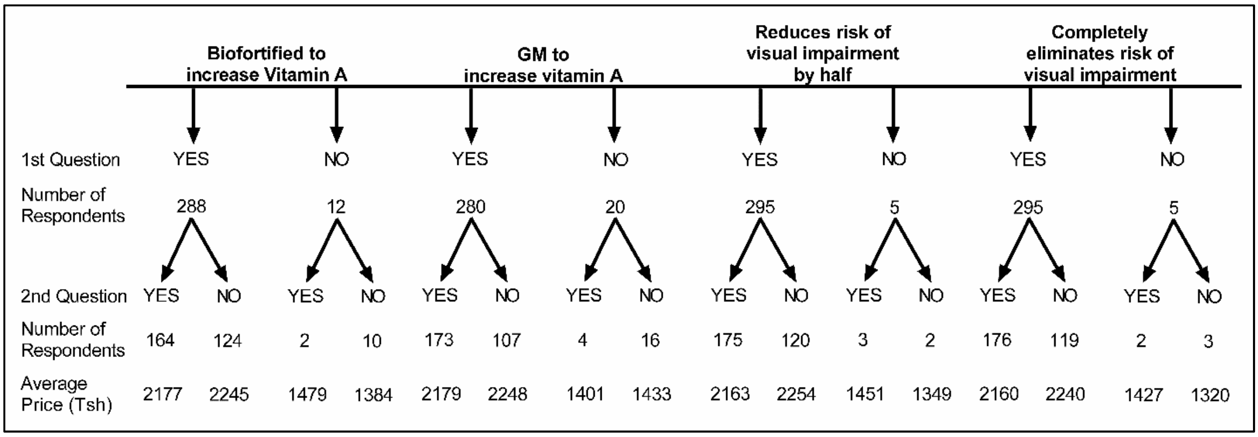

Figure 2: Responses to double-bounded dichotomous-choice contingent valuations

WTP for a kilogram (kg) of rice that can decrease the risk of severe visual impairment by half was Tsh 2 271, while WTP for a kilogram of rice that completely eliminated the risk of severe visual impairment was Tsh 2 270. WTP for a kilogram of rice that had an increased level of vitamin A from biofortification or GM was Tsh 2 267 and Tsh 2 300 respectively. On average, the respondents indicated their willingness to spend Tsh 1 711 (standard deviation = Tsh 167) for a kilogram of rice. Thus, the respondents were willing to pay a premium for rice that decreased the risk of severe visual impairment or had an increased level of vitamin A.

Table 4: Coefficient estimates for contingent valuation method

Independent variables	***Biofortified to increase vitamin A***	***GM to increase vitamin A***	***Reduces risk of visual impairment by half***	***Completely eliminates risk of visual impairment***
Constant	7.939***	6.618***	9.298***	8.961***
	(0.712)	(0.658)	(0.857)	(0.807)
VAD risk perception	0.152	0.085	0.214**	0.206**
	(0.100)	(0.100)	(0.107)	(0.105)
VAD "I do not know"	-0.777***	-0.734***	-0.650***	-0.587***
	(0.163)	(0.163)	(0.172)	(0.168)
Blindness risk perception	0.016	0.040	-0.073	0.154
	(0.117)	(0.118)	(0.124)	(0.123)
Blind "I do not know"	0.039	0.107	0.345	0.583
	(0.354)	(0.349)	(0.360)	(0.380)
Night blindness risk perception	0.048	0.107	0.095	-0.073
	(0.111)	(0.112)	(0.118)	(0.116)
Night blind "I do not know"	-0.126	-0.075	-0.319	-0.591**
	(0.283)	(0.283)	(0.283)	(0.286)
Age	-0.021	-0.028	-0.114	-0.161***
	(0.070)	(0.069)	(0.071)	(0.073)
Education	-0.432***	-0.422***	-0.012	-0.039
	(0.105)	(0.103)	(0.108)	(0.109)
Female	-0.047	-0.110	0.033	-0.129
	(0.161)	(0.160)	(0.171)	(0.169)
Household size	-0.023	-0.008	-0.046	-0.008
	(0.043)	(0.043)	(0.045)	(0.045)
Income	0.097	0.118	0.078	0.094
	(0.071)	(0.072)	(0.077)	(0.075)
Rural	-0.158	0.045	0.094	-0.011
	(0.166)	(0.165)	(0.177)	(0.172)
Price	-0.003***	-0.003***	-0.004***	-0.004***
	(0.000)	(0.000)	(0.000)	(0.000)
Log likelihood	-482.7	-505.6	-396.6	-412.2
WTP at the means (Tsh/kg)	2 267	2 300	2 271	2 270

Note: Estimates are from maximum likelihood estimation using 300 observations. Standard errors are reported in parenthesis. *** and ** represent the 0.01 and 0.05 levels of statistical significance.

Coefficient estimates from multinomial logit estimations for the CE are shown in Table 5. All coefficient estimates were significant. Respondents preferred rice that decreased the risk of severe visual impairment, was white in colour, and had longer grain length. On average, respondents were willing to pay a premium of 894 Tsh/kg for rice that decreased the risk of severe visual impairment by half, and 1 398 Tsh/kg for rice that completely eliminated the risk. However, these premiums decreased to 452 Tsh/kg and 956 Tsh/kg respectively after accounting for the yellow colour of Golden Rice.

Table 5: Coefficient estimates for the choice experiments

Variable	Level	Coefficient	WTP for level (Tsh/kg)
Constant		5.172*** (0.283)	
Vision benefit	*Decrease risk of blindness by half*	2.708*** (0.071)	894
	Completely decrease risk of blindness	4.237*** (0.080)	1398
Colour	*Brown*	-1.187*** (0.058)	-392
	Yellow	-1.340*** (0.070)	-442
Length	*Medium*	0.900*** (0.059)	297
	Long	1.087*** (0.056)	359
Price	*Tsh/kg*	-0.003*** (0.000)	

Note: Estimates are from multinomial logit estimation using 8 100 observations. Log likelihood = -4134.001. Standard errors are reported in parenthesis. *** represents 0.01 level of statistical significance.

4. Conclusions

This study examined the risk perceptions of VAD and severe visual impairment in the urban and rural regions of Tanzania. The information resulting from this study provides insight into the types of people who are concerned about severe visual impairment. Unfortunately, it does not indicate where the concern originates, and thus cannot be completed attributable to VAD. There is evidence of disconnect between the perceived risk of being VAD and the risk of visual impairment in particularly susceptible demographics, including female and lower income respondents.

Using data from a survey of 300 rice consumers, the findings indicate that consumers were concerned about vision problems and VAD. However, it is not clear whether the survey participants understood that VAD could cause vision problems. It was found that most of the respondents had limited awareness of biofortification and GM technology. Limited awareness and knowledge were not correlated with an aversion to biofortification or GM technology. Contingent valuation and conjoint analysis methods were used to elicit consumers' WTP for rice that could decrease the risk of VAD, and thus of vision impairment. Consumers strongly preferred and were willing to pay a premium for rice with added nutritional value.

A particularly notable result of the analysis concerned respondents' risk perceptions of becoming VAD. Despite a significant number of "I do not know" responses, female and lower income respondents were more likely to think that they had zero to little risk of being VAD. This result is alarming, because females and lower income individuals are in fact more at risk of becoming VAD. In contrast, female respondents were more likely to indicate a high perceived risk of becoming blind or night blind, which are symptoms of VAD. Lower income respondents still reported zero to little risk of visual impairment. Therefore, the most at-risk respondents did not understand the relationship between visual impairment and VAD. Additionally, the perceived risk category, "Very serious risk", was chosen more frequently for VAD than for becoming blind or night blind, which may indicate that the perceived risk is greater for those respondents who know the implications of VAD. Taken together, these results suggest that additional nutrition education is necessary to effectively mitigate VAD.

There were limitations to this study. The survey was only conducted in two districts of the Morogoro region, and the awareness and WTP results for the respondents may not be the same for other districts. The use of conjoint analysis to estimate WTP for different rice attributes may also have its limitations.

For example, the number of rice-attribute combinations may not have been sufficiently varied to exactly capture preferences and WTP. In addition, the study sample included few respondents with high education levels. This demographic variable and others are important to explain differences in awareness, preferences for rice attributes, and WTP. To address such challenges, further studies could incorporate more attributes and utilise a larger and more diverse sample.

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