EDE

RESEARCH ARTICLE

Using choice modelling to identify popular and affordable alternative interventions for schistosomiasis in Uganda

Keila Meginnis,[1,2]* 🆔 Nick Hanley,[1] 🆔 Lazaaro Mujumbusi,[2,3] 🆔 Lucy Pickering,[2] 🆔 and Poppy H. L. Lamberton[1] 🆔

[1]Institute of Biodiversity Animal Health & Comparative Medicine, University of Glasgow, Glasgow, UK; [2]Institute of Health & Wellbeing, University of Glasgow, Glasgow, UK and [3]Medical Research Council/Uganda Virus Research Institute & London School of Hygiene and Tropical Medicine, Uganda Research Unit, London, UK
*Corresponding author. E-mail: Keila.meginnis@glasgow.ac.uk

Abstract

Schistosomiasis is caused by a vector-borne parasite, commonly found in low- and middle-income countries. People become infected by direct contact with contaminated water through activities such as collecting water, bathing and fishing. Water becomes contaminated when human waste is not adequately contained. We administered a discrete choice experiment to understand community preferences for interventions that would reduce individuals' risk of contracting, or transmitting, *Schistosoma mansoni*. These focused on water access, sanitation and hygiene (WASH) interventions. We compared interventions that target behaviours that mainly put oneself at higher risk versus behaviours that mainly put others at risk. We used two payment vehicles to quantify what individuals are willing to give up in time and/or labour for interventions to be implemented. Key findings indicate that new sources of potable water and fines on open defecation are the highest valued interventions.

1. Introduction

In Uganda, as in many low- and middle-income countries (LMICs), families face significant daily problems related to water access, sanitation and hygiene (WASH). In poor rural areas, access to safe water is often financially, temporally, or logistically costly, if available at all, and many families rely on lakes and rivers for their daily water needs. These waterbodies are often contaminated by a range of organisms detrimental to human health, often due to limited sanitation resources. Even when sanitation is in place, it is

often of poor quality, and does not fully contain human faeces. This results in faecal contamination of farming lands, fields, public areas and the waterbodies that are used as sources of local water supply. A lack of safe-water access and sanitation inevitably leads to increased prevalence of many water-borne diseases. Schistosomiasis is one of these diseases.

Using a stated preference discrete choice experiment (DCE), this paper examines community preferences for interventions that would improve sanitation and access to safe water in rural Uganda, in the specific context of mitigating transmission of, and individual exposure to, schistosomiasis. Schistosomiasis is ubiquitous among rural lakeshore communities in Uganda and is caused by a vector-borne parasite that infects humans through direct contact with contaminated water (Kabatereine *et al.*, 2004). *Schistosoma mansoni* larvae in the water burrow directly into the skin, develop into adult worms, which then pair up and produce eggs, which are then excreted out in human faeces. Transmission (described in more detail in the online appendix, section 1) is therefore maintained through open defecation, and inadequate containment of faeces (Loewenberg, 2014). Due to the lack of sanitation and hygiene resources in many parts of Uganda, especially in rural communities, 55 per cent of the population is at risk of contracting this disease (Loewenberg, 2014). The parasite causes abdominal pain, malnutrition, anaemia and inflamed liver and spleen (Grimes *et al.*, 2014). Left untreated it can cause more severe health problems such as liver failure and kidney cancers and up to 200,000 deaths/year, and can reduce cognitive development, work performance and general quality of life (Secor, 2014), exacerbating the poverty cycle. Our study aims to elicit local peoples' preferences for new interventions to tackle the spread and transmission of schistosomiasis through minimising risks to self through safe water access and risk to others through effective faecal containment.

For nearly 20 years, the World Health Organization (WHO) has recommended repeated mass drug administration (MDA) with the drug praziquantel to prevent severe morbidity, which requires over 75 per cent coverage for estimated disease control (WHO, 2013). Despite nearly two decades of MDA, schistosomiasis continues to be a problem in many African communities. Moreover, Praziquantel treatment does not prevent re-infection, which can occur rapidly upon contact with infected water. For example, 50 per cent of school-aged children were reinfected post treatment within 40 days (Trienekens *et al.*, 2020). Furthermore, in high prevalence areas, MDA coverage target is often being missed (Knopp *et al.*, 2016; Adriko *et al.*, 2018; Coulibaly *et al.*, 2018; Binder *et al.*, 2020), due to the transient lifestyles of at-risk individuals (e.g., fishermen), reluctance to take the drug, lack of education (specifically MDA education), inequalities in the distribution process, drug shortages, or people and groups systematically being missed by the drug distribution process (Tuhebwe *et al.*, 2015; Adriko *et al.*, 2018).

The new WHO 2021–2030 NTD Roadmap now recommends WASH interventions be combined with MDA to achieve significant improvements in schistosomiasis prevalence (WHO, 2020). However, new WASH-based interventions must achieve a high level of coverage to be successful. This study used a bottom-up approach to first gain a better understanding of how people perceive this disease and what they currently do to personally reduce their risk of infection, or of passing it on. We then identified strategies suggested by community members for potential new or scaled-up WASH-based interventions which might be popular, affordable, and therefore

more likely to reach the necessary coverage levels and to be sustainable. By doing so, we are pre-empting the challenges that MDA (arguably a top-down policy) has encountered since its wide-spread inception from 2002 onwards.[1] Our long-term aim is to inform the design of transmission models (incorporating relative willingness to work (WTW) and willingness to pay (WTP) as proxies for relative uptake levels, with effectiveness), cost-effectiveness models, and ultimately build on the knowledge base to design a set of bottom-up interventions that will be popular, affordable and sustainable.

The primary purpose of this paper is twofold: (1) To compare preferences for two types of interventions which differ in terms of the risky behaviours they address, and (2) To get conservative estimates for individuals' willingness to pay and willingness to work values for these interventions which can be used in policy analysis. In order to address (1), we use data from two DCEs administered to the same population. Each presented interventions targeting different stages of the *S. mansoni* life cycle, enabling us to compare choices across different risk domains. We categorise these two intervention types as addressing either behaviour that mainly puts oneself at risk (e.g., fetching lake water, water access, termed Risks to Self (RTS) from hereon), or behaviour that mostly puts others at risk (e.g., open defecation, inadequate sanitation, termed reducing Risks to Others (RTO) from hereon), thus distinguishing between the private and public aspects of risk reduction. To address (2) we estimated several models, before selecting an approach which provides the most conservative values for willingness to pay and work in this dataset (Equality Constrained Latent Class Model).

The remainder of this paper is structured as follows. Section 2 outlines the background of our study and explores some of the existing literature on choice experiments in LMICs. Section 3 outlines our experimental design. Section 4 outlines the methodology and the results are presented in section 5. A discussion follows in section 6, and the paper is concluded in section 7.

2. Background

2.1 Schistosomiasis as a public health problem: what are the potential benefits of interventions?

In endemic communities, the parasite *S. mansoni* is particularly difficult to avoid; individuals are at risk of infection simply by contact with infected water, for example whilst performing daily routines such as fetching water, washing clothes, bathing or whilst working (e.g., fishing). In these poor rural communities, there is a severe lack of sanitation (WHO, 2013), meaning that even if an individual knew how to reduce disease transmission, they are not always in a position to do so. We see two distinct categories where WASH interventions are capable of being effective. First, improved safe water access can limit community dependence on infected bodies of water, leading to reduced exposure time and thus reduced risks of (re)infection to individuals. Second, improved sanitation may reduce the number of eggs that reach fresh water to continue their life cycle. In a review of studies from Africa, Asia and Brazil (the main affected country in South America), Grimes *et al.* (2014) found that access to improved water and sanitation significantly lowered the likelihood of schistosome (re)infection.

---

[1]A top-down approach is when a decision-making body identifies a pre-defined policy option to address an environmental problem (Carolus *et al.*, 2018). On the other hand, a bottom-up approach is to first identify an environmental problem and use local stakeholders to identify appropriate strategies.

We thus classified potential WASH interventions at two discrete points in the parasite life cycle: Risk to Self or RTS – 'improved water access'; and Risk to Others or RTO – 'improved sanitation and use'. Exposing oneself to infected water (e.g., collecting water for washing or cooking) is categorised as a behaviour that puts oneself at higher risk. Open defecation puts the whole community, including oneself and others, at risk, as the faeces will then have a higher chance of reaching freshwater, sustaining the parasite life-cycle. In our experimental design we accounted for these two distinct behaviour groups related to two different aspects of risk-reduction benefits: mainly private risk reductions in the case of RTS versus mainly public risk reductions for RTO. We anticipated that: (i) WTP and WTW measures would vary according to whether a RTS or a RTO intervention was in question; (ii) that the effect of higher money or labour prices on choices would vary between RTS and RTO; and that (iii) different factors would explain the variation in WTP and/or WTW for mainly-private benefits as opposed to mainly-public benefits.

2.2 Previous literature

Many stated preference studies related to health in LMICs are centred around water quality and accessibility or improved health care services (e.g., Whittington *et al.*, 1998; Nam and Son, 2005; Baltussen *et al.*, 2007; Youngkong *et al.*, 2010; Abramson *et al.*, 2011; Vásquez, 2014; Gibson *et al.*, 2016). Limited economic valuation research has been performed that elicits preferences for more extensive WASH interventions. Our study adds to the DCE literature in LMICs by asking respondents not just about water quality, but also about other health practices, specifically preferences for improved WASH.

There are particular challenges of implementing a DCE in low-income communities. Mangham *et al.* (2009) and Bennett and Birol (2010) outline some of these, including assigning attributes, including non-monetary payment vehicles (e.g., Abramson *et al.*, 2011; Rai and Scarborough, 2012, 2015; de Rezende *et al.*, 2015; Gibson *et al.*, 2016; Hagedoorn *et al.*, 2020), finding appropriate survey administration modes, and low literacy levels amongst respondents (see also Christie *et al.* (2012)). To address these issues, we used attributes identified by stakeholders from the communities after several months of ethnographic research in each of the three communities, as described in more detail elsewhere (Ssali *et al.*, 2021), administered the questionnaire in person through local enumerators fluent in the local language, and used two payment vehicles.

We included both labour and money as payment vehicles in each of the choice cards, to address payment vehicle issues. Furthermore, in designing our DCE we incorporated a bottom-up approach. Bottom-up approaches embed local stakeholder strategies directly into the decision making process (Carolus *et al.*, 2018). All attributes and levels evolved directly from stakeholder suggestions, which further helps to create a sense of ownership and enhances future successful policy development.

Our study adds to the previous work of Meginnis *et al.* (2020) which examined data from the RTS choice experiment only. Their aim was to explore preferences for RTS intervention, but more specifically to examine the impact of using both monetary and non-monetary numeraires in DCEs. They calculated the shadow wage rate between labour and money to be between 15–55 per cent of the market wage rate. However, the models presented in Meginnis *et al.* (2020): (i) do not contrast interventions which target RTS with those that target RTO; and (ii) fail to address the large WTP and WTW values their models yield, which far exceeded the highest levels of monetary and labour contributions of the choice cards. As such, our paper's contribution is both a more robust set of policy-relevant valuation estimates through an Equality Constrained Latent Class

Analysis (details in section 4), and a contrasting of community preferences for RTS as opposed to RTO interventions with direct public-health policy relevance.

3. Study design

To inform the survey design, rapid ethnographic appraisal fieldwork (REA) (see Bentley *et al.*, 1988) was undertaken from September 2017–April 2018 in Mayuge District, Uganda. Data from these ethnographic studies were directly used to inform the design of the DCEs, helping to develop a bottom-up approach. Ethical approval for the REA and DCE was granted by Research Ethics Committees of the University of Glasgow College of Social Sciences (400160134), the Uganda Virus Research Institute (GC127/17/06/601) and the Uganda National Council of Science and Technology (UNCST-SS-4241). Information on the study communities and design process can be found in the online appendix, sections 2 and 3, respectively.

3.1 Risk to others design

The RTO choice cards consisted of interventions associated with providing new public latrines, cleaner latrines and introducing fines to deter open defecation. We included five attributes: (1) location of new public latrines; (2) latrine maintenance; (3) open defecation fines; (4) monthly monetary cost; and (5) weekly labour contributions.

The location of new public latrines was described to be either at the lake shore, the market place, or in a residential area located within 5 min' walk from one's household. We also included a fourth level for 'no new public latrines built'. The second attribute was for the maintenance of latrines. From the three months of REA we undertook to inform the DCE design, it was discovered that one of the largest deterrents to wider use of the few public latrines already found in the villages is their poor condition. As such, many members of the community described the public latrines as too dirty for them to want to use. In order to persuade the community to use new public latrines, we expected that a certain cleanliness standard must be maintained. We therefore included an attribute describing whether public toilets (new and existing) would be maintained at the current standard (labelled 'current') or that all public toilets would be maintained regularly to a high standard of cleanliness (labelled 'improved').[2]

In order to deter open defecation in line with current and past strategies identified during the ethnographic appraisal, we included an attribute for fines issued to individuals caught openly defecating. We suggested a fine be in place for open defecation within 30 m of the lake.[3] Alternatively, a fine for open defecation anywhere in the community could be employed, or no fine. Finally, we included two payment vehicles: monthly payment and weekly labour. Both payment vehicles were described as being payments per household and would go towards construction, maintenance and organisation of the new investments. Table 1 summarises the attributes and levels for the RTO choice cards.

---

[2]The 'maintenance' attribute was piloted and phrased to ensure respondents understood that the 'improved level' was meeting a higher level of cleanliness than the baseline (current) standard. Furthermore, in the DCE, the improved level was depicted with three gold stars, a well-accepted symbol of meeting a high standard. Nevertheless, the qualitative terminology used to describe 'maintained' could have had different interpretations for different respondents and should therefore be interpreted with caution if being used for policy decisions. Unfortunately, we do not have the data to test this formally.

[3]This is to meet the WHO suggestion that in communities with large numbers of people in close confinement, defecation be discouraged between 30 m of open water sites (Wisner and Adams, 2002).

Table 1. Attributes and levels for RTO discrete choice experiment

Attributes	Levels
Location of new public latrines	• At the lake shore • At the marketplace • Residential area within 5 min from your home • No new public latrines
Maintenance level	• All latrines would be maintained to a high standard • All latrines would be maintained like they are now
Open defecation fine	• No open defecation within 30 m of the lake • No open defecation allowed anywhere • No fine
Money (UGX per month per household)	• UGX1,500/month • UGX3,000/month • UGX6,000/month • UGX0/month
Labour (Hours per week per household)	• 1 h/week • 3 h/week • 5 h/week • 0 h/week

3.2 Risk to self design

Individuals are put at risk of contracting schistosomiasis when they wade into Lake Victoria to collect water for domestic chores (e.g., cooking, cleaning, laundry) and personal hygiene (e.g., bathing). Water is also used for washing young children in basins, cleaning motor bikes, fishing, farming, and making bricks, activities which further endanger individuals. The RTS choice cards have five attributes related to water use: (1) water source; (2) water access; (3) education campaign; (4) monthly monetary cost; and (5) weekly labour contributions.

In order to reduce the reliance on potentially infective freshwater, we included a 'new water source' attribute, with four improved levels. As safe tap water is currently paid for in the communities, people tend to limit their use for drinking as it is too costly to substitute this water for all water needs.[4] We therefore included two levels with a new tap to be built where households can either fetch two 20 litre jerry cans a day, or where households can collect ten 20 litre jerry cans a day. We hypothesised that respondents would prefer a tap with a lower restriction if they envision using tap water for all water needs, not just for drinking. Two additional levels for a new water source were also included. One was described as a sun filtration centre where water is fetched from the lake and then brought to the centre and exchanged for water which is safe for domestic chores but not for drinking. Evidence suggests that leaving infected water in the sun for 24–48 h kills any schistosome cercariae and is therefore safe to use with respect to transmission of catching bilharzia, although it is not safe to drink (Braun *et al.*, 2018; Morse *et al.*, 2020). We specify an additional attribute level with a filtration centre that exchanges lake water for water which is also safe for drinking, using a more sophisticated filtration mechanism.[5]

---

[4]This is evidenced through the initial focus group and interview data. Respondents repeatedly dismissed and laughed at the concept of using paid water (e.g., taps or boreholes) for all their water needs.

[5]This level of detail was left out of the explanations. Respondents were simply told that either water would be filtered such that it is safe for drinking and household chores or only safe for household chores and not safe for drinking.

The second attribute concerned improved access to natural bodies of water. Individuals currently wade into the lake to around mid-thigh in order to reach water deep enough to submerge their jerry cans to fill them up. Water is collected for consumption (e.g., drinking and cooking) but also for bathing, household chores (e.g., laundry), washing motor bikes, farming, etc. Time spent in the lake, as well as body surface area exposed to water, both increase the risk of infection. Furthermore, wading into the lakes (e.g., to enter boats) also exposes people to infectious water. We therefore proposed new water access points, such as piers, that extend into the lake above the water. Individuals could walk along these and access lake water by leaning over and filling up their jerry can, reducing the contact surface area as well as the total time in the water.

A remerging theme in the initial ethnographic appraisal focus groups and interviews was the desire for more health education campaigns. There is mixed evidence on whether education campaigns have any effect on behaviour change, but there is some indication that education at least affects awareness (Price *et al.*, 2015). We included three new levels concerning an education campaign, each varying the way information is presented. In these villages, past campaigns have painted murals in prominent places that use images to encourage healthy behaviour. We included a level for a mural education campaign and a level for a public radio campaign. This would utilise pre-existing loud speaker systems that play daily and would communicate safe WASH behaviours. A third level provided monthly community talks led by village health teams; individuals would need to congregate at an agreed space and listen to the presentation, participate in an activity, etc.[6]

Finally, we included the same two payment attributes as the RTO. Table 2 outlines the attributes and levels for the RTS choice cards.

A D-efficient design was generated for both the RTO and RTS choice cards in Ngene (ChoiceMetrics, 2018). Restrictions were imposed such that attribute levels that in combination did not make sense were not shown on the same alternative (for example, if contributing a monthly fee, alternatives had to have at least one improved attribute). Similarly, all new investments were restricted to either cost in money, time or both: there could not be an intervention that was completely free. Each choice card had two policy interventions with a positive labour and/or money cost, and a third option where no new interventions were implemented at zero additional money/labour cost. As most members of the communities surveyed had only limited literacy, pictures rather than text were used in the choice cards. In each choice card, enumerators described every alternative by explaining the provisions shown through the pictures. The third option was always presented as creating no new interventions. An example choice card for the RTO and RTS choice sets can be seen in figures A1 and A2 of the online appendix.

3.3 Data collection

A total of 15 choice tasks were split into three blocks for each of the RTS and RTO experimental designs.[7] Respondents were asked to complete five RTS choice tasks and five

---

[6]The exact content of the education campaign is not the focus of this study and requires further research. Respondents were told that the education campaign would deliver information on general health issues, how to avoid putting oneself at risk, and best WASH practices.

[7]Design strategy and piloting information can be found in the online appendix, section 3.

Table 2. Attributes and levels for RTS

Attributes	Levels
Water source	• Tap with 2 jerry cans • Tap with 10 jerry cans • Lake water filtration site, water made safe for domestic chores and drinking • Lake water filtration site, water made safe for domestic chores but not drinking • No new water source
Water access	• 2 new water access points • 4 new water access points • No new water access points
Education Campaign	• Mural sensitisation campaigns • Daily public radio campaigns • Monthly community village health team talks • No new education campaign
Money (UGX per month per household)	• UGX1,500/month • UGX3,000/month • UGX6,000/month • UGX0/month
Labour (Hours per week per household)	• 1 h/week • 3 h/week • 5 h/week • 0 h/week

RTO choice tasks.[8] All respondents therefore answered ten choice tasks, which is at the upper limit of what is recommended to not lead to increased respondent variance (Bech *et al.*, 2011) and kept the survey interview time under one hour in length.

The order of RTS and RTO tasks was randomised such that half the respondents saw the RTS first and the other half saw RTO first. After the DCE tasks, respondents answered questions about their behaviours concerning water use and sanitation practices. In line with recent literature on consequentiality in stated preference studies (Zawojska *et al.*, 2019), we asked respondents to answer Likert-scale questions regarding the likelihood that: (i) the survey will actually be used to affect policy interventions; (ii) payments will actually have to be made; and (iii) labour will actually have to be contributed. We also asked demographic and socio-economic questions concerning daily income, household size and education.

We surveyed 425 individuals in total. Respondents were surveyed in each village proportional to their village populations, with the largest sample coming from Bwondha ($n = 247$), then Bugoto ($n = 130$; $n = 85$ from Bugoto A and $n = 45$ from Bugoto B), followed by Musubi ($n = 45$). Respondents in each village were randomly surveyed according to a sample interval based on the desired sample size per village and the estimated number of households in that village. Sample characteristics are summarised in table A1 of the online appendix.

---

[8]For the remainder of this paper we created two heuristics for the choice experiment and called them Risk to Self and Risk to Others. This is a categorisation implied by the researchers to simplify analysis and discussion. Individuals participating in the survey were not told these categories, simply participated in a DCE regarding water access and education (Risk to Self) and another one regarding latrines (Risk to Others).

4. Methodology

Choice experiments are widely used in environmental, health and transport economics (Johnston *et al.*, 2017). The approach is based on Lancaster's (1966) theory that utility for a good is comprised of utility for a good's characteristics, and McFadden's (1974) random utility theory. The probability that a respondent *n* will choose choice alternative *i* is the probability that utility for bundle *i* is larger than utility for bundle *j*.

$$P_{ni} = \text{Prob}(U_{ni} > U_{nj}). \tag{1}$$

Utility for any alternative *i* is formed of a deterministic and random component:

$$U_{ni} = V_{ni} + \varepsilon_{ni}. \tag{2}$$

We first estimated a multinomial logit model (MNL) such that the deterministic component was comprised of *K* non-cost attributes and an alternative specific constant (ASC), and *P* payment vehicles.

$$V_i = \beta' x_{ik} + \delta' c_{ip}, \tag{3}$$

where β is the marginal utility coefficient for *K* non-cost attributes (including the ASC), and δ is the marginal utility for the *P* payment vehicles (monthly fee and weekly labour). The probability that individual *n* selects alternative *i* over alternative *j* can be written as:

$$P(U_{ni} > U_{nj}) = \frac{exp(V_i)}{\sum_j exp(V_j)}. \tag{4}$$

For both the RTO and RTS models, we first estimated an MNL, as well as a Mixed Logit Model (MXL),[9] and then calculated the marginal welfare (W) for each attribute level, i.e., the marginal WTP (or MWTP) and marginal WTW (or MWTW), using equation (5),[10]

$$W_k = -\beta_k/\delta_p, \tag{5}$$

where W_k is WTP if using the coefficient on monthly fee in the denominator, or WTW if using the weekly labour coefficient.

4.1 Equality constrained latent class model

The MNL model assumes that every respondent considers every attribute (as well as assuming that preferences do not vary across the sample for each attribute). However, it is increasingly thought that respondents in choice experiments make use of simplifying decision heuristics, given the cognitive burden of fully rational choices. One such heuristic is to ignore one or more attributes when making choices, a phenomenon referred to as attribute non-attendance (ANA) (Campbell *et al.*, 2011; Koetse, 2017). Given the possibility of this happening with our respondents, we considered an additional Equality

---

[9]Mixed logit models allow for respondent heterogeneity by assuming that model parameters are continuously distributed across individuals; for more information on MXL models, see Greene and Hensher (2003). All MXL models were estimated in R using Apollo (Hess and Palma, 2019; Hess and Palma, 2019).

[10]Standard errors for MWTP and MWTW for all models were estimated via the Delta Method (Scarpa and Alberini, 2005).

Constrained Latent Class (ECLC) model for both the RTO and RTS scenarios.[11] In order to compare the two risk domains, our analysis hinges on comparing MWTP and MWTW values; it is therefore imperative that our estimations are not inflated by artificially small (i.e., zero, or close to zero) estimations of δ_{pi}, which would inflate W_k in equation (5).[12] We therefore specifically explored payment (both money and time) ANA.

To estimate an ECLC model we assume that there are four types of respondents: people who fully attend to all attributes, and three possible ANA cases. These restrictions are such that attributes which we hypothesised respondents ignored are restricted to zero. The parameters for the attended attributes are held constant across classes, such that we are accounting only for attribute non-attendance, not preference heterogeneity between these latent classes of respondents (Koetse, 2017; Glenk *et al.*, 2019).

We explore only payment-ANA, and do not consider other forms of attribute non-attendance. This is because it is difficult to separate ANA from attribute non-importance. However, attribute non-importance is unlikely to be the case of the payment vehicle as individuals are expected to always care about the cost of an item, despite not attending to it in a specific choice context. Therefore, for the payment vehicle, non-attendance and non-importance are theoretically unconfounded (Koetse, 2017). We focused on three possible ANA strategies: ignoring the monthly monetary costs, ignoring weekly labour requirements, or ignoring both. As such, we have four possible classes, and the probability that respondent n chooses alternative i is now conditional on being in class s and can be written as:

$$P_n(i|s) = \frac{exp(\beta' x_{ik} + \delta'_{is} c_{is})}{\sum_j exp(\beta' x_{jk} + \delta'_{js} c_{js})}. \tag{6}$$

The utility of the K non-cost attributes and the ASC (β) are kept fixed across the classes.[13] For classes 2–4, the respective payment attributes are constrained to exhibit a zero fixed marginal utility. The probability that an individual n is in class s is expressed through a standard multinomial logit model:

$$\pi_s = \frac{exp(\theta_s z_n)}{\sum_{s=1}^{S} exp(\theta_s z_n)}, \tag{7}$$

where z_n represents individual co-variates to include in the class membership model. We consider several individual covariates in our class membership model, outlined in the online appendix, section 7. Marginal WTP and WTW for the ECLC models are estimated exactly as before in equation (5), except that they should be weighted according to the percentage of respondents that attended to the payment attributes.

5. Results

Tables 3 and 4 report the results from the MNL, MXL and ECLC model for the RTO and RTS data, respectively.

---

[11]ECLC models were estimated using Latent Class Gold (Latent Class Gold 5.1, 2021).

[12]The ECLC Model evolved from the MNL and MXL models producing unreasonably large WTP and WTW work values, suggesting that there was possible payment-ANA occurring amongst respondents.

[13]Keeping the ASC fixed was deliberate because we had levels of the ASC occurring in the non-ASC alternatives (i.e., zero monthly fee or zero working hours). It is shown by Glenk *et al.* (2015) that in this case, it is logical for the ASC to also be constrained across classes.

Table 3. RTO MNL, MXL and ECLC models

	Model 1: MNL			Model 2: MXL[a]			Model 3: ECLC		
	$\hat{\beta}$ (st. err)	$\widehat{WTP}$ (st. err)	$\widehat{WTW}$ (st. err)	$\hat{\beta}$ (st. err)	$\widehat{WTP}$ (st. err)	$\widehat{WTW}$ (st. err)	$\hat{\beta}$ (st. err)	$\widehat{WTP}$ (st. err)	$\widehat{WTW}$ (st. err)
Location									
The lake	1.0488 (0.1299)	13,403 (2989)	64.45 (68.21)	1.578 (0.221)	12,430 (3196)	27.41 (12.63)	1.3526 (0.1421)	911.1 (166.4)	1.42 (0.2805)
Market	1.0491 (0.1377)	13,407 (2828)	64.47 (66.72)	1.706 (0.214)	13,434 (3015)	29.62 (12.9)	1.2964 (0.1449)	873.3 (162.7)	1.361 (0.2711)
5 min from home	1.3261 (0.1271)	16,947 (3127)	81.5 (85.73)	2.079 (0.212)	16,377 (3253)	36.11 (15.79)	1.4885 (0.1312)	1002.7 (178.4)	1.5627 (0.2984)
Maintain	0.2755 (0.0746)	3,521 (1074)	16.93 (17.63)	0.448 (0.111)	3,532 (1102)	7.787 (3.779)	0.3508 (0.0756)	236.3 (63.5)	0.3683 (0.0994)
Fine issued for defecation									
Within 30 m from lake	1.2116 (0.1097)	15,484 (3356)	74.46 (80.77)	1.835 (0.176)	14,450 (3390)	31.86 (15.27)	1.5165 (0.1272)	1021.6 (176.4)	1.5921 (0.301)
Everywhere	1.4842 (0.1030)	18,967 (3847)	91.21 (98.69)	2.190 (0.180)	17,248 (3780)	38.03 (17.65)	1.7131 (0.1168)	1153.9 (192)	1.7984 (0.3351)
None	0.2804 (0.1566)	3,583 (2184)	17.23 (20.87)	−0.832 (0.362)	6,558 (3194)	14.46 (9.238)	0.3721 (0.1826)	250.7 (128.5)	0.3907 (0.2038)

(*Continued.*)

Table 3. *Continued.*

	Model 1: MNL			Model 2: MXL[a]			Model 3: ECLC		
	$\hat{\beta}$ (st. err)	$\widehat{WTP}$ (st. err)	$\widehat{WTW}$ (st. err)	$\hat{\beta}$ (st. err)	$\widehat{WTP}$ (st. err)	$\widehat{WTW}$ (st. err)	$\hat{\beta}$ (st. err)	$\widehat{WTP}$ (st. err)	$\widehat{WTW}$ (st. err)
Fee (per UGX1,000)	−0.0782 (0.0144)			−0.127 (0.023)			−1.4845 (0.2343)		
Labour[b]	−0.0162 (0.0165)	48.37 (41.30)		−0.057 (0.024)	105.5 (45.47)		−0.9525 (0.1672)	149.21 (37.21)	
Full attendance ($\pi_{s=1}$) Monthly fee ANA ($\pi_{s=2}$)							0.0434 0.0163		
Weekly labour ANA ($\pi_{s=3}$)							0.0188		
Payment vehicle ANA ($\pi_{s=4}$)							0.9215		
LL	−1861.64			−1705.36			−1776.69		
BIC	3792.16			3533.16			3698.42		

[a]Mean and standard errors of the standard deviations are reported in online appendix table A5.
[b]WTP estimates for labour are calculated such that the estimate is the shadow wage rate per hour.

Table 4. RTS MNL, MXL and ECLC models

	Model 4: MNL			Model 5: MXL[a]			Model 6: ECLC		
	$\hat{\beta}$ (st. err)	$\widehat{WTP}$ (st. err)	$\widehat{WTW}$ (st. err)	$\hat{\beta}$ (st. err)	$\widehat{WTP}$ (st. err)	$\widehat{WTW}$ (st. err)	$\hat{\beta}$ (st. err)	$\widehat{WTP}$ (st. err)	$\widehat{WTW}$ (st. err)
New water source									
Tap 2 jerry cans	0.977 (0.1549)	11,906 (2964)	15.9 (5.073)	1.445 (0.216)	10,708 (2635)	14.69 (4.257)	1.0959 (0.1608)	1,631.8 (275.1)	2.0434 (0.3963)
Tap 10 jerry cans	1.686 (0.1882)	20,544 (4876)	27.44 (5.073)	2.593 (0.295)	19,215 (4684)	26.37 (7.266)	2.0319 (0.1967)	3,025.6 (376.3)	3.7885 (0.6053)
Lake filtration- non-potable	−0.372 (0.1651)	−4,529 (2414)	−6.049 (3.457)	−0.832 (0.297)	−6,164 (2304)	−8.458 (3.657)	−0.3516 (0.1701)	−523.6 (261.1)	−0.6556 (0.3333)
Lake filtration- potable	1.013 (0.1700)	12,347 (3472)	16.49 (5.234)	1.497 (0.265)	11,094 (3272)	15.22 (4.708)	1.3002 (0.1775)	1,936.1 (299.4)	2.4243 (0.4559)
Landing sites	0.191 (0.0322)	2,322 (674.5)	3.101 (0.9142)	0.264 (0.048)	1,955 (607.8)	2.683 (0.798)	0.2132 (0.0329)	317.5 (55.7)	0.3975 (0.0803)
Sensitise									
Murals	0.338 (0.1163)	4,116 (1737)	5.498 (2.488)	0.646 (0.186)	4,784 (1554)	6.565 (2.402)	0.3623 (0.1152)	539.5 (175.8)	0.6756 (0.2364)
Public radio	0.349 (0.1109)	4,254 (1758)	5.682 (2.484)	0.671 (0.162)	4,971 (1761)	6.821 (2.487)	0.4547 (0.1119)	677.1 (171.3)	0.8479 (0.2383)
VHT talks	0.677 (0.1182)	8,253 (2367)	11.02 (3.618)	1.175 (0.193)	8,708 (2319)	11.95 (3.66)	0.7988 (0.1196)	1,189.4 (201.2)	1.4893 (0.3068)
None	−0.353 (0.2350)	−4,303 (3631)	5.748 (4.845)	−1.446 (0.408)	10,716 (4322)	14.7 (5.955)	−0.5363 (0.0573)	−829 (358.4)	−1.0381 (0.4548)

(*Continued.*)

Table 4. *Continued.*

	Model 4: MNL			Model 5: MXL[a]			Model 6: ECLC		
	$\hat{\beta}$ (st. err)	$\widehat{WTP}$ (st. err)	$\widehat{WTW}$ (st. err)	$\hat{\beta}$ (st. err)	$\widehat{WTP}$ (st. err)	$\widehat{WTW}$ (st. err)	$\hat{\beta}$ (st. err)	$\widehat{WTP}$ (st. err)	$\widehat{WTW}$ (st. err)
Fee (per UGX1,000)	−0.082 (0.01495)			−0.135 (0.026)			−0.6716 (0.0718)		
Labour[b]	−0.061 (0.0174)	174.1 (51.75)		−0.098 (0.027)	169.5 (44.96)		−0.5568 (0.2377)	185.72 (27.12)	
Full attendance ($\pi_{s=1}$)							0.1351		
Monthly fee ANA ($\pi_{s=2}$)							0.0412		
Weekly labour ANA ($\pi_{s=3}$)							0.0773		
Payment vehicle ANA ($\pi_{s=4}$)							0.7464		
LL	−1810.84			−1674.8			−1726.05		
BIC	3705.86			3502.63			3609.47		

[a] Mean and standard errors of the standard deviations are reported in online appendix table A5.
[b] WTP estimates for labour are calculated such that the estimate is the shadow wage rate per hour.

Looking first at the MNL and MXL models, the marginal utility estimates for all RTO models have the expected sign and are all significant. The ASC is negative and significant in the MXL model, signalling a preference for a programme over the status quo. This is also the case in the RTS MXL model, where there is a negative and significant disutility for the status quo over a programme. This means that on average respondents prefer having a RTO or RTS programme over the status quo. All other RTS attributes are significant, with only the non-potable water source exhibiting negative marginal utility.

Turning to the WTP and WTW values from the MNL and MXL models, we see unexpectedly large estimates. In Models 1 and 2, respondents are estimated to be willing to pay between 13,000 and 17,000 Ugandan schillings (UGX) for new public toilets and between UGX15,000–19,000 for the introduction of fines for open defecation. The median daily income was UGX4,000, therefore the WTP for these intervention attributes corresponds to roughly 10–15 per cent of monthly income. Similarly, respondents exhibit extremely large values of WTW, reaching upwards of 60 h per week for various interventions. This pattern is not as extreme, but still worrisome, in the RTS data. Models 4 and 5 find respondents are willing to pay up to UGX20,000/month for new water sources, and willing to work 27 h a week for a tap with a 10 jerry can allowance.

However, these WTP and WTW estimates from the MNL and MXL models are likely inflated upwards by non-attendance to the fee and/or labour cost attributes, since the MNL and MXL model structure do not allow for this possibility. The unrealistically large WTP and WTW estimates suggest that there was possible payment-ANA occurring amongst respondents. We therefore explored other model specifications, specifically the ECLC, to allow for payment attribute non-attendance, in order to elicit more conservative WTP and WTW values to be used in policy analysis.[14]

The ECLC explicitly accounts for potential non-attendance to the money and time cost attributes. The ECLC model in fact shows that a large portion of respondents in both the RTO and RTS models were ignoring the fee and labour attributes. In the RTO Model, 3.92 per cent were ignoring both the monthly fee and weekly labour attribute. Less than 5 per cent were considering both payment vehicles (Class 1); an additional 1.6 per cent were only considering labour (Class 2) and 1.8 per cent were only considering fee (Class 3). In the RTS ECLC Model 6, a total of 13.5 per cent of respondents attended to both cost vehicles, with 4 per cent ignoring only fee (Class 2), 7.7 per cent ignoring only labour, and 75 per cent (Class 4) ignoring both the monthly fee and weekly labour payment vehicles. While the high percentage of respondents ignoring the payment vehicles is worrisome, it is not uncommon in the literature. Erdem *et al.* (2015) found 85 per cent cost non-attendance and Scarpa *et al.* (2009) found 90 per cent cost non-attendance.

Interestingly, none of our covariates for latent class membership were significant at the 5 per cent level (see tables A3 and A4, online appendix).[15] This suggests that class membership allocation is a mostly random process, which cannot be explained by respondent characteristics. However, in RTS Model 6, being female is significant at the 10 per cent level with men more likely to be in Class 4 (ignoring both of the payment attributes).

---

[14]We additionally estimated more traditional Latent Class Models for each dataset; the results are presented in online appendix, section 11. These models support our presentation of the ECLC due to the large number of classes with insignificant or positive marginal utility for the payment vehicles.

[15]We tested for a range of co-variates and found no significant predictors. We included the final set presented here because we had strong reason to believe that these co-variates, relating directly to the risk domains, gender and income, might be influential. The model is relatively unchanged with their exclusion.

5.1 Willingness to work and pay for interventions ECLC

We are particularly interested in comparing respondents' preferences for interventions which mitigate one's own risk of contracting schistosomiasis versus interventions that primarily mitigate the risk one's behaviour causes to others. These impacts differ greatly in terms of how much of the overall benefit from a WASH investment accrues to the respondent: for RTS, most of the benefit is a private good; for RTO, most of the benefit is a public good. In order to make comparisons between the two, we first examine the attribute-level WTP and WTW estimates for the ECLC Models 3 and 6.

From the WTP values, respondents were willing to pay between UGX900–1,000 for new public latrines and willing to work between 5.59–6.45 h per month for them.[16] They were willing to pay a premium of around UGX240 or work an extra 1.58 h per month (20 min a week) for the latrines to be regularly maintained to the high standard. We asked respondents how much they agreed with the statement 'public latrines are currently well maintained'. Over half of the sample (53 per cent) disagreed with this statement. Our results confirm that respondents are willing to pay for cleaner public toilets.

Next, we move to WTP/WTW for the open defecation fines. While paying for a future fine might seem counterintuitive, these values can be interpreted as payment for the necessary cost and manpower associated with introducing and enforcing this type of regulation, since this confers benefits both to the individual respondent (a reduction in their risk levels) and to others. Respondent WTP/WTW values to introduce fines are almost the same, if not a bit larger, as their WTP for new public latrines to be built (between UGX1,020–1,150/month and between 6.45–7.31 h/month). We asked respondents whether fines should be introduced even if no public latrines were built. Some 88 per cent of the respondents agreed that fines should be introduced regardless of providing new public latrines. This helps explain the relatively large willingness to contribute for the introduction of fines for open defecation.

Looking at preferences for interventions linked to reducing RTS, respondents were willing to pay between UGX1,600–3,000/month for new, safe and potable water sources. They were willing to work between 8.6–15.91 h/month (2–3.7 h/week) for these new water sources. Our results show large demand for new water interventions. Respondents were willing to pay around UGX300/month for each new landing site and work just over 1.71 h/month; UGX500–600/month and between 2.9–3.6 h/month for education through murals and public radio, but UGX1,000/month and 6.3 h/month if that education comes through village health team (VHT) talks.

5.2 Scenario evaluations

In order to provide a more comprehensive comparison of intervention options, we evaluated a series of possible investment programmes in WASH resources. To do so, we examined the compensating surplus of moving from the status quo to an RTO/RTS intervention programme. We considered four different intervention scenarios, comprised of different combinations of attributes across our experimental design. From the marginal utility estimates in Models 3 and 6, we looked at the resulting change in utility for different programmes. This was performed using the following equation, which gives the

---

[16]In order to get monthly estimates of WTW we multiply the estimated WTW/week values by 4.3, i.e., the average number of weeks per month. For example, respondents are willing to work between 1.3–1.5 hours per week, which equates to 5.59–6.45 hours per month.

Table 5. Intervention scenarios

Attribute	RTO		RTS	
	Scenario A	Scenario B	Scenario C	Scenario D
Location	5 min from home	At the lake		
Maintain	Yes	Yes		
Fines for open defecation	Everywhere	30 m from lake		
Water source			Tap with 10 jerry cans	Lake filtration-potable
Landing sites			2	1
Education			VHT talks	Murals

standard Hanemann utility difference transformed into monetary values:

$$CS = \frac{V_1 - V_0}{\delta_p},\qquad(8)$$

where V_1 and V_0 are the (indirect) utility from the proposed intervention and the status quo, respectively. The δ_p is the coefficient on monthly fee (to calculate WTP) or weekly labour (to calculate WTW). Thus, we report compensating surplus measured both in monetary equivalents and in labour hours.

Table 5 outlines four different combinations of attribute levels to examine hypothetical 'intervention bundles'. Two scenarios relate to RTO and two are given for RTS. These scenarios varied the attribute levels to simulate what a proposed future intervention in these communities might resemble. WTP and WTW can only be examined by the different latent attribute attendance classes which considered the payment vehicles. As such, we can evaluate welfare gains from these interventions based on Classes 1 and 3 (for WTP) and for Classes 1 and 2 (for WTW). For each of the scenarios we compute the WTP and WTW, then look at relative values, by normalising Scenario A to 1 and looking at the changes in WTP/WTW for Scenarios B, C and D relative to A (since one cannot easily compare compensating surplus measured in money with compensating surplus measured in time). These values are shown in table 6.

The top half of table 6 refers to the absolute WTP and WTW values as calculated from tables 3 and 4. The bottom half is the weighted WTP and WTW of only the classes that attended to the respective payment vehicles, and assuming that the WTP/WTW are zero in classes where the payment vehicle is not attended to (Kragt, 2013; Glenk *et al.*, 2015). WTP for the RTS interventions is 5 to 9 times as high as the RTO interventions. The same holds for the WTW, although not as large. Individuals are willing to work between 4 and 6 times more for RTS interventions than for RTO interventions.

RTO interventions centre on the theme of open defecation, a problem which is common in part due to the lack of accessible and usable latrines, both private and public. Very few of our sample mentioned that they currently use public latrines: only 3.53 per cent reported using a public latrine while at home and 14 per cent while at work. Despite low usage of public latrines, our findings show that there is positive willingness to contribute for RTO interventions, but willingness to contribute levels are much larger for RTS interventions.

Table 6. Willingness to pay and work for a range of possible intervention scenarios

		WTP	WTW	Relative WTP	Relative WTW
RTO	A	2142.2	3.3387	1	1
	B	1918.3	2.9897	0.895481	0.895468
RTS	C	5679	7.1109	2.651013	2.129841
	D	3622.1	4.5355	1.690832	1.358463
		Weighted			
RTO	A	133.2448	0.19932	1	1
	B	119.3183	0.178485	0.895481	0.895468
RTS	C	1206.22	1.253652	9.052655	6.289631
	D	769.334	0.799609	5.773837	4.011675

6. Discussion

Our findings show that the most popular WASH-based intervention is a tap with up to 10 jerry cans of portable water available a day, reducing RTS. This was followed by portable filtrated water reducing RTS and fines for open defecation, reducing RTOs. The next most popular intervention was the building of new latrines, within five minutes' walk of one's home, with people willing to pay a premium in time or money for those to be maintained to a higher standard than current (often low) latrine maintenance standards. Finally, education by the VHTs was very popular, more so than education through murals or radio announcements, or new landing sites for water collection. It is worth noting that the most popular interventions, whilst they are targeted at reducing schistosomiasis transmission, would also reduce the transmission of other diseases such as diarrhoeal diseases and other faecally-transmitted infections such as soil-transmitted helminths. Interventions that would only reduce *Schistosoma* transmission, such as filtering or UV treating lake water, were less popular. Similarly, some interventions, while reducing transmission or infection, may be valued for other reasons. For example, landing sites, while reducing water contact and therefore reducing exposure, may be valued for a range of reasons, including potentially boat access for transportation or landing sites as social spaces. This may have increased willingness to pay for these investments, but further studies would be required to assess why different people would prefer different interventions, and how the perceived benefits of landing sites and other interventions break down into different benefit types for different people.

One key result from the models presented above is the evidence of a lack of attention being paid to both the monetary and labour costs of alternative options. Since the MNL models do not account for this potential choice behaviour, WTP or WTW value estimates are biased upwards. We note that this lack of attendance to the cost attributes occurred despite a high level of stated belief in the consequentiality of our survey. Respondents were extremely positive in thinking the survey would be consequential in both outcome and payment domains.[17] This stated belief may be an overestimate as these types of questions are likely to be unfamiliar to respondents; in addition, the fact

---

[17]Respondents indicated belief in high levels of payment and policy consequentiality. Over 94 per cent believed the survey would likely impact future interventions; 88 per cent believed they would likely have to pay for these interventions; and 90 per cent agreed they would have to work for these interventions.

that data were collected using in-person surveys may have led to respondents not wanting to be forthcoming with their disbelief of consequentiality. Extreme care was taken to train enumerators to be impartial recipients of respondents' survey answers. Nevertheless, we show that by using an appropriate statistical approach – the ECLC model – we can control for ANA, and for the effects this has on estimated WTP and WTW for these WASH-based interventions. When this was considered, the relative money and labour contributions were brought down to levels that better represented community income.

It is also worth noting that only a minority of respondents in our survey ever selected the status quo in any choice task. The low number of status quo choices may indicate that participants were ignoring this alternative, possibly because the monetary and time costs were perceived as very low relative to the benefits delivered; or that they were not attending to the payment vehicles as discussed above. Alternatively, the low frequency of status quo choice could also be an indication of strong preferences for any kind of WASH-based improvement, linked to the severe health risks that individuals currently face in these communities and the current lack of suitable WASH infrastructure. This is further evidence of payment-ANA; respondents are showing high valuation for any type of intervention, ignoring the associated costs. However, it is interesting that when we weight the compensating surplus estimates for each possible intervention scenario in table 5 by the fraction of those respondents who ignore the prices in the choice sets, the ranking of intervention options remains unchanged compared to the ranking without applying such weights. That is, the policy recommendation that an economist would make in terms of the priority ordering of options according to people's preferences is unaffected by the percentage of respondents exhibiting payment-ANA, even though the absolute value of benefits does, of course, change.

Finally, we note that caution should be taken when accounting for respondents' willingness to provide labour for different interventions. This survey was conducted in February, which is the dry season. Laborious activities vary during the dry and rainy seasons. For example, in the rainy season, labour is relatively intensive for farmers, with crops requiring much more attention each day, but water collection is often easier. In contrast, people can spend a good amount of their day walking to the lake to collect water in the dry season, or queueing at boreholes or taps. Preferences of respondents, especially for willingness to contribute labour, may therefore vary depending on the time of year data are collected, amongst other factors.

7. Conclusions

This is the first paper to explore preferences for two types of interventions to combat *S. mansoni* infection and transmission in rural Uganda. We find that respondents were keen for change and were willing to pay and work for new WASH interventions which would reduce health risks both to themselves (in the RTS scenarios) and to others (in the RTO scenarios). Highest values were recorded for interventions to provide new supplies of tap water which is also safe for drinking, measures to reduce open defecation, and the provision of new public latrines. In general, interventions which reduce risks to oneself were more highly valued than interventions which mainly reduce risks to other people. Respondents had a positive WTP for fines on open defecation, indicating a WTP for a reduction in the risks which this practice imposes on the community including, but not limited to, the transfer of *S. mansoni* eggs to Lake Victoria. Indeed, this may be strongly driven by other disease risks which arise from open defecation, and not just schistosomiasis alone. We also found a positive, significant WTP for the provision of new public

information campaigns to improve people's understanding of the disease cycle and how people can self-protect against risks.

Analysis of our choice data showed that many respondents appeared not to be giving consideration to the money and/or labour price of interventions, despite a high stated belief in consequentiality. This non-attendance to price led to inflated estimates of benefits from a simple MNL model and the MXL model. Using an ECLC approach we find that: (i) most respondents did not attend to money or the labour cost; and (ii) that once one allows for this, benefit estimates for each intervention are reduced substantially. With this approach, we were able to produce a ranking of alternative investment (intervention) packages in WASH facilities which takes this non-attendance into account. Stated preference studies are increasingly finding that individuals use a range of decision heuristics when answering choice experiments (Johnston *et al.*, 2017). Choice sets are difficult to answer in nature; combining this with the LMIC context and the inclusion of two payment vehicles likely created a demanding task for respondents despite the careful survey development procedures used. In such circumstances, ECLC models can help to explore the decision heuristics taken by respondents. However, very few DCE studies explore ECLC in a LMIC context. Ortega *et al.* (2019) use an ECLC model to explore preferences for drought risk in Bangladesh. They account for some cost non-attendance and find 16 per cent of respondents ignoring cost.[18] Further research is indeed needed to explore the hypothesis that ANA, specifically payment-ANA, is a likely issue in LMIC DCEs.

Building on data such as those presented in this paper, policy makers can learn from stated preference choice modelling exercises to help prioritise interventions, including those which reduce an individual's own risk versus interventions which reduce the risk an individual indirectly imposes on others in their community. The WTP and WTW estimates for both stand-alone interventions and packages of interventions can be used by policy makers to rank alternatives in terms of which command greatest public support from the community, which is crucial to the long-term sustainability of success. By better understanding respondents' WTP and WTW for different community intervention programmes, stated preference choice modelling can also aid policy makers to develop project proposals which leverage community involvement to sustain the effectiveness of interventions over time. Combined with a bottom-up development of choice options, this offers the prospect of long-lasting and effective interventions to reduce disease burdens. Comparisons of preferences can also guide policy makers about the overall popularity of interventions and help them to understand which will need to be supported at a district or national level versus those which could be sustained by community and individual buy-in.

---

[18]However, in the class where cost non-attendance was examined, other non-cost attributes were also constrained to be zero.

References

Abramson A, Becker N, Garb Y and Lazarovitch N (2011) Willingness to pay, borrow, and work for rural water service improvements in developing countries. *Water Resources Research* **47**, 1–12.

Adriko M, Faust C, Carruthers L, Moses A, Tukahebwa E and Lamberton P (2018) Low praziquantel treatment coverage for *Schistosoma mansoni* in Mayuge District, Uganda, due to the absence of treatment opportunities, rather than systematic non-compliance. *Tropical Medicine and Infectious Disease* **3**, 111.

Baltussen R, ten Asbroek AHA, Koolman X, Shrestha N, Bhattarai P and Niessen LW (2007) Priority setting using multiple criteria: should a lung health programme be implemented in Nepal? *Health Policy and Planning* **22**, 178–185.

Bech M, Kjaer T and Lauridsen J (2011) Does the number of choice sets matter? Results from a web survey applying a discrete choice experiment. *Health Economics* **20**, 273–286.

Bennett J and Birol E (eds) (2010) *Choice Experiments in Developing Countries*. UK: Edward Elgar Publishing.

Bentley ME, Pelto GH, Straus WL, Schumann DA, Adegbola C, de la Pena E, Oni GA, Brown KH and Huffman SL (1988) Rapid ethnographic assessment: applications in a diarrhea management program. *Social Science and Medicine* **27**, 107–116.

Binder S, Campbell CH, Castleman JD, Kittur N, Kinung'hi SM, Olsen A, Magnussen P, Karanja DMS, Mwinzi PNM, Montgomery SP, Secor WE, Phillips AE, Dhanani N, Gazzinelli-Guimaraes PH, Clements MN, N'Goran EK, Meite A, Utzinger J, Hamidou AA, Garba A, Fleming FM, Whalen CC, King CH and Colley DG (2020) Lessons learned in conducting mass drug administration for Schistosomiasis control and measuring coverage in an operational research setting. *American Journal of Tropical Medicine and Hygiene* **103**, 105–113.

Braun L, Grimes JET and Templeton MR (2018) The effectiveness of water treatment processes against schistosome cercariae: a systematic review. *PLoS Neglected Tropical Diseases* **12**, 1–22.

Campbell D, Hensher DA and Scarpa R (2011) Non-attendance to attributes in environmental choice analysis: a latent class specification. *Journal of Environmental Planning and Management* **54**, 1061–1076.

Carolus JF, Hanley N, Olsen SB and Pedersen SM (2018) A bottom-up approach to environmental cost-benefit analysis. *Ecological Economics* **152**, 282–295.

ChoiceMetrics (2018) *Ngene 1.2 User Manual and Reference Guide*. Australia: ChoiceMetrics. Available at www.choice-metrics.com.

Christie M, Fazey I, Cooper R, Hyde T and Kenter JO (2012) An evaluation of monetary and non-monetary techniques for assessing the importance of biodiversity and ecosystem services to people in countries with developing economies. *Ecological Economics* **83**, 67–78.

Coulibaly JT, Ouattara M, Barda B, Utzinger J, N'Goran EK and Keiser J (2018) A rapid appraisal of factors influencing praziquantel treatment compliance in two communities endemic for Schistosomiasis in Côte d'Ivoire. *Tropical Medicine and Infectious Disease* **3**, 1–11.

de Rezende CE, Kahn JR, Passareli L and Vásquez WF (2015) An economic valuation of mangrove restoration in Brazil. *Ecological Economics* **120**, 296–302.

Erdem S, Campbell D and Hole AR (2015) Accounting for attribute-level non-attendance in a health choice experiment: does it matter? *Health Economics* **24**, 773–789.

Gibson JM, Rigby D, Polya DA and Russell N (2016) Discrete choice experiments in developing countries: willingness to pay versus willingness to work. *Environmental and Resource Economics* **65**, 697–721.

Glenk K, Martin-Ortega J, Pulido-Velazquez M and Potts J (2015) Inferring attribute non-attendance from discrete choice experiments : implications for benefit transfer. *Environmental and Resource Economics* **60**, 497–520.

Glenk K, Meyerhoff J, Akaichi F and Martin-Ortega J (2019) Revisiting cost vector effects in discrete choice experiments. *Resource and Energy Economics* **57**, 135–155.

Greene WH and Hensher DA (2003) A latent class model for discrete choice analysis: contrasts with mixed logit. *Transportation Research Part B: Methodological* **37**, 681–698.

Grimes JET, Croll D, Harrison WE, Utzinger J, Freeman MC and Templeton MR (2014) The relationship between water, sanitation and schistosomiasis: a systematic review and meta-analysis. *PLoS Neglected Tropical Diseases* **8**, e3296.

Hagedoorn LC, Koetse MJ, Van Beukering PJH and Brander LM (2020) Time equals money? Valuing ecosystem-based adaptation in a developing country context. *Environment and Development Economics* **25**, 482–508.

Hess S and Palma D (2019) Apollo: a flexible, powerful and customisable freeware package for choice model estimation and application. *Journal of Choice Modelling* **32**.

Hess S and Palma D (2019) *Apollo Version 0.1.0, User Manual*. Available at www.ApolloChoiceModelling.com.

Johnston RJ, Boyle KJ, Adamowicz WV, Bennett J, Brouwer R, Cameron TA, Hanemann WM, Hanley N, Ryan M, Scarpa R, Tourangeau R and Vossler CA (2017) Contemporary guidance for stated preference studies. *Journal of the Association of Environmental and Resource Economists* **4**, 319–405.

Kabatereine NB, Brooker S, Tukahebwa EM, Kazibwe F and Onapa AW (2004) Epidemiology and geography of schistosomo mansoni in Uganda: implications for planning control. *Tropical Medicine and International Health* **9**, 372–380.

Knopp S, Person B, Ame SM, Ali SM, Muhsin J, Juma S, Khamis IS, Rabone M, Blair L, Fenwick A, Mohammed KA and Rollinson D (2016) Praziquantel coverage in schools and communities targeted for the elimination of urogenital schistosomiasis in Zanzibar: a cross-sectional survey. *Parasites and Vectors* **9**, 5.

Koetse MJ (2017) Effects of payment vehicle non-attendance in choice experiments on value estimates and the WTA–WTP disparity. *Journal of Environmental Economics and Policy* **6**, 225–245.

Kragt ME (2013) Stated and inferred attribute attendance models: a comparison with environmental choice experiments. *Journal of Agricultural Economics* **64**, 719–736.

Lancaster KJ (1966) A new approach to consumer theory. *The Journal of Political Economy* **74**, 132–157.

Latent Class Gold 5.1 (2021) Statistical Innovations. Available at https://www.statisticalinnovations.com/latent-gold-5-1/.

Loewenberg S (2014) Uganda's struggle with schistosomiasis. *The Lancet* **383**, 1707–1708.

Mangham LJ, Hanson K and McPake B (2009) How to do (or not to do) … designing a discrete choice experiment for application in a low-income country. *Health Policy and Planning* **24**, 151–158.

McFadden D (1974) Conditional logit analysis of qualitative choice behavior. In Zarembka P (ed.), *Frontiers in Econometrics*. New York: Academic Press, pp. 105–142.

Meginnis K, Hanley N, Mujumbusi L and Lamberton PHL (2020) Non-monetary numeraires: varying the payment vehicle in a choice experiment for health interventions in Uganda. *Ecological Economics* **170**, 1–12.

Morse T, Luwe K, Lungu K, Chiwaula L, Mulwafu W, Buck L, Harlow R, Fagan GH and Mcguigan K (2020) A transdisciplinary methodology for introducing solar water disinfection to rural communities in Malawi – formative research findings. *Integrated Environmental Assessment and Management* **16**, 871–884.

Nam PK and Son TVH (2005) *Household Demand for Improved Water Services in Ho Chi Minh City: A Comparison of Contingent Valuation and Choice Modeling Estimates*. Singapore: EEPSEA Research Report.

Ortega DL, Ward PS and Caputo V (2019) Evaluating producer preferences and information processing strategies for drought risk management tools in Bangladesh. *World Development Perspectives* **15**, 100132.

Price A, Verma A and Welfare W (2015) Are health education interventions effective for the control and prevention of urogenital schistosomiasis in sub-Saharan Africa? A systematic review. *The Royal Society of Tropical Medicine and Hygiene* **109**, 239–244.

Rai RK and Scarborough H (2012) Economic value of mitigation of plant invaders in a subsistence economy: incorporating labour as a mode of payment. *Environment and Development Economics* **18**, 225–244.

Rai RK and Scarborough H (2015) Nonmarket valuation in developing countries: incorporating labour contributions in environmental benefits estimates. *Australian Journal of Agricultural and Resource Economics* **59**, 479–498.

Scarpa R and Alberini A (2005) *Applications of Simulation Methods in Environmental and Resource Economics*. Netherlands: Springer.

Scarpa R, Gilbride TJ, Campbell D and Hensher DA (2009) Modelling attribute non-attendance in choice experiments for rural landscape valuation. *European Review of Agricultural Economics* **36**, 151–174.

Secor WE (2014) Pathogens and global health water-based interventions for schistosomiasis control. *Pathogens and Global Health* **108**, 246–254.

Ssali A, Pickering L, Nalwadda E, Mujumbusi L, Seeley J and Lamberton PHL (2021) Schistosomiasis messaging in endemic communities: lessons and implications for interventions from rural Uganda, a rapid ethnographic assessment study. *PLoS Neglected Tropical Diseases* **15**, e0009893.

Trienekens SCM, Faust CL, Meginnis K, Pickering L, Ericssonid O, Nankasi A, Moses A, Tukahebwa EM and Lamberton PHL (2020) Impacts of host gender on Schistosoma mansoni risk in rural Uganda – a mixed methods approach. *PLoS Neglected Tropical Diseases* **14**, 1–19.

Tuhebwe D, Bagonza J, Kiracho EE, Yeka A, Elliott AM and Nuwaha F (2015) Uptake of mass drug administration programme for schistosomiasis control in Koome Islands, Central Uganda. *PLoS One* **10**, 4–11.

Vásquez WF (2014) Willingness to pay and willingness to work for improvements of municipal and community-managed water services. *Water Resources Research* **50**, 8002–8014.

Whittington D, Davis J and McClelland E (1998) Implementing a demand-driven approach to community water supply planning: a case study of Lugazi, Uganda. *Water International* **23**, 134–145.

WHO (2013) *Schistosomiasis. Progress Report 2001–2011 and Strategic Plan 2012–2020*. Switzerland: World Health Organization.

WHO (2020) *Ending the Neglect to Attain the Sustainable Development Goals: A Road Map for Neglected Tropical Diseases 2021–2030*. Switzerland: WHO. Available at https://apps.who.int/iris/bitstream/handle/10665/332094/WHO-UCN-NTD-2020.01-eng.pdf?ua=1.

Wisner B and Adams J (2002) *Environmental Health in Emergencies and Disasters: A Practical Guide*. Switzerland: World Health Organization. Available at https://www.who.int/water_sanitation_health/hygiene/emergencies/em2002chap8.pdf.

Youngkong S, Baltussen R, Tantivess S, Koolman X and Teerawattananon Y (2010) Criteria for priority setting of HIV/AIDS interventions in Thailand: a discrete choice experiment. *BMC Health Services Research* **10**, 197.

Zawojska E, Bartczak A and Czajkowski M (2019) Disentangling the effects of policy and payment consequentiality and risk attitudes on stated preferences. *Journal of Environmental Economics and Management* **93**, 63–84.