Q-METHODOLOGY IN DESIGN

Stakeholder perspective on the context of use and application of a new diagnostic device for the diagnosis of schistosomiasis haematobium in Ibadan- Nigeria:

Master Thesis

Samenjo K.H. Tondo

July, 2021

Supervisory Team

Dr. ir. Diehl JC (Chair)

Prof. dr. ir. Van Engelen J.M.L.V(Mentor)

Delft University of Technology

Master Integrated Product Design

Faculty of Industrial Design Engineering

Stakeholder perspective on the most relevant context of use and application of a new diagnostic device for the diagnosis of schistosomiasis haematobium in Ibadan-Nigeria: Q-Methodology approach

Keywords:
Q-Methodology, Stakeholder Perspective, Schistosomiasis, Diagnostic Device, Product-service Design,

Abstract

Schistosomiasis is a Neglected Tropical Disease (NTD) that is caused by water-base parasite, putting more than 800 million people at risk. Sub-Saharan Africa accounts for approximately 93% of the world's schistosomiasis cases with the highest prevalence is found in countries like Nigeria. Current diagnostic devices for schistosomiasis haematobium in Nigeria either demonstrates poor specificity and sensitivity, too expensive and do not fit the local healthcare infrastructure. Also, the schistosomiasis diagnostic landscape in Nigeria involves a multiplicity of stakeholders with different diagnostic application and strategies that are often not met by current diagnostic devices. New diagnostic device for schistosomiasis that fit the local healthcare infrastructure and support the different stakeholder diagnostic strategies still remains a critical need. This study therefore focuses on; understanding the context of use and application for a new diagnostic that is needed to make a first use for the diagnosis of schistosomiasis haematobium? Q-methodology was applied within this study. Q-methodology investigates subjectivity by exploring how stakeholders rank-order opinion statements about a phenomenon. The method was use to understand; the subjective view-points of stakeholders on the context of use and application of new schistosomiasis diagnostic device and how these viewpoints are shared with other stakeholders within this study. As a result, four key viewpoints (factors) on the context of use and application for a new diagnostic device for schistosomiasis haematobium in Ibadan-Nigeria we pinpointed. New diagnostic device needed for the diagnosis of schistosomiasis haematobium will either need to (i) be deployable to nearby and remote communities, (ii) provide affordable diagnostic test at the grassroot or community level, (ii) test (diagnose) patients before treatment and equip community healthcare facilities and, (iv) fit the local healthcare infrastructure. The findings in this study will guide development of new diagnostic devices for schistosomiasis that matches the contextual landscape and stakeholder diagnostic strategies in Ibadan-Nigeria.

Key Findings

- New diagnostic device needed for the diagnosis of schistosomiasis haematobium in Ibadan-Nigeria will either need to (i) be deployable to nearby and remote communities, (ii) provide affordable diagnostic test at the grassroot or community level, (ii) test (diagnose) patients before treatment and equip community healthcare facilities and, (iv) fit the local healthcare infrastructure.
- The context of use and application of a new diagnostic device for schistosomiasis haematobium in Ibadan-Nigeria is largely associated with the stakeholder task or diagnostic strategies employed.

Key Implications

- Innovation leads and product-service designers should ensure new devices and tools developed for diagnosing schistosomiasis in Nigeria should fit the local healthcare facility and infrastructure, be deployable to nearby and remote communities and provide affordable test.
- Medical technology designers and companies should target the development of new schistosomiasis diagnostic devices that fulfils and improves stakeholder tasks and schistosomiasis diagnostic strategies.

TABLE OF CONTENT

INTRODUCTION

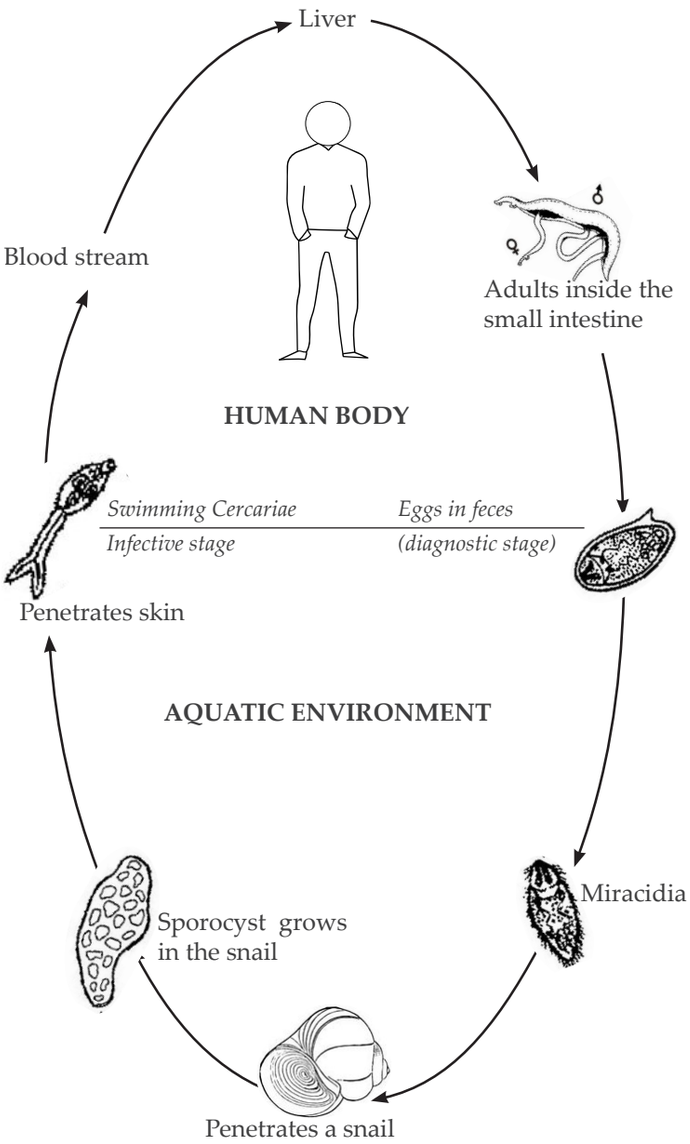


Figure 1: Life Cycle of schistosomiasis as adopted (CDC, 2019)

1.0. Introduction

Schistosomiasis is a neglected tropical disease (NTD) that is caused by water-base parasite, putting more than 800 million people at risk (Steinmann et al., 2006). **Figure 1,** shows the life cycle of schistosomiaisis and the interaction between the human body and water-based parasite. Sub-Saharan Africa accounts for approximately 93% of the world's schistosomiasis cases with the highest prevalence found in Nigeria, Tanzania, Ghana, Mozambique, and the Democratic Republic of Congo (Adenowo et al., 2015; Hotez et al., 2014). Despite the lack of accurate national data, Nigeria currently has one of the largest schistosomiasis disease burdens in the world (Onasanya et al., 2020). About 30 million people in Nigeria are affected yearly with schistosomiasis especially in rural and agrarian communities that interact with water (Ajibola et al., 2018; Ezeh et al., 2019; Nwobi et al., 2017; Onasanya et al., 2020; WHO, 2020). Safe treatment for schistosomiasis is currently performed by the use of Mass Drug Administration (MDA) using praziquantel but has fail to substantially decrease the disease prevalence and intensity. Precise and accurate diagnostic of schistosomiasis is vital for effective treatment (Weerakoon et al., 2015). However, such accurate and precise diagnostic devices for schistosomiasis in Nigeria are either: not available, to expensive, low in sensitivity, cumbersome to use, not field-adoptable in rural settings where the disease is most prevalent (Mabey et al., 2004; Sluiter et al., 2020; Van et al., 2020). Consequently, accurate diagnostic devices that fits within the context of Nigeria is still underdeveloped and remains a critical need. Within the context of Nigeria, schistosomiasis is broadly tackled through 2 approaches. That is, case management and control and elimination (Ezeh et al., 2019; Isere et al., 2015; Onasanya et al., 2020). Both approaches involve a multiplicity of stakeholders performing different task and diagnostic strategies. Within the case management approach, schistosomiasis diagnosis is primarily given at the Primary Health Care (PHC) facility and performed by healthcare workers. However, most of these primary health care facilities are; inaccessible by rural communities, have limited diagnostic laboratory infrastructure and lack well trained diagnostic personnel (Howitt et al., 2012). As such, the effectiveness in seeking diagnosis from a health care facility within the case management approach is greatly limited. Secondly, the control and elimination approach put emphasis on disease surveillance of high-risk groups such as school-age children and those whose occupations involve contact with infectious water (WHO, 2003). Possibilities to reach and identify schistosomiasis cases within the high-risk groups are often limited by lack of field-ready diagnostic tools that can identify and monitor the prevalence of the disease (Ajibola et al., 2018). The need for diagnostic tools that support the identification, control and eliminate schistosomiasis haematobium remains a critical need.

1.1. Tools and techniques for diagnosing schistosomiasis.

Standard urine filtration and Kato-Katz microscopy technique remains the recommended WHO gold standard for schistosomiasis diagnostics (PATH, 2015b). These methods heavily depend on the availability of healthcare laboratories, well-trained laboratory technologists that are often lacking in low-income countries such as Nigeria (Mabey et al., 2004). Besides, using microscopy to detect parasite eggs in urine specimens is not sensitive in detecting light infections of <50 eggs per 10mls of urine. Similarly, the sensitivity of microscopy diagnosis depends on the skill of the laboratory personnel (Ajibola et al., 2018; Braun-Munzinger & Southgate, 1992; LoVerde, 2019; Uchendu et al., 2017).

Nigeria also tackles schistosomiasis with non-clinical strategies such as school-based questionnaires that assess self-reported blood in urine and mass drug administration (MDA) using praziquantel (Onasanya et al., 2020). Such strategies have proven to be rapid and of low cost in identifying and monitoring hot spots of transmission at community level.

Method	Unit of diagnosis	Sensitivity	Specificity	Quantification	Commercially available
Colour of Urine					
Questionnaire	Red Urine	X	X	X	N/A
Visible haematuria	Macrohaematuria	X	X	X	N/A
Rapid Tests					
Reagent strip	Microhaematuria	X	X	XX	XXX
POC - CCA	Circulating cathodic antigen	XXX	XXX	XX	XXX
Microscopy					
Urine filtration	S.haematobium eggs	XX	XXX	XXX	N/A
Direct faecal smear	S. mansoni eggs, S. japonicum eggs	X	XXX	X	N/A
FECT	S. mansoni eggs, S. japonicum eggs	X	XXX	X	N/A
Kato-Katz	S. mansoni eggs, S. japonicum eggs	XX	XXX	XXX	XX
FLOTAC	S. mansoni eggs, S. japonicum eggs	XX	XXX	XXX	N/A
Mini - FLOTAC	S. mansoni eggs, S. japonicum eggs	XX	XXX	XXX	N/A
Antibody detection					
ELISA	Anti-schistosoma antibody	XXX	X	X	N/A
IHA	Anti-schistosoma antibody	XXX	X	X	N/A
Antigen detection					
UCP-LF CAA	Circulating anodic antigen	XXX	XXX	XX	N/A
DNA detection					
PCR	Schistosoma DNA	XXX	XXX	XX	N/A
LAMP	Schistosoma DNA	XXX	XXX	XX	N/A

Figure 2: Accuracy and applicability of different tests for the diagnosis of schistosoma infections adapted from (Utzinger et al., 2015).

The following grading system was used: x, low; xx, moderate; xxx, high; N/A, not applicable/not available. ELISA, enzyme-linked immunosorbent assay; FECT, formalin–ether concentration technique; IHA, indirect haemagglutination assay; LAMP, loop-mediated isothermal amplification; PCR, polymerase chain reaction; PHCU, primary healthcare unit(without microscope, centrifuge and other technical equipment); POC-CCA, point-of-care circulating cathodic antigen; UCP-LF CAA, up-converting phosphor-lateral flow circulating anodic antigen (urine-based).

On the other hand, such strategies raise concerns of missed diagnostics for several reason (Bassiouny et al., 2014; Diseases & Group, 1995; Lengeler et al., 2002; WHO, 2012). Firstly, visible haematuria in urine declines after antischistosomal treatment and several persons do not pass bloody urine which raises concerns of missed diagnosis (Uchendu et al., 2017). Secondly, 100% curative ability in administering single-dose and multidose regimens of praziquantel haven't proved to work (El Ridi & Tallima, 2013; Hoekstra et al., 2018; Munisi et al., 2017). Relying only on praziquantel treatment is not an effective strategy for control and elimination of schistosomiasis. Thirdly, Nigeria have prioritized praziquantel for school-aged children leaving adults and pre-school children uncovered during MDA (Van et al., 2020). Which means that several adults are likely to have schistosomiasis and are not being treated. Consequently, the need for accurate identification of patients requiring treatment, remains an unmet need for Schistosomiasis control and elimination (Mabey et al., 2004).

New tools for S schistosomiasis haematobium are making progress globally (Colley et al., 2013; Glinz et al., 2010; Knopp et al., 2014; van Dam et al., 2013). These new tools range from simple and rapid diagnostic techniques to sophisticated DNA analysis as seen in **Figure 2**. However, these tools and technologies are not designed for specific context of diagnosis in Nigeria, are expensive and not deployable in low-income countries. Furthermore, these tools do not address the diagnostic contextual needs within the healthcare system in Low and Middle-Income Countries (LMICs) as most of the devices are designed with the western context in mind. In fact, the World Health Organization (WHO) estimates that 70% of medical equipment coming from western context do not work within the health care system in low-income countries; due to the limitations with infrastructure, lack of train personnel and spare parts for equipment maintenance (Howitt et al., 2012). New devices towards schistosomiasis diagnostics will therefore need to take into consideration product requirements or specifications that are applicable to the local context. Therefore, schistosomiasis diagnostic tools with high quality, sensitivity and works within the local context remains an unmet need.

1.2. Stakeholder involvement in schistosomiasis diagnostics.

It can be inferred from scientific literature that the diagnostics of schistosomiasis in Nigeria involves a multiplicity of stakeholders. This comprise of seven categories of stakeholders within the four levels (Policy and Economic, organizational, healthcare and community) of the healthcare system as proposed by Onasanya et al., 2020. See **Figure 3.**

1.2.1. Policy and economy

Policy and Economic stakeholders have a wider interphase with more than one level of the health system simultaneously. There interact with the community, local, and state government and/or at the federal government level. Such stakeholders include organization within the Non-Governmental Organization (NGO), (academia) research and finance sector. Stakeholders within the policy and economic environment perform technical, supervisory and financing activities targeting the schistosomiasis control and elimination.

1.2.2. Organizational level

The organizational stakeholders are in charge of programmatic parts of schistosomiasis control as well as gathering and using information about schistosomiasis for program planning. These include; Medical Officer of Health (MOH), Primary Health Care (PHC) coordinator, Neglected Tropical Disease (NTD) Officer, Disease Surveillance and Notification (DSNO) Officer and Teachers. There are interested in the device easing workflow and improving diagnosis, thereby helping their output. These stakeholders also demonstrate technical power and are well versed with strategies for control and elimination. These strategies among others include school-based deworming campaigns, monitoring and reporting notifiable cases of schistosomiasis to healthcare facilities.

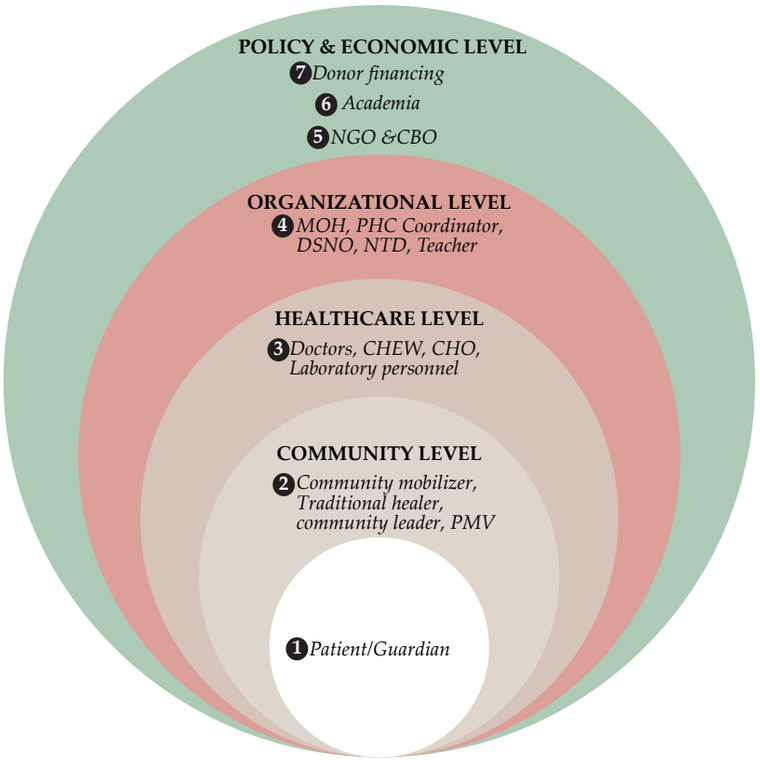


Figure 3: Seven stakeholder categories, within the four level of healthcare system in South-West Nigeria (Onasanya et al., 2020)

1.2.3. Healthcare level

Stakeholders at the healthcare level include medical personnel involved and interested in the device improving the diagnostic process and increasing efficiency. Especially in hard to reach areas. They demonstrate social power base on their continuous residence within the community. These are: doctors, Community Health Officers (CHO), Community Health Extension Workers (CHEWS) and laboratory technicians.

1.2.4. Community level

Community stakeholders comprise of patients or guardians of patients with schistosomiasis related diseases. These stakeholders are embedded within the same community network however do not possess any expert or technical knowledge on schistosomiasis diagnosis. They however, communicate and seek care when affected or burden by schistosomiasis. Also included in the community stakeholders are traditional healers, community leaders, community mobilizers and Patent Medicine Vendor (PMV).

These stakeholders within the four level of the healthcare system have the interest, power and position within the schistosomiasis landscape in Nigeria to influence the uptake and use of existing and new technologies for the diagnosis of schistosomiasis (Onasanya et al., 2020a). It is therefore crucial to ensure new diagnostic devices take into consideration the different needs, context of use and application of the different end users. Taking into account stakeholder needs will not only be crucial for the development of new diagnostic device but also aid in pinpointing roll-out strategies that guarantee the uptake and sustain use of these new diagnostic devices?

1.3. Gaps from Theory and Research Aim

The use of microscopy to detect parasite eggs in urine specimens is not sensitive in detecting light infections, is labor intensive and depends on the skill of the laboratory personnel. Other test and technologies for detecting schistosomiasis haematobium infection are either not designed for the context in Nigeria, lack specificity, are expensive or not deployable in Nigeria. Furthermore, diagnostic device needs to be not dependent on medical context such as availability of healthcare laboratories and well-trained laboratory technologists. Consequently, the need for contextual low cost diagnostic tools with high quality, sensitivity and enable rapid and accurate detection of schistosomiasis in Nigeria are increasingly important (PATH, 2015a).

According to the United to Combat NTDS report on Delivering on Promises and Driving Progress (Uniting to Combat NTDs, 2017), new tools for schistosomiasis diagnostics still remains an unmet need. New diagnostic device for schistosomiasis still need to take into account Target Product Profile (TPP) that fits: (i) local context (use case), (ii) local infrastructure (iii) contextual device requirement or performance and (iv) commercialization or effective roll-out strategy (PATH, 2015b; Uniting to Combat NTDs, 2017). Fulfilling such TPP contributes to the progress on the development of new diagnostic device for schistosomiasis; commissioned by United to Combat NTDs London Declaration to support WHO road map and end the epidemic of NTDs by 2030 (Uniting to Combat NTDs, 2017).

To address this issue, project INSPiRED – Inclusive diagnoStics for Poverty RElated parasitic Disease in Nigeria and Gabon aims to create a new diagnostic device for diagnosing schistosomiasis haematobium infection that is; easy to use, affordable, reliable and fits into the healthcare system and country's model of care (Onasanya et al., 2020). Project INSPiRED aims to deliver a diagnostic device that is most effective and efficient for management and control of schistosomiasis. However, the use of existing or future diagnostic devices for schistosomiasis haematobium diagnosis in Nigeria involves a multiplicity of stakeholders with different needs and diagnostic strategies. It is therefore crucial to

understand the schistosomiasis diagnostics landscape and stakeholder needs that will ensure a new diagnostic device is designed and useful in the context of Nigeria. As such, the objective of this thesis is to explore and understand the stakeholder perspective (viewpoint) on; what is the most relevant context of use and application for a new diagnostic device in Ibadan-Nigeria that is needed to make a first use for the diagnosis of schistosomiasis haematobium? The context of use describes the interactions that occur between the stakeholders (actors) and the diagnostic device (object) or location and the application describes the action of putting the diagnostic device into operation or use (PATH, 2015a). Similar to the research question, 4 fundamental sub-research questions (SRQ) guided this study as shown below.

Research Question.

What are the stakeholder perspective on most relevant context-of-use and application for a new diagnostic device in Ibadan-Nigeria that is needed to make a first use for the diagnosis of schistosomiasis haematobium?

SRQ 1: Diagnostic program/method.

In which diagnostic program (inclusive of diagnostic method) should the new device be used for diagnosing S. haematobium? Examples of programs include case management and control and elimination. Likewise, examples of methods amongst many include: WHO gold standard of microscopy, rapid point of care test, reagent strips, etc.

SRQ 2: Infrastructure and location.

In what infrastructure and location should the new diagnostic device be deployed to make its first use? For example, should the new device be deployed in a laboratory setting in a primary health center, health post, or in teaching/research facilities, field-deployable stations, etc.

SRQ 3: Product requirement.

What product requirements are needed in the new diagnostic device? Aspects of product requirements involve: product performance, cost, cleaning, power connectivity.

SRQ 4: Role-out strategy

What strategies should be employed to guarantee a successful roll-out of the new diagnostic device?

MATERIALS & METHOD

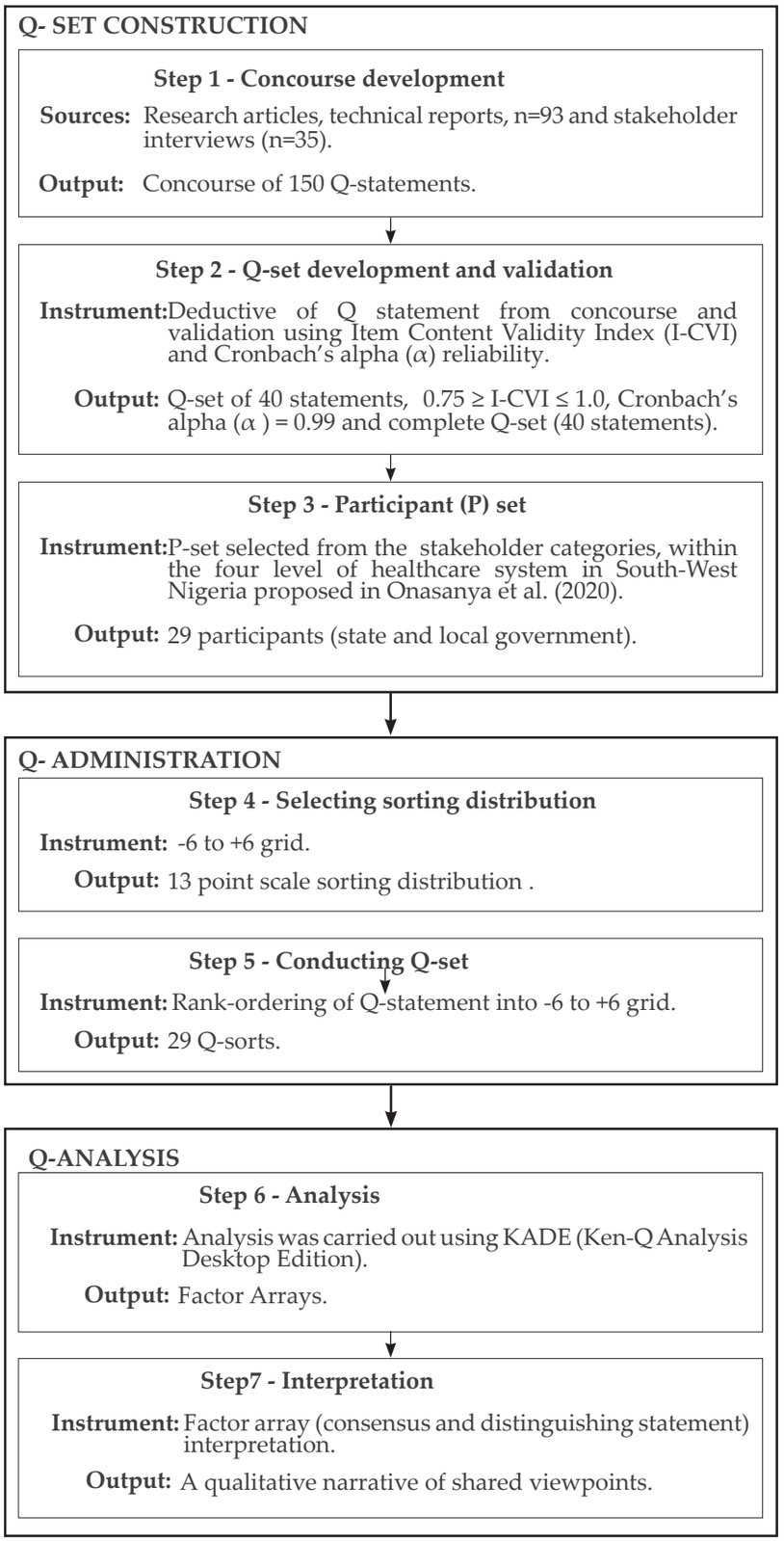


Figure 4: A seven step Q methodology study process (Damio, 2016)

2. Material and Method

A Q-methodology (Q-study) research was conducted within this study. Q-methodology is a research method that investigates subjectivity (Stephenson, 1953) by exploring how participants rank-order opinion statements (or often referred to as items) about a particular phenomenon of interest into a normal distribution grid (Barker, 2008; Paige & Morin, 2016). Q-methodology puts emphasis on understanding the subjective viewpoints of participants on a particular issue affecting them and how these viewpoints are shared with other participants within the same study environment (Barker, 2008). As opposed to conventional survey research where participants rate items in a questionnaire, Q-methodological studies compare opinion statements (items) between participants in a rank ordering procedure known as a Q-sort. Subsequently, each participant's rank-order (Q sort) is correlated with other participant's Q-sorts. Through a factor analysis the participants who share similar ways of thinking begin to emerge. The outcome of Q-study reveals viewpoints perceived among a group of participants within a particular phenomenon which can be further understood holistically. Hence, making Q methodology research suitable for this study.

The schistosomiasis haematobium diagnosis in Nigeria involves a multiplicity of stakeholders. These stakeholders have different strategies and opinions on how schistosomiasis diagnostics should be addressed in Nigeria. These stakeholder perspectives not only include the differences in opinion but also the similarities that can be further understood and guide the development of new schistosomiasis diagnostic devices For a new diagnostic device to be used in the context, it is important to understand the perspective of the stakeholders.

Within this study, Q-methodology research was guided by seven different steps embedded within three different levels (Damio, 2016). The three levels involved: Q-set construction, Q-administration and Q-analysis and interpretation as seen in **Figure 4.**

2.1. Q-set construction

2.1.1. Concourse development.

A Q methodology concourse is a collection of opinion statement from literature reviews, interviews and ordinary conversations that offers insights into human behaviors and topic of interest (Stephenson, 1980). Within this study, a concourse of 150 statements was developed from literature review (n=93) and stakeholder interviews (n=35) as shown in **Appendix B**. Scientific literature, journal articles, conference proceedings, NGO and government reports related to Schistosomiasis diagnosis in Low and Middle-income Countries (LMICs) were reviewed. A variation of terms and their combinations were searched in academic databases such as Pubmed, Science Direct, Google Scholar and Google search. Examples of such keywords terms included: Schistosomiasis diagnostic (tools), Schistosomiasis stakeholder (involvement) in Nigeria, Application (and context of use) of diagnostic tools for S. haematobium, Diagnostic approaches (strategies) for Schistosomiasis. In the same way, the interviews involved stakeholders within the four levels of healthcare system (see **Appendix C**). These interviews provided opinion statements to the concourse and similarly supported or rephrased opinion statements found in literature. Populating the concourse aimed at capturing the breadth and depth of opinions on the topic of interest (McKeown & Thomas, 2013). Collection of opinions were continued until data saturation (no further new opinions).

2.1.2. Q-set development and validation

A Q set is a selection of statements drawn from the concourse. 40 statements where selected from the concourse using a deductive approach (Paige & Morin, 2016; Watts & Stenner, 2012) to make up the Q-set as seen in **Appendix D**. The statements were selected based on four considerations as proposed by Uniting to combat NTDS Target Product

Reliability Statistics

Cronbach's Alpha	Cronbach's Alpha Based on Standardized Items	N of Items
.993	.995	40

Figure 5. Cronbach's alpha calculated using windows SPSS 26.

Profile (TPPs). There included: context (use case), (ii) infrastructure and location deployment, (iii) device requirement (design, performance and commercialization) and (iv) roll-out strategy for new diagnostic device for diagnosing schistosomiasis. (PATH, 2015b; Uniting to Combat NTDs, 2017).

The selection of statements for the Q-set required an important consideration such as the number of statements and the estimated time required for rank-ordering. The larger the number of Q statements, the more time is needed for rank-ordering. Estimates suggest that a study with 50 statements takes about 30 to 60 mins to rank-order (Akhtar-Danesh et al., 2008). Besides, rank ordering 40 to 60 opinion statements is sufficient to elicit existing points of view (Brown, 1980; Watts & Stenner, 2012). The 40 selected statements in the Q-set provided good coverage in relation to the research questions. Every individual statement was clear and made its own original contribution to the Q set without creating unsightly gaps or redundant overlaps as proposed by Watts & Stenner (2012).

Unique to this study, domain experts and a Q methodology expert reviewed the selected 40 statements in the Q-set. The domain experts provided expertise regarding schistosomiasis in the context of Nigeria and the Q methodology expert provided advice on the construction of the Q statements. Cronbach's alpha (α) reliability coefficient was used to measure internal consistency of the statement and Item Content Validity Index (I-CVI) value measured the Content validity of the Q statement (Zamanzadeh et al., 2015). In measuring the content reliability and validity, the experts scored each of the Q statements for readability, clarity of statement and heterogeneity (breadth and depth) (Paige & Morin, 2016) as shown in **Table 1.**

	Not at all	Somewhat	Mostly	Completely
The statement is clear and unambiguous as would be read by the participants	1	2	3	4
The statement illustrates heterogeneity (depth and breadth)	1	2	3	4

Table 1. Content validity and reliability questions as each of the Q-statements. 1 = not at all; 2 = somewhat, 3 = mostly, 4 = completely.

The statistical analysis of Cronbach's alpha reliability coefficient using Windows SPSS 26, resulted to a value of 0.99 (see **Figure 5**) that is acceptable and higher than the Nunnally norm of 0.7 (Nunnally & Bernstein, 1978).

Item Content Validity ensured the statements in the Q-set included all the items that are essential and undesirable items removed by eliciting expert advice (Taherdoost, 2016; Valenta & Wigger, 1997). Due to the subjectivity nature of Q-methodology research, Face-Validity of the statements was addressed by leaving the statements as found in literature or mentioned by participants. However, words were slightly edited for grammar and readability. On the other hand, Item (statement) Validity did not apply to this study of subjectivity since the meaning of an item can be interpreted differently (Valenta & Wigger, 1997). The interpretation of the item becomes apparent in the rank-ordering of the Q-set. Based on ratings performed by 4 experts, 32 statements scored an I-CVI value of 1.00, 8 statements with I-CVI value of 0.88, and 1 statement with I-CVI score of less than 0.80. See **Appendix E.**

Experts suggested minor changes in wording of statements to improve clarity and readability especially for the Q-statements with I-CVI values of less than 0.80 (Zamanzadeh et al., 2015). As a result of expert feedback, minor edits where made on 2 statements (including statement with ICVI values greater than 0.80) and 38 statements remained unchanged. Examples of the edited Q-statements are shown in **Appendix D**.

2.1.3. Participant (P) Set.

Within this study, 29 participants were selected from three of the four levels of healthcare system in South-West Nigeria as shown in **Table 2**. This included participants from the policy and economic, organization and healthcare level. Participants within the community level were not included in this study. Community level participants prioritize access to healthcare and have little or no expert knowledge on schistosomiasis diagnosis. As such, community level participant was not suitable for this study.

The 29 participants were sufficient to establish and compare the different viewpoints expressed in the Q-set. Kline, (2014) suggest a Q-set that contains at least twice as many Q-statements than participants might be a good rule of thumb for selecting the number of participants. However, Stephenson, (1953) argued that good studies and analysis have easily be carried out with considerably less participants.

All selected participants had medical and practical knowledge on schistosomiasis diagnosis and demonstrate high power and interest in the adoption of new diagnostic technologies for schistosomiasis diagnosis in Nigeria (Onasanya et al., 2020).

Stakeholder level	Stakeholder	Number of Participants	
		Local Gov't	State Gov't
Policy and Economy level	NGO	1	1
	Financing		2
	Academia/Researcher	1	1
Organizational level	Medical Officer of Health (MoH)/ Primary Healthcare Coordinator (PHC)	1	1
	Disease surveillance Notification Officer (DSNO)	1	1
	Neglected Tropical Disease Officer (NTD)	2	1
Healthcare level	Medical Doctor	1	2
	Community Health Extension Worker (CHEW)	1	1
	Laboratory Technician	4	2
	Community Health Officer (CHO)	4	1

Table 2. Stakeholders in the participant (P) - set.

2.2. *Q-administration*

2.2.1. Selection of sorting distribution

Data collection in Q methodology involved participants rank-ordering statements on a fixed normal distribution. This fixed normal distribution created an opportunity for a standardized and uniform comparison of the Q sorts compared to a free distribution (Watts & Stenner, 2012). Within this study, participants rank-ordered 40 statements into an 13-point scale (-6 to +6) sorting grid with the poles labelled 'most agree' to 'most disagree' as shown in **Figure 6**. A 13-point (-6 to +6) fixed normal distribution. These poles were designed to capture very strong feelings (positive or negative) on what is the most relevant context of use and application for schistosomiasis diagnostics in Nigeria.

The range and slope of the distribution was selected to provide a fine-grained ranking on what is the most relevant context of use and application

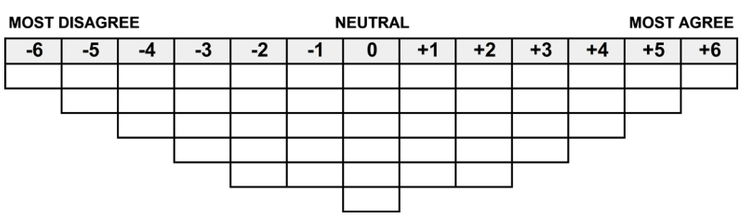


Figure 6. A 13-point (-6 to +6) fixed normal distribution.

of schistosomiasis diagnostic in Nigeria. Such flatten distributions maximized the participant's expertise knowledge of the topic in achieving a granular rank-order (Watts & Stenner, 2012).

2.2.2. Conducting Q-sort.

The study was conducted with ethical approval from the Research Ethics Committees at the University of Ibadan-Nigria (REF UI/EC/21/0100) and Technical University of Delft, Netherlands. Participants were assured that participating in the study was voluntary and information collected were anonymized and treated with confidentiality. All participants signed and provided informed consent before participating in the study and were allowed to withdraw from the study at any given moment.

29 Q-sorts were conducted within this research. Q-sorts were conducted using Easy-HtmlQ 2.0 web application; a web base platform for Q-administration (Banasick, 2016/2021). This provided an opportunity to administer Q-sort remotely within the boundaries of COVID-19 pandemic that did not allow for face-to-face meetings. With an easy to use interface, Easy-HtmlQ provided participants with the ability to familiarize themselves with the Q-statements on digital cards which reduced cognitive load. Participants were first provided with the opportunity to organize the cards into three piles: Q-statements they strongly agreed with, Q-statements they strongly disagree with and the ones they were neutral or had no opinion. The pile of pre-organized statements was further ranked on the grid from 'most agree' (+6) to 'most disagree' (-6). The sorting exercise was completed with post-interview question to capture reason why statements ranked extreme corners of the grid. Each Q sorting lasted approximately, 35 – 45 minutes per participant.

2.3. Q-analysis

2.3.1. Analysis

Analysis was carried out using KADE (Ken-Q Analysis Desktop Edition) version 1.2.1 (Banasick, 2019; Rahma et al., 2020). KADE provided a simple an interactive visualization to manipulate and interpret the data gathered. Q sorts were entered into KADE for intercorrelation and factors (apparent common viewpoints) were identified using centroid factor analysis and varimax rotation. Varimax procedure of rotation provided the most mathematically preferred solution in generating factors that when put together accounts for the maximum amount of study variance (Watts & Stenner, 2012). Factors were retained for extraction if they had eigen values (EV) ≥ 1.00 and two or more significant loading (0.05 significant) following extraction (Brown, 1980; Watts & Stenner, 2012). Loadings of ≥ 0.31 (calculated as $1.96 \times 1/\sqrt{n}$, where n is the number of statements) were significant.

2.3.2. Interpretation

The factors were further interpreted using factor arrays. The factor array provided the best possible estimates of relevant and holistic viewpoints (Watts & Stenner, 2012). Statements with a statistical significance ($P \leq 0.05$) were considered distinguishing (indicated with *) statement (Brown, 1980; Exel & Graaf, 2005). Viewpoints were established by qualitatively characterizing the statements from each of the factors (Qurtas & Shabila, 2020). The results and interpretation of the analysis was summarized in a qualitatively rich narrative with a coherent overview of different viewpoints (Factors), its element and line of reasoning.

RESULTS

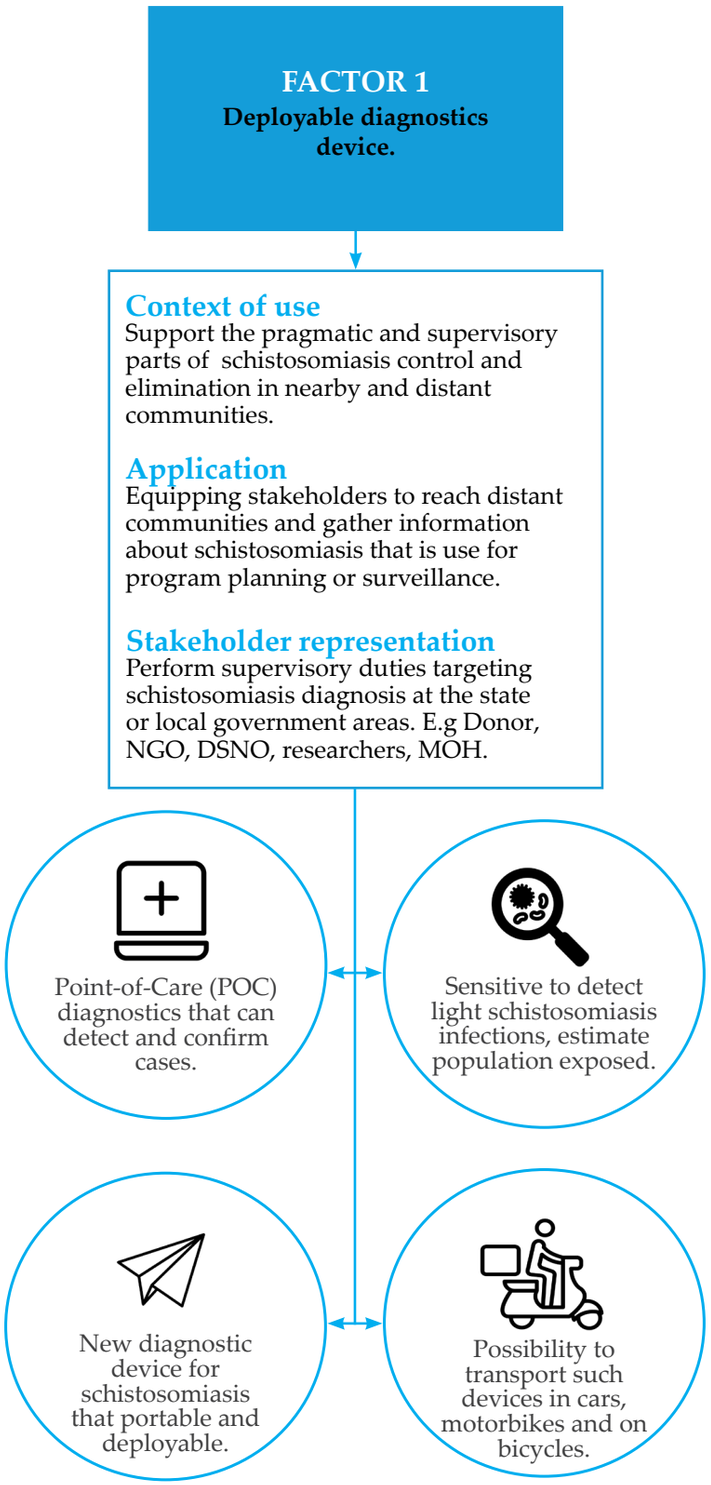


Figure 7. Factor 1 product-service design parameters.

3. Results

Following a by-person factor analysis of the 29 Q-sorts, four distinct factors (stakeholder viewpoints) emerged on the most relevant context of use and application of a new diagnostic device for the diagnosis of schistosomiasis haematobium in Ibadan-Nigeria as shown in **Table 3**. One of the factors that emerged was a bipolar factor. The four distinct factors are closely associated with the stakeholder task and strategies employed for schistosomiasis case management or control and elimination. The complete factor array of the 40 statements can be seen in **Table 4.** The four factors accounted for 33% of the total study variance. A total study variance of 33% fell short of 2% when compared to the widely accepted range of atleast 35% - 40% of the study variance (Kline, 2014). However, a low variance is not necessarily problematic and can be meaningless (Brown, 1980; Cuppen, 2010; Watts & Stenner, 2012)). In fact, resulting to only mathematical solutions in Q-methodology is not necessary the best and further deprives the opportunity to properly explore and engage with the data (Watts & Stenner, 2012). Five factors solutions would have offered a much higher total explained variance, however produced unclear and inconsistent factors. As a result, selecting four factors was most useful and produce consistent clustering of factors (viewpoints) on the most relevant context of use and application of a new diagnostic device for schistosomiasis haematobium in Ibadan-Nigeria.

It should be noted that while interpreting a factor, the statement number and its corresponding rank as in the Factor array is represented as [statement; score]. For, example [24; -1] means statement 24 is ranked at -1 along the sorting grid (-6 to +6). This system of interpretation produce a succinct and holistic narrative as it shows how statements are linked within a factor (Ladan et al., 2019). A general consensus (statement 32) was established which emphasized the need for device that can be easily cleaned and disinfected to prevent re-contamination.

Factor	No of sorts	Viewpoint Themes
Factor 1	10	Deployable diagnostic device the support the pragmatic and supervisory parts for schistosomiasis control and elimination.
Factor 2	5	Affordable diagnostic test at the grassroot level.
Factor 3+	2	Test and identify disease before treatment.
Factor 3-	2	Equipping health facilities.
Factor4	5	Diagnostic device that fits the local infrastructure.
Confounded.	3	
Non-significant loads.	2	
TOTAL	**29**	

Table 3. Factors (viewpoints) of stakeholders on the most relevant context and application for new diagnostic device for diagnosing schistosomiasis haematobium in Nigeria.

3.1. Factor 1 (F1): Deployable diagnostic device the support the pragmatic and supervisory parts for schistosomiasis control and elimination.

Factor 1 (F1) has an eigen values (EV) of 4.77 and explains 16% of the total variance. Ten participants loaded significantly in this factor. All in the positive pole. All ten participants were decision makers performing duties at the state level and supervise activities targeting schistosomiasis diagnostics in South-West Nigeria. Four participants in Factor 1 represent the Policy and economic level of healthcare system of which: two are involved within the (donor) financing, a schistosomiasis coordinator within the NGO sector and a researcher (academia) at a state university level. These participants perform supervisory, financing and technical activities targeting the control and elimination of schistosomiasis in South-West Nigeria. F1 also involved a Disease Surveillance Notification Officer (DSNO) and a Medical Officer of Health (MOH) within the state (federal government) level. The DSNO and MOH are representative of the organizational level of healthcare system. They are in charge of pragmatic parts of schistosomiasis control such as gathering and using information about schistosomiasis for program planning.

No	Statement	Factors				
		F1	F2	F3+	F3-	F4
	Context (Use Case)					
1	Microscopy using a concentration technique is the recommended method to prove active schistosomiasis, despite its low sensitivity and need for expert users.	0	-1	-1	-2	-3
2	Diagnosis should include the identification of Schistosoma parasites in both humans and water sources that may be contaminated.	+2	0	+4	+2	0
3	Mass screening and diagnosis should be carried out alongside mass drug administration with praziquantel.	-2	-3	4	-2	5
4	Schistosomiasis surveillance enables programme managers to monitor the effectiveness of intervention strategies and identify which populations require continuing interventions.	-1	+5	+2	-1	+3
5	The availability of Rapid Diagnostic Test (RDTs), which requires only minimal infrastructure, would improve diagnosis and surveillance simultaneously.	+3	-2**	+3	+2	+5
6	Implementing an affordable and simple point-of-care (POC) diagnostics solution will reduce the financial burden of equipment and personnel at each health facility.	0**	-2	-2	4**	-1
7	Point-of-care diagnostics that can detect and confirm cases immediately will reduce the risk of missed or misdiagnosed cases.	+2	0	-3*	0	1
8	The quantification of egg excretion helps to assess the transmission potential of populations living in endemic areas.	-1	-2	1	-1	-2
9	Schistosomiasis control programs should target school-aged children only.	-6	-6	-1**	-5	-6
10	Due to the low level of education and lack of training among community health workers, incorrect treatment is often prescribed.	-3*	-1	0	0	3**
11	Presenting data on the severity of schistosomiasis infection of specific locations will guide the development of strategies for effective case management and control elimination.	+1	+2	-6**	+3	+1
12	Passive case detection, based on people's self-reporting, has been considered a less expensive strategy for the control of schistosomiasis.	-3	-2	6**	0	0
13	Prevalence and intensity of infection is often higher among children than among adults.	0	-1	-3	+1	0
	Infrastructure and location					
14	Schistosomiasis diagnosis should be done closest to the community as it reduces the time to carry samples back to the laboratory.	0	+1	2	0	+4
15	Diagnostic and treatment campaigns should target school-age children, adolescents and those whose occupations involve contact with infectious water (e.g fishing, farming, irrigation, and domestic tasks in water).	-2	+3	+1	+1	-1
16	Simple, rapid point-of-care (POC) tests should be used in primary health care settings where patients often travel long distances to access healthcare facilities.	-1	-1	-2	+2	+2
17	Diagnostic devices should be deployed in primary health care centres, clinics and health posts since they are the most lacking in equipment.	-4*	+4	-1*	+5	1*
18	Testing of urine samples for schistosomiasis with school-based surveys should be done at the school location.	-1	+1	0	-2	-5
19	It is convenient to treat patients for schistosomiasis infection without a confirmed diagnosis due to the delay in receiving test results from referral hospitals.	-5	-5	-5	-4	-4

Table 4. The 40 statements and the factor array scores of the four factors. (*) distinguishing statement significant at <0.05 and (**) distinguishing statement significant at < 0.01

No	Statement	Factors				
		F1	F2	F3+	F3-	F4
	Product requirement					
20	Schistosomiasis elimination calls for developing novel diagnostic tools with higher sensitivity and specificity than microscopes.	+1	3**	-4	-1	-3
21	Diagnostic device for schistosomiasis with minimal to no sample preparation is ideal.	-2	-3	-2	-3	-5*
22	The diagnostic device should quantify eggs to provide an estimation of the number of people that have been exposed to schistosomiasis in a population.	5*	-5**	+1	-1*	+2
23	Devices should be easy to use by medical personnel and health workers such as Community Health Extension Workers (CHEWS), Community Health Officers (CHO), Laboratory scientists to detect and diagnose schistosomiasis infected patients.	+1	+2	0	-5	-2
24	Patient samples should be processed in batches to get a faster turnaround time and increase the efficiency of sample processing during mass campaigns or sensitization meetings.	0	0	+1	-4**	+3
25	Ideal diagnostic approaches should allow the concurrent detection of several pathogens in different biological samples such as urine, blood and stool.	+3	0	+3	-3*	+1
26	Diagnostic devices should be sensitive enough for detecting very light schistosomiasis infections.	+4	-3	+5	-1	-1
27	Diagnostic devices should have their own reliable power sources due to the unstable power connectivity in rural and distant communities.	+6	-1	-1	+6	+6
28	The best diagnostic devices should be easy to transport safely in cars, on motorbikes, and bicycles to remote locations.	4*	+1	-4	+2	-1
29	Diagnostic devices should be compact and portable so that it can be easily deployed in the community.	+2	0*	3	3	-3**
30	Diagnostic devices/tests should identify and map out areas with a large spread of schistosomiasis and be able to trace the source of the disease.	3*	0	0	0	-1
31	Devices should be locally repaired and maintained by local technicians in case of breakdown.	0	+2	-5**	+4	0
32	The device should be easy to clean and disinfect to prevent re-contamination.	+1	+1	0	+1	+2
	Roll out strategy					
33	The cost per diagnostic test should be free (covered by the Government).	-1	4*	0	+1	-2
34	Cost per diagnostic test should be less than 1000 Naira (€2).	-5**	6*	-3	3*	-2
35	Mass drug administration campaigns should be accompanied by mass diagnostic and disease awareness campaigns.	-2	2	2	1	0
36	Data from diagnostic devices should be accessible to stakeholders (local government, DSNO, MOH, Researchers and NGOs) to enhance planning.	+1	+5	+2	0	+2
37	New interventions should consider training the health care workers at the community level and the informal sector (PMVs and traditional medicine) to increase coverage to diagnostics.	-3	+1	-1	-6**	0
38	Diagnostic tools for schistosomiasis should be deployed and used at the community level by PMVs and community mobilizers as they already serve as trusted stakeholders in the community.	-4	-4	1**	-3	-4
39	The role of the village/community head is important in the acceptance of the new diagnostic device.	+5	-4*	-2*	+5	1**
40	Patients with schistosomiasis should be tested before being treated.	+2	+3	+5	-2**	+4

Table 4 - Conitunue. (*) distinguishing statement significant at <0.05 and (**) distinguishing statement significant at < 0.01

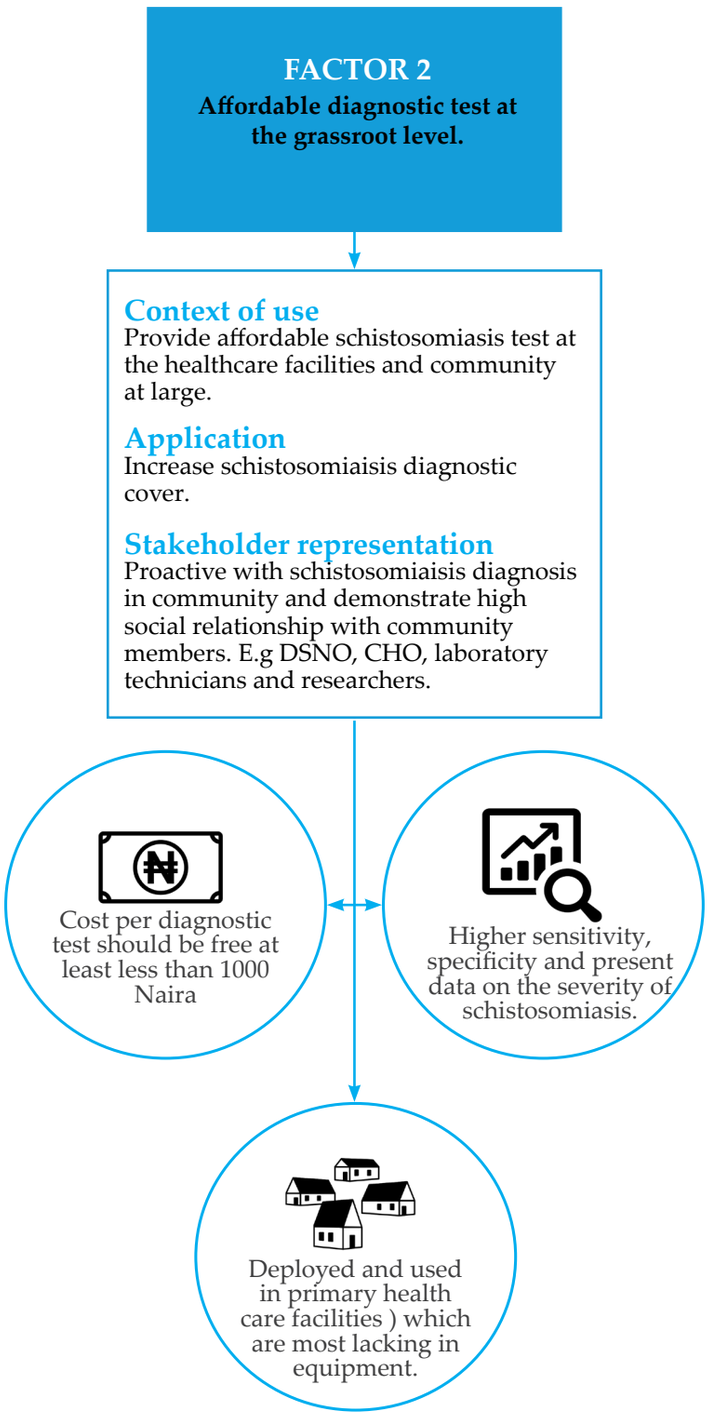


Figure 8. Factor 2 product-service design parameters.

Similarly, F1 included two laboratory technologists, a medical doctor and a Community Health Extension Worker (CHEW) at a state run healthcare facility. These participants are representative of the healthcare level that are interested in devices that improve schistosomiasis diagnostic process and increase efficiency.

Respondent of Factor 1 (see **Figure 7**) emphasized the need for new diagnostic device for schistosomiasis that is deployable. These new diagnostic devices should be deployed to remote, distant or any healthcare facilities that lacks basic equipment [29; +2, 17; -4*]. Transportation of such devices in cars, motorbikes and bicycles should be made possible [28; +4*]. The availability of such deployable diagnostic devices will increase the ability to map out areas with large spread of schistosomiasis and trace the source of the disease [30; +3*]. The new diagnostic devices should be sensitive enough for detecting very light schistosomiasis infections, quantify eggs and estimate population exposed to schistosomiasis [22; +5*]. However, the estimated population exposed to schistosomiasis should not be limited to only school aged children [9.-6]. These new schistosomiasis diagnostics devices deployed in the field will require their own reliable power sources due to the unstable power connectivity in rural and distant communities in South West Nigeria [27; +6].

Respondents in Factor 1 further recognized the need for Point-of-Care (POC) diagnostics that can detect and confirm cases immediately [7; +2]. Implementing an affordable and simple POC diagnostics solution will reduce the financial burden of equipment and personnel each distant or nearby healthcare facility [6; 0**, 34; -5**]. Simple POC devices will limit the treatment of patients for schistosomiasis infection without a confirmed diagnosis due to the delay in receiving test results from referral hospitals. [19; -5].

Respondent in F1 see community leaders and representatives as key influencers to creating awareness and disseminating information about new diagnostic device or method for schistosomiasis [39; +5]. However, they raised concerns involving non-clinical professionals in advancing schistosomiasis diagnostic cover [37; -3, 38; -4].

3.2. Factor 2 (F2): Affordable diagnostic test at the grassroot level.

F2 has an EV of 1.88 and explains 6% of the total variance. Five participants loaded significantly in this factor. All in the positive pole. The five participants are stakeholders operating in Local Government Areas (LGAs). These included: two primary health care laboratory technicians and a Community Health Officer (CHO). These participants are interested in new diagnostic device improving the diagnostic process and increase efficiency. They are proactive within the community and demonstrate high social relationship with the community members. Also, one participant (academia/researcher) was representative of the policy and economy level. This participant provides technical expertise targeting the control and elimination of schistosomiasis at LGAs. Lastly, F2 included a DSNO (organizational level) at the local government who gathers and use information about schistosomiasis for planning purposes.

F2 respondents (see **Figure 8**) emphasized the cost per diagnostic test should be free (covered by the Government) or at least less than 1000 Naira (2 USD) [33; +4*, 34; +6*]. Free or affordable diagnostic test will help increase diagnostic cover in the communities. It will improve the ability to identify and confirm infected areas (or patients) in need of treatment, mass drug administration or disease awareness campaigns [35; +2, 19; -5, 3; -3,]. With affordable diagnostic test, treatment campaigns will not only target school-age children [9, -6] but include other high-risk group. Other high-risk groups include adolescents and those whose occupations involve contact with infectious water [15; +3].

Respondent in F2 further emphasized developing novel diagnostic tools (or devices) with higher sensitivity, specificity and present data on the severity of schistosomiasis [20; +3**, 11; +2]. This will enable effective planning, control and elimination of schistosomiasis [36;5, 4; +5] at the community level. These new diagnostic tools should be deployed and used in primary health care facilities (health centers, health posts, clinics, etc.) which are most lacking in equipment [17, +4, 23; +2, 38; -4].

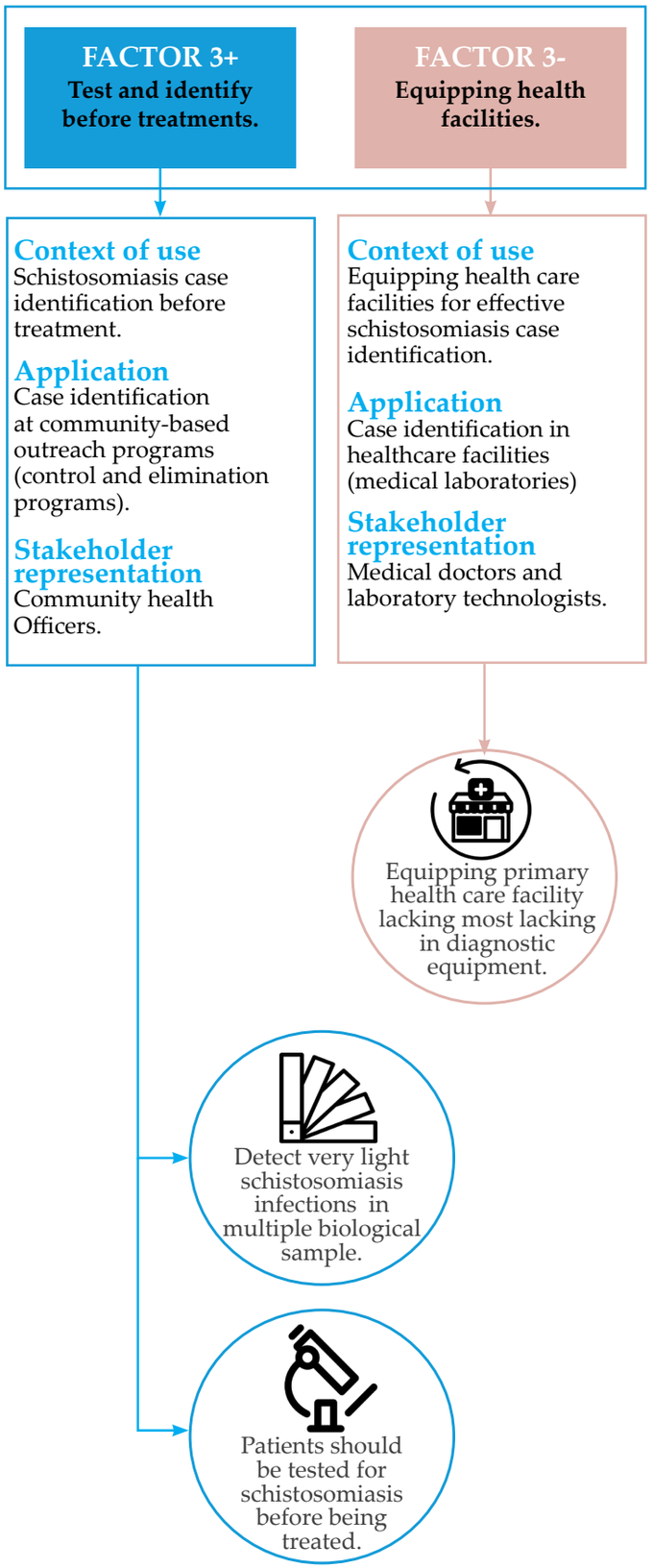


Figure 9. Factor 3 product-service design parameters.

3.3. Factor 3 (F3): Test and identify disease before treatment / Equipping health facilities.

F3 has an EV of 1.65 and explains 6% of the total variance. 4 participants loaded significantly in this bipolar factor. Two in the positive pole (F3+) and two in the negative pole (F3-). All loaders in F3 are representative of the healthcare level. Loaders in F3+ are both CHOs who are interested in new diagnostic device improving the diagnostic process and increase efficiency in targeting the control and elimination of schistosomiasis. Loaders in F3- included a laboratory technician at a private laboratory (private practice) and medical doctor at a tertiary health facility that offers specialized healthcare in the form of community-based outreach.

Respondent in F3+ (see **Figure 8**) strongly emphasize that passive case detection, based on people's self-reporting has been considered a quick and less expensive strategy for the control of schistosomiasis. [12; +6**]. However, they also emphasized that patients should be tested for schistosomiasis before being treated [40; +5, 3; +4, 19; -5] especially during community-based outreach programs. These diagnostic devices (test) should be sensitive and detect very light schistosomiasis infections [26; +5] in multiple biological (urine, blood and stool). The concurrent identification schistosoma parasites in human and water sources could potentially advance the identification schistosomiasis. [25; +3]. F3- respondents did not emphasize the need to test patients for schistosomiasis before treatment [40; -2**] as seen by respondents in F3+. Likewise, F3- respondents did not see need for the concurrent detection of several schistosomiasis in different biological samples such as urine, blood and stool. [25; -3].

Respondents in F3- (see **Figure 9**) focused on equipping primary health care centers, clinics and health posts since they are the most lacking in equipment with new diagnostic devices. [17; +5, 16; +2]. They emphasized diagnostic devices should be compact, portable, locally repaired (or maintained) and have reliable power sources due to the unstable power connectivity in rural and distant communities. [27; +6, 31; +4, 6; +4**]. On the other hand, F3+ respondents were not keen on local repairability and maintenances of new diagnostic devices in case of breakdown. [31; -5**].

F3- respondents admit the use of presenting data on the severity of schistosomiasis infection of specific locations [11; 3]. Such data will guide the development of strategies for effective case management and control elimination. However, respondents in F3+ strongly did not see the need of presenting data on the severity of schistosomiasis infection of specific locations [11; -6].

F3- respondents emphasized village (community) leaders have an important role to play in the role out of new diagnostic device in the community [39; 5]. But on the other hand, raised concerns on training community member with no clinical expertise to detect and diagnose schistosomiasis cases [23; -5] [37; -6**].

3.4. Factor 4 (F4): Diagnostic device that fits the local infrastructure.

F4 has an EV of 1.35 and explains 5% of the total variance. Five participants loaded significantly in this factor. All in the positive pole. The participants consisted of an Neglected Tropical Disease (NTD) officers and medical doctors providing supervisory activities targeting schistosomiasis diagnostics community in multiple LGAs. Also included in F4 was an NTD officer, a CHEW and a CHO (nurse/midwife) stationed at a community healthcare facility in LGAs. F4 respondents are interested identifying schistosomiasis cases with the healthcare facilities and the community. There are interested new diagnostics device improving the diagnostic process.

Respondents in F4 (see **Figure 10**) emphasized availability of rapid or simple point of care diagnostic test which requires only minimal infrastructure in communities, would improve diagnostic coverage and surveillance simultaneously [5; +5, 16; +2]. Such device should not necessarily require a minimal to no sample preparation [21; -5*]. Simple POC devices requiring minimal infrastructure will reduce incorrect diagnostics and treatment caused by unskilled health workers [10; 3**]. Screening using simple or rapid

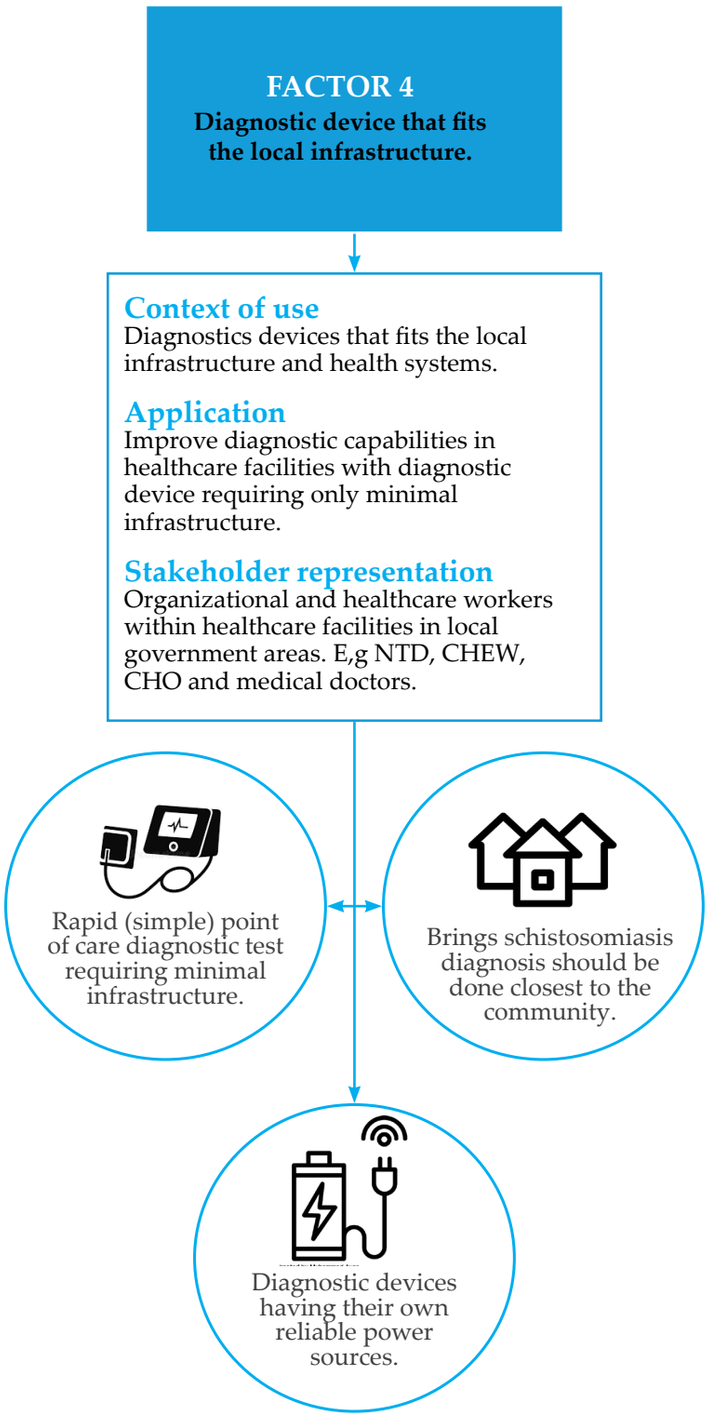


Figure 10. Factor 4 product-service design parameters.

diagnostic device will further enhance the implementation of mass drug administration strategies and improve diagnostic cover beyond school-aged children [3; +5, 16; +2, 9; -6, 18; -5]

F4 respondents believe schistosomiasis diagnosis should be done closest to the community (rural/distant) as it reduces the time to carry samples back to the laboratory [14; +4]. Patient samples can be processed in batches to increase the efficiency of sample processing during mass campaigns or sensitization meetings. [24; +3]. New diagnostic devices deployed in rural and distant community would however require their own reliable power sources [27; +6].

3.5 Validation of results

The aforementioned four factors were qualitatively discussed with 3 healthcare practitioners with experience in the medical, research and practical expertise in schistosomiasis diagnosis in Nigeria. The experts shared their perspective on the four factors but were also allowed to point out viewpoints that did not reflect practices within schistosomiasis diagnostics landscape in Ibadan-Nigeria. Interestingly, all the experts validated the four factors and noted them to be priorities for new diagnostic device for schistosomiasis in Ibadan-Nigeria. All four factors were representative of viewpoints shared within the schistosomiasis diagnostic landscape in Ibadan Nigeria. Most importantly, the experts were able to relate the viewpoints expressed in each factor to the stakeholder representation within that factors. This implied that the stakeholder perspective (viewpoint) on the most relevant context of use and application of a new diagnostic device for schistosomiasis haematobium was greatly associated with the stakeholder's schistosomiasis diagnostic role, task or strategies. Each of the factors expressed was seen as key components that will improve the technical, supervisory and diagnostic process for schistosomiasis haematobium in Ibadan Nigeria.

DISCUSSION & CONCLUSION

Context of use
Support the pragmatic and supervisory parts of schistosomiasis control and elimination in nearby and distant communities.

F1

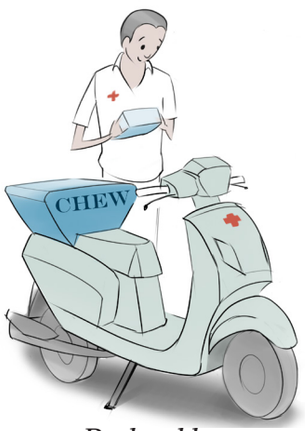
Application
Equipping stakeholders to reach distant communities and gather information about schistosomiasis that is use for program planning or surveillance.

Stakeholder representation
Perform supervisory duties targeting shcistosomiasis diagnosis at the state or local government areas. E.g Donor, NGO, DSNO, researchers, MOH.

Infrastructure/Location
Nearby or distant communities and health facilities.

Product requirement
1. Compact and portable.
2. Transport safely in cars, on motorbikes, and bicycles to remote locations.
3. High sensitivity.
4. Identify and map out areas with a large spread of disease.
5. Quantify eggs and estimate exposed population.
6. Have their own reliable power sources.

Roll out strategy
Leveraging social power of community leaders to creating devices awareness, uptake and sustained use.



Deployable diagnostic device.

Figure 11. Factor 1 - Context of use and application for a new diagnostic devices in Ibandan-Nigeria.

4. Discussion and conclusion

This study explored stakeholder perspective on the context of use and application for a new diagnostic device for schistosomiasis haematobium in Ibadan Nigeria using Q methodology. The study revealed two key findings. Firstly, the study revealed four distinct viewpoints (F1, F2, F3, F4) on the context of use and application of new diagnostic device that is needed to make a first use for the diagnosis of schistosomiasis haematobium in Ibadan-Nigeria. These four viewpoints emphasized the need for new diagnostic devices for schistosomiasis that are: (i) deployable to near and remote communities, (ii) provide affordable diagnostic test at the grassroot or community level (ii) test (diagnose) patients before treatment and equip community healthcare facilities and, (iv) fit the local healthcare infrastructure. Secondly, the study indicates that the context of use and application of a new diagnostic device for schistosomiasis haematobium in Ibadan-Nigeria is largely associated with either the stakeholder task or diagnostic strategies employed.

4.1. The four factors (view points) and their implications.

4.1.1. Factor 1 (F1) - New diagnostic device that is deployable to nearby and remote communities.

Factor 1 showed a need for new diagnostic device for schistosomiasis that is deployable in both nearby and remote communities (See **Figure 11**). This viewpoint in F1 was shared among stakeholder (NGOs, government, program coordinators, health workers and researchers at the state and LGAs) who gather and use information targeting schistosomiasis to enhance decision making and planning. This implies, new diagnostic devices for schistosomiasis that is deployable to nearby and remote communities will support the pragmatic and supervisory parts in schistosomiasis control and elimination. Such pragmatic and supervisory parts include the gathering, mapping, monitoring and using information about schistosomiasis for program surveillance and planning (Utzinger et al., 2015).

Furthermore, new diagnostic device for schistosomiasis that is deployable will create an opportunity for a point-of-care (POC) diagnostics that can detect and confirm schistosomiasis cases in very hard to reach communities (context of use). Studies have showed that hundred million of the world's most vulnerable and disadvantaged people still have limited or no access to healthcare; especially the poorest who live in the most remote and hard to reach communities. (Tchuem Tchuenté et al., 2017). With deployable diagnostics devices, individuals and communities can receive schistosomiasis diagnostics health services irrespective of their location or status. This will ultimately reduce the socio-economic health inequalities and create a universal healthcare coverage (World Health Organization, 2014).

New portable and deployable diagnostic device for schistosomiasis will also require new and innovative product requirement. This implies, product requirement for new deployable diagnostic device will direct and advance the development of new diagnostic devices that match the schistosomiasis diagnostic need to the local healthcare context. (PATH, 2015b; Sluiter et al., 2020). Factor 1 proposes key product requirements for new deployable schistosomiasis diagnostic device in Ibadan-Nigeria. These product requirements include: (i) the ability for a deployable device to be portable and compact, (ii) sensitive for detecting very light schistosomiasis infections, (iii) quantify eggs, (iv) map out areas with a large spread of schistosomiasis and be able to trace the source of the disease, (v) transport safely in cars, on motorbikes, and bicycles to remote locations and, (vi) have their own reliable power source due to the unstable power connectivity in rural and distant communities in South West Nigeria.

Factor 1 and all other factors (F2, F3, F4) also see community leaders and representatives are key influencers to creating awareness and disseminating information about new diagnostic device or method for schistosomiasis. This implies, such high social power possessed by the community leaders and representatives can be leveraged during the roll-out of a new schistosomiasis diagnostic device in Ibadan Nigeria.

Context of use
Provide affordable schistosomiasis test at the healthcare facilities and community at large.

F2

Application
Increase schistosomiaisis diagnostic cover.

Stakeholder representation
Proactive with schistosomiaisis diagnosis in community and demonstrate high social relationship with community members. E.g DSNO, CHO, laboratory technicians and researchers.

Infrastructure/Location
1. Primary health care facilities (health centers, health posts, clinics, etc.)
2. Targeting high-risk group at the community level.

Product requirement
1. Higher sensitivity, specificity.
2. Present data on the severity of schistosomiasis.
2. Deployable.

Roll out strategy
1. Cost per diagnostic test should be free (covered by the Government) or at least less than 1000 Naira (2USD).
2. Capture realtime diagnostic data and that is accessible by to stakeholders to enhance planning.

Affordable diagnostic test

Figure 12. Factor 2 - Context of use and application for a new diagnostic devices in Ibandan -Nigeria.

Context of use
Schistosomiasis case identification before treatment.

F3+

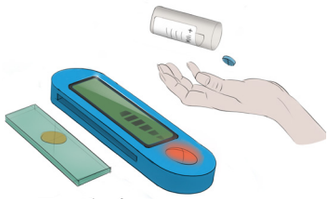
Application
Case identification at community-based outreach programs (control and elimination programs).

Stakeholder representation
Community health Officers.

Infrastructure/Location
Diagnose patient on site (community or healthcare facility) before treatment.

Product requirement
1. Sensitive detect very light infections.
2. Detect schistosomiasis in multiple biological (urine, blood and stool) and water bodies.

Roll out strategy
Test before mass drug administration (MDA)



Test before treatment

Figure 13a. Factor 3+ (Bipolar) - Context of use and application for a new diagnostic devices in Ibandan - Nigeria.

4.1.2. Factor 2 (F2) – Affordable diagnostic test at the grassroot level.

Factor 2 emphasizes the need for an affordable diagnostics test that can support proactive case management and control and elimination programs at the grassroot level (see **Figure 12**). Viewpoints in Factor 2 was shared among stakeholder who perform or support schistosomiasis diagnostics activities at the LGAs. These stakeholders included; healthcare laboratory technicians, CHO, DSNO and researchers. They are proactive within the community and demonstrate high social relationship with the community members. This implies, stakeholders in factor 2 are interested in new diagnostic device improving the diagnostic process and increase efficiency to identifying schistosomiasis case at the grassroot or community level.

Stakeholders associated with Factor 2 emphasize the need for an affordable diagnostic test at the grassroot level. Affordable test will improve diagnostics coverage at the healthcare facilities and community. The cost of diagnostic test still presence a huge challenge especially in low resource setting like Nigeria (Ajibola et al., 2018). Examples of diagnostic test as such immunoblot assays that cost around 3.75USD per test or more have equally been considered not affordable (Abdel-Fattah et al., 2011; Stothard et al., 2014). Likewise affordable test such as Kato Katz, Circulating Cathodic Antigen (CCA) and Schistosoma mansoni Cercarial Transformation Fluid (SmCTF-RDT) test that cost between 1USD to 2USD are however lacking or not commercially available in endemic countries (Adriko et al., 2014; Coulibaly et al., 2013; Hinz et al., 2017). Consequently, Factor 2 respondents emphasize the need for new diagnostic tools which can provide free diagnostic test (financed by the Government/donors) or at least less than 1000 Naira (2USD) per test. Such affordable diagnostic cost implications will allow for more community members to test for schistosomiasis. Also, it will increase diagnostic cover in the communities and improve the ability to identify or confirm infected areas (and patients) in need of treatment, mass drug administration or disease awareness campaigns.

Factor 2 further stresses the need to include product functionality that can capture and present real time data on the severity of schistosomiasis. Research has shown that the usage of IoT-based devices that collects and share real time data can predict factors that are favorable for schistosomiasis transfer (Kassé et al., 2019). This implies, the ability for new diagnostic device to capture and share real-time data will enhance schistosomiasis surveillance (planning and monitoring) and identify populations require continuing interventions. Product requirement for such smart-data capturing devices will however need to be have high specificity and sensitivity to detecting light schistosomiasis cases or areas.

4.1.3. Factor 3 (bipolar factor): Test and diagnose patients before treatment (F3+) / Equip community healthcare facilities (F3-).

Factor 3 being a bipolar factor (F3+ and F3-) emphasize the need to test and identify schistosomiasis presence for administering treatment and on the other hand emphasized the need to equip community healthcare facilities.

Factor 3+ emphasized the need to test and confirm the presence of schistosomiasis before treatment at healthcare facilities and during community-based outreach or control and elimination programs (see **Figure 13a**). Viewpoints in Factor 3+ was shared among Community Health Officers (nurses, midwives, and community health workers) who perform schistosomiasis diagnostics activities such as Mass Drug Administration (MDA) at the LGAs. The national control program for schistosomiasis in most endemic area such as Nigeria comprises of mass drug administration (MDA) using praziquantel (Ross et al., 2015). However, the program has not culminated to morbidity reduction due to factors such as poor drug coverage, infrequent monitoring and evaluation, and rapid reinfection rates (Oyeyemi, n.d.; Ross et al., 2015). This implies that, the development of new diagnostic device that detect schistosomiasis cases before treatment will complement and ensure and effective planning and roll-out MDA strategies. Similarly, testing for presence of schistosomiasis before treatment will identify schistosomiasis cases and areas in need of treatment with praziquantel. Product requirement

Context of use
Equipping health care facilities for effective schistosomiasis case identification.

F3-

Application
Case identification in healthcare facilities (medical laboratories).

Stakeholder representation
Medical doctors and laboratory technologists.

Infrastructure/Location
Primary health facilities most lacking in equipment.

Product requirement
1. Compact and portable,
2. Locally repaired (or maintained).
3. Have their own reliable power source.

Roll out strategy
Leveraging social presence of community health workers and leader as device influencers.

Equipping health facilities

Figure 13b. Factor 3- (Bipolar) - Context of use and application for a new diagnostic devices in Ibandan - Nigeria.

Context of use
Diagnostics devices that fits the local infrastructure and health systems.

F4

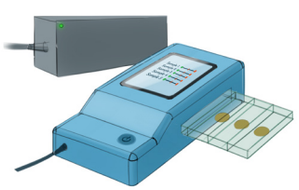
Application
Improve diagnostic capabilities in healthcare facilities with diagnostic device requiring only minimal infrastructure.

Stakeholder representation
Organizational and healthcare workers within healthcare facilities in local government areas. E,g NTD officers, CHEW, CHO and medical doctors.

Infrastructure/Location
Healthcare facilities closest to the community (rural/distant).

Product requirement
1. Process patient samples in batches to increase diagnostics efficiency.
2. Have their own reliable power source.

Roll out strategy
1. Affordable test. Covered by the Government or at least less than 1000 Naira (2USD).
2. Present data on schistosomiasis severity.



Diagnostic device that fits the local infrastructure.

Figure 14. Factor 4 - context of use and application for a new diagnostic devices in Ibandan - Nigeria.

for new diagnostics device that enhance test before treatment will include: (i) diagnostic devices (test) that is sensitive in detecting very light schistosomiasis infections and, (ii) ideally detect schistosomiasis in different biological samples (such as urine, blood and stool) and water bodies.

Secondly, Factor 3- emphasized the need to equip health facilities that are most lacking in equipment (see **Figure 13b**). Viewpoints in Factor 3- was shared among health workers (medical doctors and laboratory technician) within the private and tertiary healthcare facility. Equipping healthcare infrastructures such as health centers, post and clinics closest to the community will increase the ability to effectively identify, manage schistosomiasis cases and improve morbidities (Kaiglova et al., 2017). Besides, equipping health facilities in the local communities will reduce the burden on patients who often travel long distances to access treatment and are unable to return for test results (Mabey et al., 2004). Factor 3- further stresses the need to equip healthcare facilities with new diagnostic devices that are; (i) compact and portable (ii) locally repaired (or maintained) and, (iii) have reliable power sources due to the unstable power connectivity in rural and distant communities. Such product requirement will gurantee a susatained used of new diagnostic devices for schistosomiaisis within the context of Ibadan Nigeria.

4.1.4. Factor 4 (F4): Simple diagnostic device that fits the local healthcare infrastructure.

Factor 4 emphasizes the need for simple diagnostic device or test that fits the local infrastructure (see **Figure 14**). In Nigeria, the use of advance diagnostic device for schistosomiasis such as microscopy and molecular screening methods have been explored(Ajibola et al., 2018). However, the uptake and sustained use of such diagnostic devices or methods have been hampered by infrastructural factors such as; lack of highly skilled manpower to operate the devices, limited supply chain logistics, lack of spare parts and interrupted power supply.(Ajibola et al., 2018; Aryeetey et al., 2013; Ibironke et al., 2011; Mabey et al., 2004). The availability of simple diagnostic devices such as Rapid Diagnostic Test (RDTs), which requires only minimal infrastructure in the context of use, would improve diagnosis and surveillance simultaneously. Viewpoints in Factor 4 was shared among stakeholders at the organizational and healthcare level. This included NTD officers, medical doctors, CHEW and CHO. They are interested in new diagnostics device improving the diagnostic process.

Furthermore, the implication of simple diagnostics device that fit the local healthcare infrastructure will reduce the dependency on highly skilled technologies to operate diagnostic devices that are often limited in the LGAs. Health workers with adequate training on the schistosomiasis diagnostic process will be able to perform diagnostic test with such simple diagnostic devices. Also, the availability of simple diagnostic devices for schistosomiasis that fits the local infrastructure will much improve the ability for diagnosis to be done closest to rural and distant communities. Besides, the availability of simple diagnostic devices closest to the communities will reduce the long-distance travels required by patients to accesses healthcare facilities. It further reduces the time to carry samples back to centralized laboratories for processing as results can be gotten at the point of care. Such simple devices will require to have their own reliable power sources, deployable, capture and share real time data on the severity of schistosomiasis cases and process patient samples in batches especially during mass diagnosis programs.

In the roll out of such simple diagnostic devices requiring only minimal infrastructure, factor 4 emphasize the need for an affordable diagnostic cost. Factor 4 recommends that the cost of schistosomiasis diagnosis should be free (covered by the government/donor) or at least less than 1000 Naira (€2). This will create an incentive for community members to seek diagnostic healthcare service and ultimately increase schistosomiasis diagnostic cover. Likewise, Factor 4 emphasize the need to include real time data collection and sharing features on simple diagnostic device that fit the local healthcare infrastructure. Such data will contribute and improve the stakeholder program planning and continues schistosomiasis surveillance.

4.2. Reflection on the use of Q-methodology study in the field of product-service design.

Q-methodology within this study was used as a co-creative tool to understand different viewpoints (among different stakeholders) on a particular phenomenon. Within this study, they existed different opinions on what is the most relevant context of use and application for a new diagnostic device for schistosomiasis in Ibadan Nigerian. Such different opinions among a multiplicity of stakeholders increased the complexity to pinpoint design factors and parameters needed for the development of a new diagnostic device for schistosomiasis haematobium. Consequently, Q methodology provided the opportunity to capture the different viewpoints (four factors mentioned above) that can direct the product-service development phase for a new diagnostic device for schistosomiasis haematobium in Ibadan Nigeria. It further served as a method to navigate the fuzzy front-end of design process and understand the design opportunities for a new diagnostic device for schistosomiasis.

Other co-creative and exploratory design tools such as context mapping and card sorting could be applied within this study. However, the strength of Q-methodology as applied in this study was centered around understanding design opportunities and future design direction within a topic that is highly subjective (opinionated) among a multiplicity of stakeholders. It further allowed for a systematic and rigorous qualitative - quantitative (statistical analysis) procedures that was scientifically valid and reproduceable. On the downside, Q-methodology is lengthy process. Within this study, three months was spent understanding and gathering viewpoints from different stakeholders and another two months conducting and analyzing the Q sorts. This can be regarded as a lengthy process in design especially when short iterative design sprints are advised during the fuzzy-front end of the design process. Time allocated to completing this design study was therefore a factor considered when selecting Q methodology as the primary research or exploration method.

This study demonstrated the ability to use Q-methodology in the field of product-service design. The use of Q methodology in product-service design served as a new approach to participatory design and exploration especially during fuzzy front end of the design process. The design industry might benefit from using such rigorous and scientific methodology especially in areas where there are high levels of subjectivity around a phenomenon.

4.3. Study reflection and limitations

Q-methodology was selected for this study because of its ability to explore a subjective topic in a more systematic and rigorous manner among small sample size of diverse respondents. Although, a large samples size is not required for a Q methodology study, the findings within this study are not generalized beyond the participant's pool. On the other hand, the factors that emerged from this study might be applicable to other similar settings. Future research should examine the same topic using different qualitative and quantitative techniques to examine the factors that emerged within this study with a much larger sample size.

Secondly, this study was conducted remotely using virtual digital platforms due to COVID-19 travel and in-person bans and restrictions. There qualitative in-person discussion where not possible. In-person qualitative discussion have the potential to evoke spontaneity and reveal latent viewpoints that improves the richness of discussions. However, conducting this study via a digital platform was the best suited means during the heat of COVID-19 outbreak. On the positive side, administering this study via digital platforms meant written instruction and discussions within this study had to be clear and precise. It required much time to prepare such clean and concise instructions and produced a richer material for Q sorting and discussions.

4.4 Conclusion

This study revealed four viewpoints on the context of use and application of a new diagnostic device in Ibadan-Nigeria using a Q-methodology. These 4 factors emphasized the need for new diagnostic device that is needed for the diagnosis of schistosomiasis haematobium in Ibadan-Nigeria will either need to: (i) be deployable to near and remote communities, (ii) provide affordable diagnostic test at the grassroot or community level (ii) test (diagnose) patients before treatment and equip community healthcare facilities and, (iv) fit the local healthcare infrastructure. New device for diagnosing schistosomiasis haematobium still remains an unmet need. The findings in this study will guide the development of new devices for diagnosing schistosomiasis haematobium that fit the local healthcare infrastructure, include certain product requirement that are applicable and can be rolled-out in the context of Ibadan–Nigeria. Similarly, the development of new diagnostic device for schistosomiasis haematobium in Ibadan Nigeria will need to target and improve the stakeholder task or diagnostic strategies employed for schistosomiasis management, control and elimination.

Acknowledgment

This research was supported by INSPiRED project that is funded by the NWO-WOTRO Science for Global Development program, Grant Number W07.30318.009. We thank members of the INSPiRED project who provided invaluable support. We also want to thank Opeyemi Oladunni and Adeola Onasanya for assisting in the coordinating the field research in Nigeria amidst the global COVID-19 pandemic. Similarly, we thank Dr.ir, Jan Carel Diehl and Prof. dr. ir. Van Engelem J.M.L.V who provided coaching and technical guidance on crafting and executing this master thesis. We thank all the respondents who participated in this study.

References

1. Abdel-Fattah, M., Al-Sherbiny, M., Osman, A., Charmy, R., & Tsang, V. (2011). Improving the detection limit of quantitative diagnosis of anti-S. haematobium antibodies using Falcon Assay Screening Test (FAST) ELISA by developing a new standard curve. Parasitology Research, 108(6), 1457–1463. https://doi.org/10.1007/s00436-010-2198-y
2. Adenowo, A. F., Oyinloye, B. E., Ogunyinka, B. I., & Kappo, A. P. (2015). Impact of human schistosomiasis in sub-Saharan Africa. The Brazilian Journal of Infectious Diseases: An Official Publication of the Brazilian Society of Infectious Diseases, 19(2), 196–205. https://doi.org/10.1016/j.bjid.2014.11.004
3. Adriko, M., Standley, C. J., Tinkitina, B., Tukahebwa, E. M., Fenwick, A., Fleming, F. M., Sousa-Figueiredo, J. C., Stothard, J. R., & Kabatereine, N. B. (2014). Evaluation of circulating cathodic antigen (CCA) urine-cassette assay as a survey tool for Schistosoma mansoni in different transmission settings within Bugiri District, Uganda. Acta Tropica, 136, 50–57. https://doi.org/10.1016/j.actatropica.2014.04.001
4. Ajibola, O., Gulumbe, B. H., Eze, A. A., & Obishakin, E. (2018). Tools for Detection of Schistosomiasis in Resource Limited Settings. Medical Sciences, 6(2). https://doi.org/10.3390/medsci6020039
5. Akhtar-Danesh, N., Baumann, A., & Cordingley, L. (2008). Q-methodology in nursing research: A promising method for the study of subjectivity. Western Journal of Nursing Research, 30(6), 759–773. https://doi.org/10.1177/0193945907312979
6. Aryeetey, Y. A., Essien-Baidoo, S., Larbi, I. A., Ahmed, K., Amoah, A. S., Obeng, B. B., Lieshout, L. van, Yazdanbakhsh, M., Boakye, D. A., & Verweij, J. J. (2013). Molecular Diagnosis of Schistosoma Infections in Urine Samples of School Children in Ghana. The American Journal of Tropical Medicine and Hygiene, 88(6), 1028–1031. https://doi.org/10.4269/ajtmh.12-0571

7. Banasick, S. (2019). KADE: A desktop application for Q methodology. Journal of Open Source Software, 4(36), 1360. https://doi.org/10.21105/joss.01360
8. Banasick, S. (2021). Shawnbanasick/easy-htmlq [JavaScript]. https://github.com/shawnbanasick/easy-htmlq (Original work published 2016)
9. Barker, J. H. (2008). Q-methodology: An alternative approach to research in nurse education. Nurse Education Today, 28(8), 917–925. https://doi.org/10.1016/j.nedt.2008.05.010
10. Bassiouny, H. K., Hasab, A. A., El-Nimr, N. A., Al-Shibani, L. A., & Al-Waleedi, A. A. (2014). Rapid diagnosis of schistosomiasis in Yemen using a simple questionnaire and urine reagent strips. Eastern Mediterranean Health Journal = La Revue De Sante De La Mediterranee Orientale = Al-Majallah Al-Sihhiyah Li-Sharq Al-Mutawassit, 20(4), 242–249.
11. Braun-Munzinger, R. A., & Southgate, B. A. (1992). Repeatability and reproducibility of egg counts of Schistosoma haematobium in urine. Tropical Medicine and Parasitology: Official Organ of Deutsche Tropenmedizinische Gesellschaft and of Deutsche Gesellschaft Fur Technische Zusammenarbeit (GTZ), 43(3), 149–154.
12. Brown. (1980). Political Subjectivity: Applications of Q Methodology in Political Science. By Steven R. Brown. (New Haven: Yale University Press, 1980. Pp. xiv + 355. $35.00, cloth; $9.95, paper.). American Political Science Review, 75(3), 737–738.
13. Colley, D. G., Binder, S., Campbell, C., King, C. H., Tchuem Tchuenté, L.-A., N'Goran, E. K., Erko, B., Karanja, D. M. S., Kabatereine, N. B., van Lieshout, L., & Rathbun, S. (2013). A five-country evaluation of a point-of-care circulating cathodic antigen urine assay for the prevalence of Schistosoma mansoni. The American Journal of Tropical Medicine and Hygiene, 88(3), 426–432. https://doi.org/10.4269/ajtmh.12-0639
14. Coulibaly, J. T., N'Goran, E. K., Utzinger, J., Doenhoff, M. J., & Dawson, E. M. (2013). A new rapid diagnostic test for detection of anti-Schistosoma mansoni and anti-Schistosoma haematobium antibodies. Parasites & Vectors, 6(1), 29. https://doi.org/10.1186/1756-3305-6-29
15. Cuppen, E. H. W. J. (2010). Putting Perspectives into Participation: Constructive Conflict Methodology for Problem Structuring in Stakeholder Dialogues. https://research.vu.nl/en/publications/putting-perspectives-into-participation-constructive-conflict-met
16. Damio, S. M. (2016). Q Methodology: An Overview and Steps to Implementation. Asian Journal of University Education, 12(1), 105.
17. Diseases, U. B. S. P. for R. and T. in T., & Group, R. U. S. (1995). Identification of high-risk communities for schistosomiasis in Africa: A multicountry study (TDR/SER/PRS/15. Unpublished). Article TDR/SER/PRS/15. Unpublished. https://apps.who.int/iris/handle/10665/59095
18. El Ridi, R. A. F., & Tallima, H. A.-M. (2013). Novel Therapeutic and Prevention Approaches for Schistosomiasis: Review. Journal of Advanced Research, 4(5), 467–478. https://doi.org/10.1016/j.jare.2012.05.002
19. Exel, J., & Graaf, G. (2005). Q Methodology: A Sneak Preview.
20. Ezeh, C. O., Onyekwelu, K. C., Akinwale, O. P., Shan, L., & Wei, H. (2019). Urinary schistosomiasis in Nigeria: A 50 year review of prevalence, distribution and disease burden. Parasite (Paris, France), 26, 19. https://doi.org/10.1051/parasite/2019020
21. Glinz, D., Silué, K. D., Knopp, S., Lohourignon, L. K., Yao, K. P., Steinmann, P., Rinaldi, L., Cringoli, G., N'Goran, E. K., & Utzinger, J. (2010). Comparing diagnostic accuracy of Kato-Katz, Koga agar plate, ether-concentration, and FLOTAC for Schistosoma mansoni and soil-transmitted helminths. PLoS Neglected Tropical Diseases, 4(7), e754. https://doi.org/10.1371/journal.pntd.0000754
22. Hinz, R., Schwarz, N. G., Hahn, A., & Frickmann, H. (2017). Serological approaches for the diagnosis of schistosomiasis – A review. Molecular and Cellular Probes, 31, 2–21. https://doi.org/10.1016/j.mcp.2016.12.003
23. Hoekstra, P. T., Casacuberta Partal, M., Amoah, A. S., van Lieshout, L., Corstjens, P. L. A. M., Tsonaka, S., Assaré, R. K., Silué, K. D., Meité, A., N'Goran, E. K., N'Gbesso, Y. K., Roestenberg, M., Knopp, S., Utzinger, J., Coulibaly, J. T., & van Dam, G. J. (2018). Repeated doses of Praziquantel in Schistosomiasis Treatment (RePST) – single versus multiple praziquantel treatments in school-aged children in Côte d'Ivoire: A study protocol for an open-label, randomised controlled trial. BMC Infectious Diseases, 18. https://doi.org/10.1186/s12879-018-3554-2
24. Hotez, P. J., Alvarado, M., Basáñez, M.-G., Bolliger, I., Bourne, R., Boussinesq, M., Brooker, S. J., Brown, A. S., Buckle, G., Budke, C. M., Carabin, H., Coffeng, L. E., Fèvre, E. M., Fürst, T., Halasa, Y. A., Jasrasaria, R., Johns, N. E., Keiser, J., King, C. H., … Naghavi, M. (2014). The Global Burden of Disease Study 2010: Interpretation and Implications for the Neglected Tropical Diseases. PLOS Neglected Tropical Diseases, 8(7), e2865. https://doi.org/10.1371/journal.pntd.0002865
25. Howitt, P., Darzi, A., Yang, G., Ashrafian, H., & Wilson, E. (2012). Technologies for global health. The Lancet. https://doi.org/10.1016/S0140-6736(12)61127-1
26. Ibironke, O. A., Phillips, A. E., Garba, A., Lamine, S. M., & Shiff, C. (2011). Diagnosis of Schistosoma haematobium by Detection of Specific DNA Fragments from Filtered Urine Samples. The American Journal of Tropical Medicine and Hygiene, 84(6), 998–1001. https://doi.org/10.4269/ajtmh.2011.10-0691
27. Isere, E. E., Fatiregun, A. A., & Ajayi, I. O. (2015). An overview of disease surveillance and notification system in Nigeria and the roles of clinicians in disease outbreak prevention and control. Nigerian Medical Journal: Journal of the Nigeria Medical Association, 56(3), 161–168. https://doi.org/10.4103/0300-1652.160347
28. Kassé, B., Gueye, B., Diallo, M., Santatra, F., & Elbiaze, H. (2019). IoT based schistosomiasis monitoring for more efficient disease prediction and control model. 1–6.
29. Kline, P. (2014). An easy guide to factor analysis. Routledge.
30. Knopp, S., Salim, N., Schindler, T., Karagiannis Voules, D. A., Rothen, J., Lweno, O., Mohammed, A. S., Singo, R., Benninghoff, M., Nsojo, A. A., Genton, B., & Daubenberger, C. (2014). Diagnostic accuracy of Kato-Katz, FLOTAC, Baermann, and PCR methods for the detection of light-intensity hookworm and Strongyloides stercoralis infections in Tanzania. The American Journal of Tropical Medicine and Hygiene, 90(3), 535–545. https://doi.org/10.4269/ajtmh.13-0268
31. Ladan, M. A., Wharrad, H., & Windle, R. (2019). eHealth adoption and use among healthcare professionals in a tertiary hospital in Sub-Saharan Africa: A Qmethodology study. PeerJ, 7, e6326. https://doi.org/10.7717/peerj.6326
32. Lengeler, C., Utzinger, J., & Tanner, M. (2002). Questionnaires for rapid screening of schistosomiasis in sub-Saharan Africa. Bulletin of the World Health Organization, 80(3), 235–242.
33. LoVerde, P. T. (2019). Schistosomiasis. Advances in Experimental Medicine and Biology, 1154, 45–70. https://doi.org/10.1007/978-3-030-18616-6_3
34. Mabey, D., Peeling, R. W., Ustianowski, A., & Perkins, M. D. (2004). Diagnostics for the developing world. Nature Reviews. Microbiology, 2(3), 231–240. https://doi.org/10.1038/nrmicro841
35. McKeown, B., & Thomas, D. (2013). Q Methodology. SAGE

Publications, Inc. https://doi.org/10.4135/9781483384412
36. Munisi, D. Z., Buza, J., Mpolya, E. A., Angelo, T., & Kinung'hi, S. M. (2017). The Efficacy of Single-Dose versus Double-Dose Praziquantel Treatments on Schistosoma mansoni Infections: Its Implication on Undernutrition and Anaemia among Primary Schoolchildren in Two On-Shore Communities, Northwestern Tanzania. BioMed Research International, 2017, 7035025. https://doi.org/10.1155/2017/7035025
37. Nunnally, J. C., & Bernstein, I. (1978). Psychometric theory. New York: MacGraw-Hill. _ d. Intentar Embellecer Nuestras Ciudades y También Las.
38. Nwobi, B. C., Ogoshi, C. S., Nduka, F., Mayberry, A., Olamiju, F., Mohammed, A., Adamani, W. E., Isiyaku, S., Ngige, E. N., Anagbogu, I. N., & Nebe, O. J. (2017). Epidemiological mapping of schistosomiasis and soil transmitted helminthiasis in 19 states and the federal capital territory (fct), Nigeria. https://doi.org/10.4269/ajtmh.abstract2016
39. Onasanya, A., Keshinro, M., Oladepo, O., Van Engelen, J., & Diehl, J. C. (2020). A Stakeholder Analysis of Schistosomiasis Diagnostic Landscape in South-West Nigeria: Insights for Diagnostics Co-creation. Frontiers in Public Health, 8. https://doi.org/10.3389/fpubh.2020.564381
40. Oyeyemi, O. T. (n.d.). Schistosomiasis Control in Nigeria: Moving Round the Circle? Annals of Global Health, 86(1), 74. https://doi.org/10.5334/aogh.2930
41. Paige, J. B., & Morin, K. H. (2016). Q-Sample Construction: A Critical Step for a Q-Methodological Study. Western Journal of Nursing Research, 38(1), 96–110. https://doi.org/10.1177/0193945914545177
42. PATH. (2015a). Diagnostics for Neglected Tropical Diseases. https://www.path.org/resources/diagnostics-ntd/
43. PATH. (2015b). Target Product Profile: Schistosomiasis Surveillance Diagnostic. https://www.path.org/resources/tpp-schistosomiasis-surveillance-diagnostic/
44. Qurtas, D. S., & Shabila, N. P. (2020). Using Q-methodology to understand the perspectives and practical experiences of dermatologists about treatment difficulties of cutaneous leishmaniasis. BMC Infectious Diseases, 20(1), 645. https://doi.org/10.1186/s12879-020-05365-0
45. Rahma, A., Mardiatno, D., & Rahmawati Hizbaron, D. (2020). Q methodology to determine distinguishing and consensus factors (a case study of university students' ecoliteracy on disaster risk reduction). E3S Web of Conferences, 200, 01003. https://doi.org/10.1051/e3sconf/202020001003
46. Ross, A. G. P., Olveda, R. M., Chy, D., Olveda, D. U., Li, Y., Harn, D. A., Gray, D. J., McManus, D. P., Tallo, V., Chau, T. N. P., & Williams, G. M. (2015). Can Mass Drug Administration Lead to the Sustainable Control of Schistosomiasis? The Journal of Infectious Diseases, 211(2), 283–289. https://doi.org/10.1093/infdis/jiu416
47. Sluiter, M., Onasanya, A., Oladepo, O., van Engelen, J., Keshinro, M., Agbana, T., Van, G.-Y., & Carel Diehl, J. (2020). Target product profiles for devices to diagnose urinary schistosomiasis in Nigeria. 2020 IEEE Global Humanitarian Technology Conference (GHTC), 1–8. https://doi.org/10.1109/GHTC46280.2020.9342953
48. Steinmann, P., Keiser, J., Bos, R., Tanner, M., & Utzinger, J. (2006). Schistosomiasis and water resources development: Systematic review, meta-analysis, and estimates of people at risk. The Lancet. Infectious Diseases, 6(7), 411–425. https://doi.org/10.1016/S1473-3099(06)70521-7
49. Stephenson, W. (1953). The Study of Behavior. Q-Technique and Its Methodology. (First Edition). University of Chicago Press.
50. Stephenson, W. (1980). Consciring: A General Theory for Subjective Communicability. Annals of the International Communication Association, 4(1), 7–36. https://doi.org/10.1080/23808985.1980.11923791
51. Stothard, J. R., Stanton, M. C., Bustinduy, A. L., Sousa-Figueiredo, J. C., Dam, G. J. V., Betson, M., Waterhouse, D., Ward, S., Allan, F., Hassan, A. A., Al-Helal, M. A., Memish, Z. A., & Rollinson, D. (2014). Diagnostics for schistosomiasis in Africa and Arabia: A review of present options in control and future needs for elimination. Parasitology, 141(14), 1947–1961. https://doi.org/10.1017/S0031182014001152
52. Taherdoost, H. (2016). Validity and Reliability of the Research Instrument; How to Test the Validation of a Questionnaire/Survey in a Research. International Journal of Academic Research in Management (IJARM), 5. https://hal.archives-ouvertes.fr/hal-02546799
53. Tchuem Tchuenté, L.-A., Rollinson, D., Stothard, J. R., & Molyneux, D. (2017). Moving from control to elimination of schistosomiasis in sub-Saharan Africa: Time to change and adapt strategies. Infectious Diseases of Poverty, 6(1), 42. https://doi.org/10.1186/s40249-017-0256-8
54. Uchendu, O., Oladoyin, V., Idowu, M., Adeyera, O., Olabisi, O., Oluwatosin, O., & Leigh, G. (2017). Urinary schistosomiasis among vulnerable children in a rehabilitation home in Ibadan, Oyo state, Nigeria. BMC Infectious Diseases, 17(1), 487. https://doi.org/10.1186/s12879-017-2591-6
55. Uniting to Combat NTDs. (2017). 2nd Progress Report: Delivering on Promises and Driving Progress. Uniting to Combat NTDs. https://unitingtocombatntds.org/reports/2nd-report/
56. Utzinger, J., Becker, S. L., van Lieshout, L., van Dam, G. J., & Knopp, S. (2015). New diagnostic tools in schistosomiasis. Clinical Microbiology and Infection: The Official Publication of the European Society of Clinical Microbiology and Infectious Diseases, 21(6), 529–542. https://doi.org/10.1016/j.cmi.2015.03.014
57. Valenta, A. L., & Wigger, U. (1997). Q-methodology. Journal of the American Medical Informatics Association, 4(6), 501–510.
58. van Dam, G. J., de Dood, C. J., Lewis, M., Deelder, A. M., van Lieshout, L., Tanke, H. J., van Rooyen, L. H., & Corstjens, P. L. A. M. (2013). A robust dry reagent lateral flow assay for diagnosis of active schistosomiasis by detection of Schistosoma circulating anodic antigen. Experimental Parasitology, 135(2), 274–282. https://doi.org/10.1016/j.exppara.2013.06.017
59. Van, G.-Y., Onasanya, A., van Engelen, J., Oladepo, O., & Diehl, J. C. (2020). Improving Access to Diagnostics for Schistosomiasis Case Management in Oyo State, Nigeria: Barriers and Opportunities. Diagnostics, 10(5), 328. https://doi.org/10.3390/diagnostics10050328
60. Watts, S., & Stenner, P. (2012). Doing Q Methodological Research: Theory, Method and Interpretation. SAGE Publications Ltd. https://doi.org/10.4135/9781446251911
61. Weerakoon, K. G. A. D., Gobert, G. N., Cai, P., & McManus, D. P. (2015). Advances in the Diagnosis of Human Schistosomiasis. Clinical Microbiology Reviews, 28(4), 939–967. https://doi.org/10.1128/CMR.00137-14
62. WHO. (2003). Malaria Rapid Diagnosis, Making it Work, Informal Consultation on Field Trials and Quality Assurance on Malaria Rapid Diagnostic Tests, 20-23 January 2003: Report [Technical Report]. Manila : WHO Regional Office for the Western Pacific. http://iris.wpro.who.int/handle/10665.1/6070
63. WHO. (2012). Accelerating work to overcome the global impact of neglected tropical diseases: A roadmap for implementation: Executive summary. WorldHealth.https://scholar.googleusercontent.com/scholar.
64. WHO. (2020). Schistosomiasis. https://www.who.int/news-room/fact-sheets/detail/schistosomiasis

65. World Health Organization. (2014). Making fair choices on the path to universal health coverage: Final report of the WHO Consultative Group on Equity and Universal Health Coverage.
66. Zamanzadeh, V., Ghahramanian, A., Rassouli, M., Abbaszadeh, A., Alavi-Majd, H., & Nikanfar, A.-R. (2015). Design and Implementation Content Validity Study: Development of an instrument for measuring Patient-Centered Communication. Journal of Caring Sciences, 4(2), 165–178. https://doi.org/10.15171/jcs.2015.017