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Water quality awareness and barriers to safe water provisioning in informal communities: A case study from Ndola, Zambia

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Abstract. Local water providers in developing nations typically view shallow hand-dug wells as traditional and backward sources of water supply. It has long been assumed that the urban poor do not have the ability to develop these in a way that allows them to be classified as 'improved' in terms of the Millennium Development Goal for water, believing that users do not understand the factors that constitute safe water and the threats to these sources. Our assessment of the level of environmental knowledge held by local water-users in Ndola in Zambia demonstrates a coherent understanding of the safety of their water sources, the quality of these, the threats to them, and the fundamentals of how their local hydrology works, all of which is contrary to the perspective of key informants who are involved in water supply. Despite their environmental awareness, the majority of users did not generally protect their wells from contamination nor treat their water. The apparent paradox between awareness of risks to water and implementing protection of that water source is a function of the complex suite of socially manifested attitudes, habits and behaviours when it comes to water protection and treatment, which is exacerbated by vulnerable community and family structures and entrenched poverty. For meaningful outcomes in improved access to safe water to be realised providers need to increase their engagement with the informal communities, moving deeper into community-based participatory planning and recognise the societal and cultural factors that are entrained into these communities water supply practices. A key part of this involves the need for providers to move away from simple knowledge-based education to the more holistic form of skill-based health education.

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1. Introduction

Informal communities situated at the periphery of urban areas are a common feature of rapidly urbanising populations in Africa (Ballantyne, Oelofse, 1999; Oelofse, 2003; Kimani-Murage, Ngindu, 2007; Binns et al., 2012). These communities are comprised from fragmented populations of migrants, disenfranchised families, and intergenerational urban poor. Given the informal status of these communities there is normally little, or no, formal provision of water and no formal wastewater infrastructure, and as a result, achieving water security in the context of informal supply is a major challenge (Thobani, 1997; Galiani et al., 2005; Smiley, 2013; Kooy, 2014; Misra, 2014). These communities are left to purchase water from small-scale vendors or abstract water from what are frequently unreliable and unsafe surface water or groundwater sources (Kooy, 2014; Misra, 2014), however, these practices have long been seen as small-scale, traditional and backward by the formal sector, and many believe that these practices provide water that is of sub-optimal quality (Misra, 2014). Despite reaching the Millennium Development Goal (MDG) target for safe water in 2012, at an aggregate level globally, 748 million people still lack access to improved water supply across 76 countries, 43% of whom are in sub-Saharan Africa (WHO/UNICEF JMP, 2014). Thus in sub-Saharan Africa there remains a systemic failure to provide a secure source of drinking water and on-going challenges to regional water security. Informal communities dominate the urban areas of these countries, constituting 70% of all residents (UN Habitat, 2003), therefore, specific attention needs to be given to addressing the ability of residents to develop their own improved water sources under informal supply conditions (Kimani-Murage, Ngindu, 2007). Local providers, whether from the formal sector or NGO organisations, have typically assumed that urban poor do not have the ability to develop these improved sources on their own (Tognacci *et al.* 1972; Dunlap, 1975; Van Liere, Dunlap 1978; Preston, Fuggle, 1986; Khan, 1992; Alston, 1993), however, this paper demonstrates there exists a disconnect between these views and the current practices and level of environmental awareness in informal communities, based on the city of Ndola, Zambia (Fig. 1). Developing from this, new prospects for skill-based health education are outlined, providing the opportunity for local providers to help informal communities take their current water sources from unimproved to improved through increasing their knowledge and skill sets, and over the long-term, developing positive attitudes to water protection, and moving towards securing improved and safe access to water.

Ndola is located within the Copperbelt Province of Zambia, where informal communities are widespread (Fig. 1). The Copperbelt Province has had a protracted history of mineral extraction, being naturally rich in copper and cobalt. These mining activities have resulted in the rapid urbanisation of the region, focussing on six cities (Ndola, Luanshya, Kitwe, Mufulira, Chingola, and Chililabombwe) (Fig. 1). However, an economic downturn associated with declining copper prices from the 1980s, along with economic mismanagement, and underfunding, led to regional recession (Fraser, Lungu, 2009; Fallivier *et al.,* 2005). Localised recession and economic uncertainty also contributed to

the collapse and relocation of major manufacturing firms from Ndola and Luanshya (EAZ, 2002; Hampwaye, Rogerson, 2010). The community response to this economic decline was migration to the largest regional centre, with Kitwe now growing into the second largest city in Zambia, and leading to the widespread uptake and expansion of urban agriculture (Hampwaye, Rogerson, 2010).

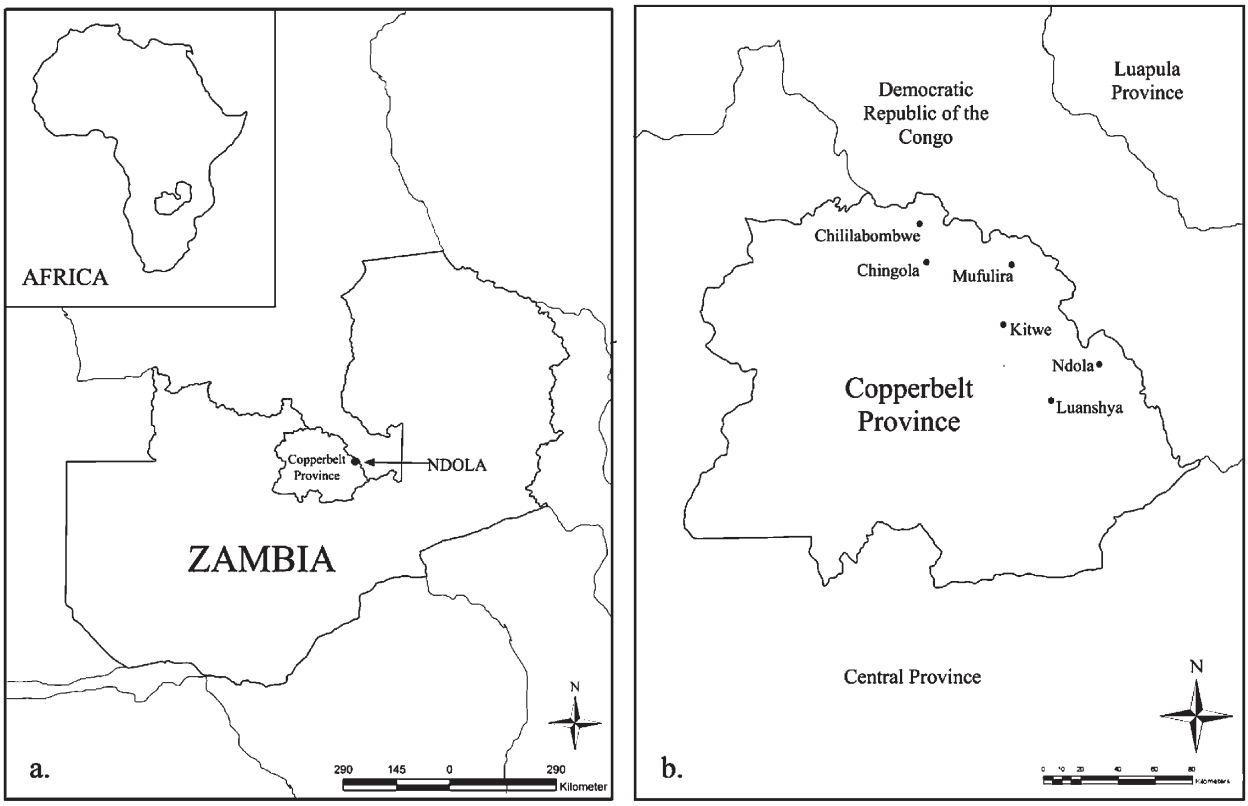

Fig. 1. (a) Location of Zambia in Africa and (b) Layout of the Copperbelt Province including the location of major mining towns

Source: Authors

Informal communities in Ndola are primarily located along the urban periphery and predominantly reside in single-roomed households built from handmade mud bricks and mortar. Each household has etched out a small plot around the dwelling demarcated by fence lines and herbaceous borders and within each plot is a hand-dug shallow well for water supply and a pit latrine. There are no formal, or informal, drainage networks so that during the rainy season (November to April), excess overland flow washes into unprotected wells. Given the small size of the plots shallow wells are frequently less than 20 m. from pit latrines. Thus, these communities face challenges of protecting water supplies from faecal contamination from both surface and subsurface flow (Bedient et al., 1994; Morris *et al.,* 2003; Nachiyunde et al., 2013).

Adjacent to these communities are riparian strips, which are usually planted in peri-urban agriculture and irrigated by border dykes or, in some instances, directly sustained by the natural wetland conditions within the riparian zone. Many of the urban waterways are potentially compromised by unregulated dumping of waste, the legacy effects of unregulated pollution associated with manufacturing and mining, non-point source pollution from the urban environment, and washing and bathing (Petterson, Ingri, 2000, 2001; Czech Geological Survey, 2003; Kambole, 2003; Morris et al., 2003; von der Heyden, New, 2004; World Bank, 2009; Nachiyunde et al., 2013; Nyamber et al., no date). The environmental degradation of the Copperbelt is poorly quantified due to limited temporal and spatial geochemical data from both pristine and polluted are-

as. Recent work has highlighted concern with heavy metal enrichment in soils associated with the metal smelting areas of the region (Ettler et al., 2012), and potential anthropogenic or geogenic pollution of groundwater from tailing impoundments, residue heaps and high-density informal settlements (von der Heyden, New, 2004). However, the potential for heavy metal pollution as a direct consequence of mining activity is considered low in the Copperbelt due to the natural buffering and mineral retention of the carbonate-rich substrate, and doping of mine drainage with lime (Sracek et al., 2012).

It is against the historical backdrop of rapid urbanisation, and subsequent economic collapse with the decline in manufacture and mining, that the informal communities of Ndola have evolved, and that the challenges to water security are a manifestation of little, or no, investment in water infrastructure since colonisation. Urban water supply in Zambia falls under a series of management contracts held between local authorities and commercial companies (Dagdeviren, 2008), these having evolved as a result of the neoliberal reform that swept through developing nations in the 1990s as privatisation was seen as the solution for addressing the world's water problems (Rivera, 1996; Parker, Kirkpatrick, 2005; Hall, Lobina, 2006; Tecco, 2008; Bakker, 2010). For Zambia, commercialisation was used as a surrogate for privatisation, a common theme throughout developing nations, as multinational companies could not guarantee a return on investment (Dagdeviren, 2008). The Kafubu Water and Sewage Company (KWSC) assumed the responsibility for water supply in Ndola in 2000 as a direct result (Dagdeviren, Robertson, 2008). Today, however, formal supply through KSWC remains low as only 7% of the population is connected to the piped network, and while water kiosks have been established in 11 of the un-piped communities, purchase levels are low, partly due to cost (20 litre containers for KR50 (US$0.10)), and partly due to the perception of poor quality, with reports of kiosk water being green and smelly (Liddle *et al.,* 2014). Communities supply their own water, the majority from shallow hand dug wells, and while the formal sectors involvement within these practices is non-existent, NGO organisations are involved, to some degree, through education outreach and the provision of bacteriological decontamination solutions (e.g. bio-sand filters, UV treatment, chemical treatment) (Liddle et al., 2014).

This study sought to investigate some of the social dimensions to water security in these communities, in particular, how local providers and local users perceive water provision and quality in Ndola, and how local providers view local users ability to source improved water. Local water users in informal communities were asked whether they perceive their sources of water as safe, how they assess this, how the water in their shallow well got there, and who they perceive as being responsible for water provisioning. To understand these local issues in detail, we also interviewed key informants, otherwise referred to as local providers, these being people involved either directly or peripherally in water provisioning to these communities, to assess their perceptions of the challenges to water security for these communities – asking them the same questions, only these were answered for how they saw informal communities – i.e. did they think that users understand what safe water is and the potential threats to this? The perspectives of both users and key informants were then compared to assess whether these aligned (or otherwise) in terms the local understandings of what constitutes safe water within informal communities.

2. Data collection

Key informants in water provisioning were interviewed in English through an open-ended question format and their responses recorded and transcribed. Key informants were identified using a snowball approach, where key informants involved in water provision were identified by their role in NGOs, commercial installation of boreholes, or local body authorities. In total nine key informants in water provisioning were interviewed, and while 55% were NGO employees, these were spread across three different NGOs. Participants were asked a series of open-ended questions, with follow-up questions where appropriate. Interviews with the local water-users were undertaken in the local language, Bemba and carefully translated by an indigenous speaker and transcribed to English. Participants were asked a series of open-ended questions, with

follow-up questions where appropriate. Water users were randomly selected during a parallel study of the physical state of shallow well water quality in different informal communities around Ndola, including Baluba, Kaniki, Mapalo, Nkwazi, Kantolomba, Maria Chimona, MacKenzie and Ndeke. Twenty water users from across these communities were interviewed in detail. Interview data was transcribed and key themes allowed to emerge.

These interviews were based solely on people's perceptions, and while this is typically seen to be a bias within studies, in this case, it was the aim – to understand how key informants perceive water users ability to comprehend what safe water is, and then to understand how water users actually do perceive this. Visiting multiple communities removed the risk of potential bias of only interviewing any one community. In parallel, interviewing people from across different NGOs and organisations within the city similarly reduced the risk of bias. From a reader's perspective, it must be realised that all conclusions made are based on key informant and users opinions. Based on the fact that the researchers were foreign females, there was the possibility that participants may have been reserved in wanting to participate and to be honest in their responses. The involvement of the local field assistant is believed to have aided in reducing this limitation. Although also a female, she is well educated, and respected by the local people.

3. Results

3.1. Key informants perception of water quality in Ndola and their perspective on local users water quality awareness

All of the nine key informants interviewed identified bacteriological contamination to be a major problem in Ndola, all stated that this is the most immediate water related health risk in the city. Additionally, key informants understood the potential risks associated with dissolved contaminants, recognising the potential for metal contamination as a function of local mining practices. Concern was mainly attributed to surface waters, these being highly contaminated with both bacteria, originating from human and animal waste, and heavy metals as rivers run through contaminated mining soils and tailing dumps. Regarding the use of shallow wells in informal communities, key informants saw these as unacceptable sources, one arguing that "every shallow well in the region is severely polluted" (Key Informant #5), a perspective that lies in stark contrast to the geochemical assessment of water quality of shallow wells undertaken within Ndola (Liddle et al., 2014). The validity of this statement is controversial, and highlights the perspective of water suppliers' about the inadequacy of shallow wells in providing safe water. This comment, amongst others, originates from the understanding of surface water – groundwater interactions among the key informants. Key informants understood the risks of subsurface horizontal movement of contaminants from nearby pit latrines, as the size of properties in these informal communities has restricted the distance between wells and pit latrines. Deep boreholes were, therefore, seen as the only option for safe water supply in Ndola as key informants agreed that these are protected from surface water interactions, although iron contamination, either from natural sources or from poorly constructed wells, was identified as a potential problem.

Acknowledging the potential for mining contamination, key informants recognised that there were water quality risks that could not be assessed by visual, odour or taste assessments and that these risks could only be established through chemical testing. Based on this assumption, most key informants argued that water could not be assumed safe in Ndola unless treated. When asked what the safest source of water is for locals, one key informant responded, "anything that is chlorinated" (Key Informant #2), while another stated that, if people don't filter it [their water], well it's their own fault, they deserve to die, it's as simple as that…if people want to play around with their lives, sure, but me, I've never fancied much with Russian Roulette" (Key Informant #4).

While key informants understood the wide range of potential threats to water in Ndola and the need to treat water, it became clear though the interview process that they do not believe that local users have the same level of understanding. In fact, most key informants stated that users possess no

knowledge as to true water quality and users simply assess quality based on colour, odour, and immediate illness. Furthermore, key informants argued that users within informal communities do not understand surface - groundwater processes, and possess no knowledge of how water ended up underground in the first instance. Key informants were very opinionated in these areas and the magnitude of their opinions is shown in Table 1. One key informant raised the issue of rural – urban migration in this and the role that cultural practices play in their water use habits. Referring to users lack of surface water use, it was argued that this was not a function of believing that these sources were unsafe, as would be assumed, but rather a function of cultural decency, users not drinking from these sources as someone may be taking a bath upstream, hence out of respect you do not use these sources. According to Key Informant #1, this has "nothing to do with bacteria or mining." While all key informants believed that local Ndola users do not acknowledge mining as a problem, an interesting point was raised by one who had recently worked in Solwezi, an intensive mining town. Local users in Solwezi were aware of mining issues, however, they saw these contaminants to be minerals, hence, believed they were drinking 'mineral water', and did not identify the potential risks to human health through metal toxicity.

Table 1. Examples of Local water users understanding of water quality and groundwater processes from the perspective of key informants in Ndola

"Most residents have no idea about the quality of their water unless they can either see or taste that is it not suitable for drinking. Often the first indication of poor water quality is diarrhoea or vomiting" (Key Informant #5).
"The average person doesn't think of things [contamination] like that. They want water. As far as they are concerned they are pumping it from underground, it is underground there can be *no* contamination, it is underground. They do not think of how that water got there in the first place. They pump it up, goes into their tank and then into their house" (Key Informant #4).
"Some people have sunk boreholes, and when they were sinking them they did not [think] about where they were sinking - many [are] very close to the sewer systems and then they have problems. [They say], 'Oh the water is supposed to be safe from boreholes, how come we are getting this stomach problem?'" (Key Informant #7).
"If it is cold it is good. The fact that it has coliform organisms in it, or lead or cobalt certainly doesn't enter the equation. They [local users] do not link mining and groundwater contamination…they don't even think about all the dog urine and faeces round the well" (Key Informant #4).
"They [local users] have no idea [about water quality] other than the colour of the water" (Key Informant #6).

Source: Authors

Key informants continued to disregard the fact that local users possessed any knowledge when referring to their ability to locate pit latrines in relation to their wells, asserting that local users do not understand the threat of these to their wells due to subsurface horizontal movement of contaminants. Key Informant #9 simple stated, "they [local users] don't know where to put their latrine and the hand dug well." However, as stated by one key informant, this may not be a case of a lack of knowledge, but rather a space issue, as "in the rural villages most groundwater water is free from *e. coli* – there are no pollution sources, they site their wells further from their pit latrines than [they do] in urban [areas]. But in urban they do not have enough room to do this" (Key Informant #3). Key informants further disregarded local users when it came to well protection and water treatment. It was widely agreed that locals are simply 'lazy' in regards to protection and treatment and that they have the resources to protect their wells and in many cases treat their water, yet many users do not follow through with these practices. For example, one NGO we interviewed provides bio-sand filters for water treatment, however, on returning to the communities, they often find that locals no longer use their filters. When asked whether they are using their filters, users responded with, 'no we just drink [from the well].

To the follow up question of, 'have you been getting sick', users respond, 'yes, yes, but I was busy, I sell at the market, so no one at [is] home [to use the filter]' (Key Informant #9).

3.2. Users' perception of water quality and their water quality awareness

In light of the lack of formal supply in the informal communities of Ndola, water users have come to understand that they are responsible for providing their own water. When asked whose responsibility it is to provide safe drinking water, most [95%] users believed that it was ultimately the council's responsibility, although they recognised that the ultimate responsibility was their own: "it is the council's responsibility to provide water, but when it's not coming, it's your responsibility" (Water-User #20). Another responded similarly, remarking that, "I'd be dead waiting for [the council to provide] water, so it's my responsibility" (Water-User #20). Such pragmatism underlines the water provisioning in these communities, where shallow wells now dominate supply, all twenty users that we interviewed being dependent on this type of source. These practices are culturally embedded within society, having stemmed from rural practices (Key-Informant #1), and today, water users in Ndola are successfully able to meet their water needs on a daily basis, without assistance from the formal sector.

Within these techniques of supply, local water users across Ndola showed a relatively coherent understanding of the safety of their water sources, the quality of these, the threats to them, and the fundamentals behind how their local hydrology works, all of these findings being contrary to the key informants views. For the majority of water users (90%), shallow wells were their only source of water, however, within this, users were well aware that their shallow wells may not be safe sources of water, yet, as stated by Water-User #2 "we drink it [shallow well water] because we have no other choice." For those who do have access to alternatives, these opportunities have been taken, for example, 10% of respondents now rely on either boreholes or municipal supply for their drinking water needs.

When asked what they understood water quality to mean, all respondents understood safe drinking water to be clean from bacteriological contamination. Users understood that "leaves and other particles [can] fall into the well making it easy for bacteria to breed" (Water-User #1). Users also held contamination concern as neighbours are able to throw things into their wells, for example, one user also lamented that the well was close to the edge of the property so that anyone could "throw anything in there at night, or poison us, and you would not know" (Water-User #3). An awareness of the threat of their pit latrines to the quality of their well water was also evident, one user stating that, "the pit latrine is near the well making it possible for water underground to mix" (Water-User #1), while another further reiterated this finding, stating that, "the pit latrines in our community are sometimes dug near the wells. This made us concerned that our water is being contaminated with human waste… when the pit latrine is full the water flows into the well, and the water underground is able to interact between the well and the pit latrines" (Water-User #4). Users understood subsurface flow and recognised that contaminants could migrate flow from the pit latrines to their shallow wells, however, users lamented that since their plots of land were so small, and that their neighbours were so close, there was little they could do to ameliorate that risk.

An understanding of subsurface flow continued to appear as users were asked how the water got into their wells, further contradicting the key informants' perceptions of users knowledge. All twenty respondents knew that the water in the well was stored underground, some of whom expanded on this, understanding how the water got there in the first place. For example, one user stated that "[the] water comes from a river under [ground]" (Water-User #20), while another stated that "after rainfall the water sinks into the ground" (Water-User #3). Users further understood the basic principles of hydrology in relation to overland flow and the need to "build a ridge around the well to protect it from dirty water that might flow in it" (Water-User #3). However, while 65% of respondents understood to need to either build a ridge or cover their wells, only 15% had any form of well opening protection. When asked why there was little follow through, impediments were seen as primarily financial "some [people] don't manage to cover wells because of money" (Water-User #2), and an-

other elderly respondent answered, "I know that it should be covered, but I have six grandchildren and all my children are dead, who is there to help me?" (Water-User #1).

As identified by the key informants, users had no concept of dissolved contaminants being a potential threat to water quality. When characterising what good water is, the responses fell around the themes of "no smell", "it's not thick [with sediment]" or "no colour" with some respondents commenting, "it has no taste". The presence of insects was seen as a potential threat to water quality, one users stating that "in the rainy season there are some insects, so we think it's not good . . . insects that fly about the well also get in" (Water-User #20). To this end, 90% of respondents understood the need to treat their water, through either chloride, UV or bio-sand filter methods. Knowledge of success through treatment was abundant (Table 2), however, uptake in actually doing so was not consistent as only 50% of those who knew about the need for treatment actually followed through on with this on a regular basis.

Table 2. Local water users understanding of the need to treat their shallow well water

"When we use the filters and sunlight to treat our water for drinking we reduce the occurrence of diarrhoea and other water borne diseases" (Water-User #7).
"The taste is different because water direct from the river and the well feels thicker in the mouth than the water from the filters which is has a unique, better and lighter taste" (Water-User #7).
"The water is safe for drinking because we use filters" (Water-User #6).
"The taste is very different. Water from the filter has a unique and better taste than water from the well" (Water-User #10).
"We use chloride to kill those white insects, we know its dead when it doesn't walk on the water anymore" (Water-User #20).
"[Filtering water] gets rid of particles in the water, this improves the taste and appearance" (Water-User #8).
"We add chlorine or boil our water before drinking to remove germs" (Water-User #9).
Water from the well has bacteria, before we use as drinking water we have to add chlorine (Water-User #1).
We draw water and add chlorine before use, which improves the taste (Water-User #3).

Source: Authors

4. Ensuring safe water access in the informal communities of developing nations

Past research has suggested that an understanding of environmental processes, and therefore a strong awareness of environmental problems, is positively correlated with socio-economic variables (Tognacci *et al.*, 1972; Dunlap, 1975; Van Liere, Dunlap 1978; Preston, Fuggle, 1986; Khan, 1992; Alston, 1993). In the case of this study it could be assumed that as education and wealth decrease, so will users knowledge of hydrological processes and the risk of contamination of their water sources. While local providers tended to support this assertion, we challenge this perspective, asserting that users within the informal communities of Ndola do in fact understand the hydrological processes that determine the quality of water in their wells, and also those that pose a threat to the quality of this water. However, while users possess knowledge, practical follow through implementation with regards to protecting their wells and treating their water on a regular basis was limited. Eighty-five per cent of those who knew about the need for well protection did not follow through with this, while 50% of those who knew about the need for water treatment also did not follow through. Local providers recognised this and attributed this lack of follow through to be 'laziness', however, we argue that this lack of protection and treatment is actually a factor that has been created by the disconnected perspectives between local providers and local users.

General 'laziness' alone does not adequately explain the lack of implementation of water source protection. Rather, this is a function of a complex suite of socially manifested attitudes, habits and behaviours when it comes to water protection and treatment that is exacerbated by vulnerable com-

munity and family structures and entrenched poverty. For example, men are typically responsible for digging and protecting wells in these communities, however, it is the men who are also often out earning an income for the family every day, hence preoccupied, or in some extreme cases, grandmothers have become the head of the household, left to look after children who have been orphaned due to HIV/AIDS. In these cases, grandmothers are simply physically and financially unable to protect their wells, this being further demonstrated through the lives of widows. Based on discussions with local people the severity of the financial impediments are greatly exacerbated in these cases, this being a function of the cultural practices that surround the death of a husband. When a husband dies, it is normal within the Zambian culture for his family to take everything from the wife as it is believed that they own her possessions, based on the dowry that the husband's family originally paid to the wife's family at the time of engagement (Key-Informant #1). Widows are therefore pushed into a spiral of poverty, lacking not only the financial resources needed to protect their wells, but also the physical strength that leads to men being responsible for this task. We would typically assume that at this point the local community would come together and support one another, helping these young women and grandmothers, however, there appears to be a lack of support for one another in these communities, a further factor in the complex suite of socially manifested attitudes, one key informant describing the jealousy that she has seen among households within the same community (Key-Informant #8). Simply put, if one family starts to succeed, others immediately tear them down, potentially contributing to water-users fear of their neighbours poisoning their wells if they increase the protection surrounding them.

Local providers have long believed that users need to be educated if well protection and treatment practices are to change and, as a result, past and current programmes have been based on providing knowledge and equipment. However, in light of the previously explained complex suite of socially manifested attitudes, habits and behaviours, users no longer simply need knowledge, they need long-term attitude changes. While the NGOs in Ndola believe that they are connecting with the informal communities in a meaningful way, the disconnectedness of perspectives that we found suggests otherwise. We, therefore, argue for better collaborative management of water security in informal communities that focuses on skill-based health education, with community-based participatory planning and involvement as the foundation.

Differing from traditional health education – which solely delivers knowledge – skill-based health education adds the new focuses of equipping locals with skills and working on generational attitude changes (WHO, 2003). All three of these aspects are important in any water awareness programme, as without all three, community follow-through will be limited, as is the case currently in Ndola. Firstly, in relation to water education, knowledge provides the necessary understanding of hydrological processes and the potential for contamination of water sources (WHO, 2003). Part of this education needs to be focused on the negative consequences of not protecting and treating water in order to motivate users to actually follow through for the benefit of their families' health (WHO, 2003). Secondly, water education must encourage a change in users' attitudes, encouraging them to view water protection and treatment as important and extremely valuable chores within their daily life. Attitudes originate as a function of personal biases, preferences and subjective assessments and these lead to users acting in certain ways, for example, protecting or not protecting their wells (WHO, 2003). Attitudes are typically engrained within individuals from an early age, hence behavioural change is extremely challenging (Curtis et al., 2009; Mosler, 2012), however, this must be addressed if users practices are to improve as knowledge is void if it is not accompanied by a positive attitude towards practical implementation. Lastly, skills are required to practically follow though, where education must enable people to carry out specific behaviours that their newly acquired attitude values (WHO, 2003).

Local providers work in Ndola has to date been too focused on the knowledge aspect of this, increasing users awareness of the need to protect their wells and treat their water, and providing resources for this, however, knowledge alone does not lead to behavioural change. Local providers work must now move towards skill-based health education, providing environments where positive attitudes and skills are developed, working towards

voluntary behaviour changes within informal communities (WHO, 2003; O'Reilly *et al.,* 2008; Mosler, 2012). Local providers must engage with water users at a deeper level, and not simply malign the users' failure to treat or improve their water sources as simply a function of laziness, and design practical skill-based health education around their current needs. The following text will provide the practical examples for how the current water awareness programmes in the city have contributed to the lack of follow though, namely due to the education not being directed towards both males and females. Any future skill-based health education needs to be implemented through participatory planning, where the current flaws of the water awareness education system, hence the water protection and treatment behaviours that need to change, will not be known unless local knowledge is assessed and acknowledged (WHO, 2003; Mosler, 2012). Community involvement through participatory planning will ensure that the current disconnect between what the key informants think users need, and what users actually need, will be avoided (Chambers, 1983; Ballantyne, Oelofse, 1999).

One aspect of the cultural construct of the informal communities in Ndola that recognition must be given to the role of gender in water provision. Current NGO water awareness education targets women, however, we found this to be key deterrent in transferring knowledge to practice in these communities. Gender roles are socially embedded throughout sub-Saharan Africa where women typically play the reproductive role, being responsible for household tasks, family health and the provision of water (Barrett, Browne, 1995; Rathgeber, 1996; Taylor, 2009). The need to educate women in these areas has been well known since the 1970s when the women in development approach was founded, this being associated with the UN Women's Decade (1976-1985) (Barrett, Browne, 1995; Taylor, 2009) and as a result, local NGOs in Ndola have specifically targeted women in their water awareness education. The women in Ndola now display a comprehensive understanding of the need to protect their water sources to improve household hygiene and sanitation, this being a common theme across sub-Saharan Africa (Rathgeber, 1996). However, while women understood this, their wells remained unprotected, as water awareness education has failed to recognise and acknowledge the gender specific roles that males also play in water provision, whereby men are solely responsible for digging the wells and protecting wells, as previously explained. Women receive the knowledge, yet the men also need this knowledge and an attitude that values the need for protection if follow through is to occur in these informal communities, particularly since the construction of raised well openings (in conjunction with a cover) is the most effective at reducing contamination risk (Liddle *et al.,* 2014). Constructing a raised well barrier requires access to bricks, mortar or concrete and requires investment of time (primarily by men), and money to purchase the construction materials. If male members of the community are not a part of the education programmes for water protection, these strategies are effectively lost from the narrative around water security. This is further the case with water treatment where it is women who are the focus of education outreach, yet it is the men who typically work and who are in control of the household finances needed to purchase treatment supplies. It is well recognised that males distribution of finances in sub-Saharan Africa is challenging (Rathgeber, 1996; Peter, 2006; Taylor, 2009), and men need to be included in any future skill-based health education if their attitude towards water protection and treatment, and the need to spend money on this, is to change. The need to identify and act upon gender roles in communities provides just one example of how participatory planning must be part of future water awareness education as it will allow local providers to gain a coherent understanding of the societal and cultural structure, and the issues that need to be accounted for in the design of future programmes (Chambers, 1983; Ballantyne, Oelofse, 1999).

Future skill-based health education must not be limited to adults but rather also invest in school, community or church-based learning for children and must become the long-term strategy for delivering the knowledge and skills needed for water protection and treatment, as well as for fostering the positive attitudes that need to become an integral part of society. Changing attitudes and resultant habits and behaviours must be the foundation of any education that is looking for follow through (Mosler, 2012), and children provide the perfect

channel for this as these three aspects begin to develop at a very young age (Scott et al., 2007; Curtis et al., 2009; Mosler, 2012). While behavioural change in adults is difficult, children are responsive to changes; hence they must be viewed as being ready, reachable and the most important target in skill-based health education (Alibhai, Ahmed, 2001; Tobin, van Koppen, 2005; O'Reilly et al., 2008). Furthermore, children already play a vital role in helping their mothers collect water (Barrett, Browne, 1995), and the need to entrain these good habits in them from a young age, both for girls and boys.

Focusing on the formal school situation as an example, the current curriculum in Zambia is lacking vital hygiene and sanitation education, as one key informant stated, that "the school curriculum needs to include a specific health and hygiene segment designed to illustrate the need of proper water and sanitation practices including hand-washing, proper cooking procedures and waste management" (Key Informant #5). In light of this, school skill-based health education must become part of the school curriculum and this education must be based on participation if children are to develop a sense of responsibility around water protection and treatment (Hart, 1997). Having developed a sense of responsibility, children are then able to transfer this into their home lives, enabling them to make positive decisions and provide the motivation needed in households for well protection and water treatment (WHO, 2003). Skill-based health education in schools must replicate the natural learning patterns of children, hence teachers need to firstly model well protection and water treatment-allowing the children to observe this, and then practice it themselves on a daily basis at school (WHO, 2003). Simply listening to a teacher describe the need to protect and treat water will not lead to a change in the attitudes and ability to follow through at home for these children, rather children need to learn by doing (Wilson *et al.,* 1992; Tobler, 1998; WHO, 2003). The positive habits that need to be formed in these children will only be cultivated by continual repetition of the desired behaviour (Mosler, 2012).

Through this participation, children have the ability to act as catalysts in promoting environmental awareness and action in their own families (Hart, 1997). For example, a study the viability of school run hygiene and sanitation skill-based education found that students were highly receptive when learning about the need to treat water, with 99% of children being able to articulate the need to treat water (using the provided Water Guard technology) while 56% of children had then taken these practices home and taught their parents (O'Reilly et al., 2008). As a result, 'Water Guard' awareness among parents increased from 79% to 91% as a result of children's learning and subsequent influence, while actual use increased from 25% to 46% (O'Reilly et al., 2008). Furthermore, 17% of children had taught their friends from other schools these practices (O'Reilly *et al.,* 2008). Above all, in any school based education attempt, it must be ensured that school becomes a safe and secure place for children that aids their learning and their ability to practice and master their skills, they will then feel confident in taking these skills home and teaching their parents (CARICOM & UNICEF, 1999; WHO, 2003). This example shows the power of equipping children with skill-based health education, however, this must not be limited or contained simply within the school curriculum, but rather NGOs, community groups and church groups must also be involved at a community grassroots level if this is to reach the children within informal communities who do not attend school.

Having used the lack of well protection and water treatment in Ndola as an example, this paper has highlighted the importance in breaking down constructed knowledge barriers between providers and communities in any natural resource development scheme. When there exists disconnectedness in perceived failures between users and providers there is limited potential to alleviate poverty, no matter how intensive the effort. In any development undertaking, community management must be at the forefront, following the theory of participatory planning, also known as bottom-up development (Chambers, 1983). Communities must be involved in the planning, design, and implementation (Head, 2007), and providers must understand the societal structure and hence the social and cultural issues that will need to be accounted for in the design of any project (Chambers, 1983; Webb, 1991), for example the gender roles found in Ndola. Children must be central to this if generational attitude changes are to be achieved (Alibhai, Ahmed, 2001; Tobin, van Koppen, 2005; O'Reilly *et al.,* 2008).

Local communities have a readiness and willingness to experiment and innovate on their own, and this must be included in any project design (Chambers, 1983) and through their inclusion, a sense of ownership will develop, this being crucial in increasing community motivation for participation and follow through (Binns et al., 2012). Furthermore, communities that collaboratively improve their water mitigate the risk of jealously or dysfunction that exists between households, a crucial aspect noted within our case study in Ndola.

5. Conclusion

Water users within the informal communities in the city of Ndola understand the hydrological processes that affect their shallow wells and the potential contamination risks associated with these processes including pollution from overland runoff and nearby pit latrines. As a result, users understand the need to protect their wells and treat their water, although the practical implementation in protecting and treating water sources is limited. While the local providers have used this lack of follow through to argue that users do not possess any water quality or hydrological knowledge, we claim that a lack of knowledge is not the issue but that rather it is a function of the mal-alignment of perspectives between the local providers and the local users. While providers continue to want to educate women, we argue that a greater emphasis needs to be placed on community-based participatory programmes, namely skill-based health education, coupling the current knowledge based education with skills and long-term attitude changes among the local users, both female and male. We argue that the attitudinal aspect of skill-based health education is the core component which is currently missing in local providers work within Ndola, and that this is a key factor in the failure to actualise well protection and water treatment knowledge in users daily lives. Attitude change, and habitat and behavioural changes, is a gradual and dynamic process, one that occurs in stages over time (Lauby et al., 1998; Thevos et al., 2000; O'Reilly et al., 2008), hence local providers must begin to incorporate this, especially within school programmes if long-term improvements are desired within the informal communities. Within this skill-based health education the societal and cultural structure of informal communities must be recognised and allowed for, in particular the differing gender roles within household water provision and lack of community support for each other, factors that have not been allowed for in Ndola. For example, men hold the power to protect wells and purchase treatment supply and it is crucial that they are included in any future education if their attitudes towards helping in this area are to change. Furthermore, and above the need to include men in education, is the need to develop a new level of community co-operation, removing competition, dysfunction or mistrust between community members (WHO, 2003). Any future approach to improving water security in informal communities in sub-Saharan Africa must strive to address the implicit gender roles in water protection, and move beyond considering the engendered roles of water collection. In particular, it must be recognised that the disenfranchisement of the elderly and widows greatly impedes their access to improved water, and perpetuates poor water access to subsequent generations. Thus, outreach into such communities needs to adopt a skills-based health education that is strongly founded on community-based participatory programmes and that generational effort needs to take place.

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