Case study on disaster risk reduction and public health implications management in South Africa.

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Abstract

Water pollution and service delivery issues have long plagued South Africa due to historical inequality in the water service delivery, technical capacity shortages, primary water scarcity and the semi-arid/arid climate in the country. Two initiatives are described in this article. The first one is a health promotion about preventing water pollution was run as a combination of the computer-based quiz, an information poster, interactive model and a take-home information leaflet. That was implemented at the 2014 National festival of Science and Technology held in Grahamstown, South Africa. The second initiative is the use of the H_2S kit as a tool to assess disaster risk/hazard from microbial contamination of potable water resources used by students and staff at Rhodes University at 5 sampling sites between 30th July 2017 and 5th September 2017. Some infrastructure integrity of the potable water infrastructure and the policy used to deal with water outages were analysed; and modifications are proposed where applicable based on the study results. After an educational intervention, there was a significant improvement in the overall participants' percentage knowledge scores about prevention of water pollution (*p*-value = 0.009) at 5 % level of significance. The intervention results showed significant improvement post-intervention among the participants who attended or had attended independent schools (*p*-value = 0.024). The H_2S microbial water testing initiative indicated that 90% of the rainwater samples were positive for faecal contamination or were suspected of the being faecally contaminated. On the other hand, while and all municipal water samples were negative for fecal contamination. Integrity of the rainwater harvesting infrastructure was sound, but treatment by the additional of bleach and the installation of filters on all rainwater harvesting campus installed on campus. A regular monitoring of the microbial water quality on campus was implemented and the results were communicated to the respective Rhodes University stakeholders. That was accomplished using WhatsApp and email.

Introduction

South Africa's total population was estimated at 55 908 900 in 2016 and grew by an estimated at by 1.19-1.24 % per annum (StatsSA, 2016). The country has reached medium level of human development with the human development index reaching 0.666 in 2014 (UNHDI, 2016). The country is semi-arid to arid as the average annual precipitation has been reported to be around 450-495 mm (Tadross and Johnston, 2012; WB, 2016). The water resources are further put under pressure due to heavy reliance on mining, agriculture and the water-intensive electricity generation in the economy of the country (PSA, 2016a). South Africa has met its Millennium Development Goal for the population's access to improved drinking water resources well before the 2015 deadline (PSA, 2016b). However, challenges in the water service delivery remain and they include pipe breaks and other complications (Luyt et al., 2012; MacKenzie, 2014; Madondo and Tandlich, 2018). Causes include gaps in financial management and unfilled/acting posts at the National Department of Water and Sanitation (PSA, 2016c). The complicated financial relationships and unsettled debts among various state and public stakeholders in the water and waste treatment sector seemed to be an ongoing problem (PSA, 2016d). Overreliance by the South African National Government on state-linked and government-sponsored institutions to drive development of new solutions in the provision of drinking water further exacerbate the situation (PSA, 2016e).

During a 2016 parliamentary briefing it was revealed by the officials from the National Department of Water and Sanitation that up to 57 % of all dams supplying raw water for treatment and potable purposes in South Africa are privately-owned (PSA, 2016b). Thus government's problem with drinking water service delivery can also be caused by fact that a critical part of the water services infrastructure is not under direct control of the state. A national water security plan for the period of 2016-2030 was introduced to Parliament of South Africa in August 2016 (PSA, 2016a). Better management and improvements infrastructure have been ongoing in South Africa for many years. Water Loss Programme from the Nelson Mandela Metropolitan Municipality (NMMM) is an example of implementation of a programme which consisted of at least some of the following elements (Rabe et al., 2012, page 9-12): audit of the water leaks and their causes in the municipal jurisdiction, GPS and door-to-door data collection and digitization, identification of illegal connections, education campaigns. All the mentioned activities were part of water conservation and water demand management (Rabe et al., 2012, page 9-12). As a result, the total demand for potable water was decreased in NMMM, number and sources of leaks were eliminated and new jobs were created for artisans (Rabe et al., 2012, page 9-12). Similarly, an active leak control programme from the City of Johannesburg is another a good example (Rabe et al., 2012, page 17-19).

Specialised grant agency which is devoted to water research, i.e. the South African Water Research Commission, has been continuously funding research into improved water resource management and the improvement in the water service delivery to the South African population. Examples of this include the guidelines for reducing water losses in the municipal reticulation framework (MacKenzie, 2014). Contamination of drinking water and the compromised hygiene can contribute to the development/presence of disaster hazards from waterborne diseases. Management of potential water contamination sources includes effective sanitation waste management. This becomes a problem in peri-urban settlements where the sewage collection infrastructure is not available. Here decentralised solutions such as the DEWATS system (which provides the ability to irrigate subsistence gardens and to generate biogas Rabe et al., 2012, page 13-16). Decrease of water demand can also be achieved by the use and reuse of greywater in household gardening (e.g. Cele et al., 2017; Nondlazi et al., 2017). A critical element of the successful water resource management is effective involvement of water consumers, their education and the up-to-date knowledge about the status of the water quality in the target areas.

Several studies by the authors and others have shown that drinking water provided by municipalities to the consumers in the Eastern Cape Province of South Africa is microbially-contaminated (e.g. Tandlich et al., 2014; Malema et al., 2018). The contaminated drinking water could contain disease causing organisms which are predominantly of faecal origin which are transmitted through drinking water (Ashbolt, 2004). The presence of waterborne pathogens in drinking water and other factors, including the improper treatment of drinking water before consumption increase the chances of waterborne disease outbreaks (Ashbolt, 2004). The water status needs to be elevated as the critical source in decision making. A fundamental prerequisite of this strategy is to involve the community, as water consumers, into the process of water provision and to make them educated and engaged stakeholders. With young people as the integral part of the society and as future leaders, conveying awareness and health education about water conservation and pollution will positively influence the behaviors and attitudes of the community towards the water challenge.

In addressing the critical community needs and forming a stronger community engagement relationship, some higher education institutions have developed and implemented service-learning programme in creating public health awareness which prepare students for their roles as health care professionals (Srinivas et al., 2013). In South Africa, this is part of the community engagement which forms one of the three pillars of the academic project at each public higher education institution in the country (Tandlich et al., 2018). Therefore, to build on the concept of environmental health promotion and address the challenge of the conservation of water faced in the Eastern Cape, and other parts of South Africa, students and academics from the Faculty of Pharmacy, Rhodes University, South Africa, designed a final year research project based on service learning principles for fourth year pharmacy students. This service learning was used at the 2014 National Festival of Science and Technology (SciFest), held in Grahamstown, South Africa, to create basic awareness of the conservation of water amongst the young attendees mainly school learners.

Provision of piped water is desired by the entire South African population, but will be problematic to implement in isolated and rural areas due to cost and logistical barriers. Access to drinking water and meeting of the government water provision targets (PSA, 2016a), in rural areas can be increased by installing rainwater harvesting systems (RWHS). This is supported by recent data from Guatemala (Elgert et al., 2016). Problems with using RWHS as a source of drinking water often include microbial quality of the harvested rainwater (Tandlich et al., 2014; Elgert et al., 2016; Malema et al., 2018). This means the regular testing of microbial water quality is an absolute must from the public health point of view in South Africa (Tandlich et al., 2014; as supported by the findings of Malema et al., 2018). In isolated and rural areas, frequency of microbial testing and compliance monitoring of microbial water quality can be hampered by the distance to accredited laboratories (Luyt et al., 2012).

Under these conditions, microbial compliance water monitoring of the harvested rainwater could be performed by simple tests that do not necessarily require access to a fully accredited laboratory. One such test is the improved hydrogen-sulphide test kit (designated as kit in further text; Luyt et al., 2012; Tandlich et al., 2014). This has been modified by addition of 0.5 % deoxycholate based on previously developed media and the results of a literature research (Tandlich et al., 2014). One of the limitations to date has been the limited ability of the kit to detect low levels of indicators microorganisms, i.e. around 0-2 colony-forming units per 100 mL (designated as CFUs/100 mL; Tandlich et al., 2012). Using the 2012 data, some of the authors of this paper proposed that the probability of false negative results can be decreased to 0.6 % by modifying the sampling protocol (Nhokodi et al., 2016). Rhodes University and Grahamstown/Makhanda are well known for having poor water quality. In this project we were assessing the water quality from roof catchment systems (JOJO tanks) and indoor tap water.

Materials and Methods

For the health promotion intervention, students from the honour-level class in the Bachelor of Pharmacy degree at Rhodes University participated in the activity as an elective/research project and signed the confidentiality forms. The health promotion intervention was approved by the Faculty of Pharmacy Ethics Committee under tracking number PHARM-2014-04. The second author pharmacy student designed a quiz under supervision by fourth, fifth and seventh authors. The quiz administration was targeted at school learners from the age of 11 and above to create awareness of water pollution and how to prevent it and ways to conserve water. The quiz was designed on the basis of “what, why and how” in terms of water pollution and water conservation which consisted of 8 questions with multiple-choice answers. The quiz was designed to determine amongst the SciFest attendees, the pre-intervention level of knowledge of the conservation of water, water pollution and how to prevent it and was followed by an educational intervention slides which provided information regarding the questions asked in the pre-intervention quiz. Immediately after the intervention the post-intervention quiz followed.

Local school learners (27 school learners) from different local schools participated in the pilot study of the quiz, which resulted in changes being made to the quiz from the gathered feedback from all school learner. Using a specially designed computer program written by Prof. Wentworth known as BKnow® software, the quiz was then adapted for use on a computer by the sixth author. This BKnow® software was used to incorporate multiple-choice questions into a Microsoft PowerPoint presentation using Microsoft PowerPoint 2013. The participants then chose the option which they thought was correct from the multiple-choice options available to them from each option that appeared on one slide. The demographic data which included age, gender and type of school (Independent or Government Funded) of the respondents as well as the responses to the quiz were captured and analyzed statistically. Gatekeeper permission were obtained from the school principals in the government schools located in the Makana Local Municipality.

Dependent *t*-tests on test percentage scores and the McNemar and χ^2 tests on the percentage of correct answers given for each question before and after the intervention were used to assess whether the intervention made a difference in the understanding of water pollution, as well as its causes and effects. Independent *t*-tests and ANOVA procedures were performed to test for age, gender and type of school (independent of government-funded) effects on test percentage scores before and after the intervention. Means and standard errors were calculated for pre- and post-intervention scores. All tests were performed using the statistical programming language, R, and significance was set at the 0.1 to 5 % level of significance (R Project, https://www.r-project.org/about.html).

The attendees of the exhibit were both adults and children. Attendees who were 11 years of age and older participated in the quiz. Gatekeeper permission to conduct the health promotion was obtained from the organisers of the Scifest. Each group of children that participated in quiz and the first activity was accompanied by a teacher. The nature of the programme was explained to the teacher and the children. Verbal consent was obtained from teacher and the potential participants, before the children took the quiz. The verbal consent is justified as the SciFest can be considered a public space which is busy, e.g. similar to interviewing customer in a store. Participation of the children or minors in the quiz is likely to provide the children with the opportunity to acquire new knowledge on water pollution and its prevention. This is a non-therapeutic research and potential benefits to the children are clear in a water-scarce country such as South Africa. Therefore the research meets the ethical standards that applied to research with human participants in South Africa in 2014 (Chapter 9 paragraph 71 of the national Health Act no. 61 of 2003). Verbal consent to participate was also obtained from all quiz participants older than 18 years of age.

Majority of the participants attended rural or township schools where access to computers is limited, hence the design of a user-friendly method of entering responses was vital. On the computer keyboards, coloured stickers were placed on three keys: the up arrow, down arrow and the Enter key. The Enter key was used to select the participant's choice of answer and the up and down arrows allowed navigation between the answer options. Once the enter key was suppressed, the next slide automatically appears and answers to previous questions or slide could not be changed. The same questions appeared in both pre-intervention and post-intervention slides. Participants received a response congratulating them if they provided or selected a correct answer, for the post-intervention questions only. The participants were automatically taken back to the relevant intervention slide which provided the correct answer, if they provided or selected an incorrect answer. By suppressing the enter key, the next slide/ question automatically appears. The participants' scores for both pre- and post-intervention appeared at the end of both quizzes, this way the participants were made aware of the difference, if any, after the intervention. Assistance was provided by the pharmacy students and/ or one of the lecturers involved in the research project if needed. An isiXhosa- speaking interpreter (local language) was available for participants who could not understand English.

A poster was designed which consisted of 8 points from the summary in the intervention slides from the quiz and pictures relating to the points. The poster was used as a tool in giving information to teachers, parents and school learners who were not participating in the quiz. The posters were also printed on A4 pages and were then handed out to anyone who attended the exhibit which served as a reminder of what was learned from the exhibit, the posters were also made available to other members of the community, e.g. family and friends. An interactive model aimed at participation of school learners aged 10 and below was designed. Participants were asked questions with the aid of pictures which were related to conservation of water, water pollution and how to prevent water pollution. If the participants provided a correct answer, a yellow smiley face was revealed; if the participants provided a partly correct/ incorrect answer, a blue confused/ partly smiley face was revealed in response; if the participants provided an incorrect answer, a yellow sad face was revealed in response.

For the second intervention from this study, 5 sampling sites were chosen around Rhodes University campus which covered the rainwater harvesting systems with various levels of treatment. Two municipal water sampling sites were added to compare the water quality on the Rhodes University campus with that of the rainwater. The hydrogen-sulphide test kits (designated as kits in further text) were prepared and data evaluated as outlined by Tandlich et al. (2012) and Tandlich et al. (2014). Sampling was done as outlined by Tandlich et al. (2014). Assessing the integrity of the rainwater harvesting infrastructure and the potable water supply, the following approach was taken. Each tank was examined for any cracks, gutter pipes were checked and examined for proper fitting to the collection tank. The taps were also checked if they were functioning properly and any leakages where present. For the indoor sampling sites, the taps were functioning, for any leakages and if they were properly mounted.

Results and Discussion

First intervention

Demographics of the participants were captured in the first five questions of the quiz, in which 374 participants took part. The data obtained show that 100 participants (26.7 %) were 11 to 13 years old, 151 participants (40.4 %) were 14 to 16 years old, 95 (25.4 %) participants were 17 to 19 years old and 28 participants (7.5 %) were 20 years or older. Of the total number of participants, 198 (52.9 %) were female and 176 (47.1 %) were male. Regional distribution shows that 334 (89.3 %) attended or had attended a school in the Eastern Cape Province, while the remaining 40 (10.7%) were schooled in the other South African provinces. The demographics show that 292 participants (78.1 %) attended or had attended a government school, while the remaining 82 (21.9 %) attended or had attended an independent school. The first assessment of the participants' knowledge was to determine whether the participants knew what the effect of unsafe and unclean water is. Of these, 321 participants (85.8 %) were aware that unclean/unsafe water could make one sick, while the remaining 53 (14.2 %) thought that unclean/unsafe water could be used for drinking and cooking.

The results from the pre- and post-intervention study are shown in Table 1. These results show that the participants had reasonable prior knowledge of what water pollution is, how it can be avoided, and the related risks of using unclean water (overall percentage score 64.1%). The questions with the lowest correct percentage scores were Questions 6 ("How can waterborne diseases like Cholera be avoided?"), 4 ("When can germs be found in drinking water?"), and 3 ("What effect does water pollution have on the water?”), which were answered correctly by 52.7 %, 53.7 % and 58.8 % of the participants, respectively. Questions 1 and 5, on the other hand, were answered correctly by the most participants, 77.5% and 75.7%, respectively (see Table 1). Of the 374 quiz participants who took part in the pre-intervention questions, 63.9% (n=239) continued through to the post intervention questions. McNemar’s dependent χ^2 test was used and the results are shown in Table 1.

Table 1. Frequencies (count and %) of correct answers for pre-intervention quiz (n=374) and Quiz observed frequencies (with percentages) of correct responses for the pre- and post-intervention questions, and the means ± standard errors of pre- and post-intervention percentage scores (n=239).

	Observed frequencies (counts and %) of correct answers for pre-intervention quiz (n=239)	**Observed frequencies (counts and %) of correct responses for the pre- and post-intervention questions, and the means ± standard errors of pre- and post-intervention percentage scores (n=239)**		
Question	Pre-Intervention Frequency	Pre-intervention Frequency	Post-intervention Frequency	*P-value* (1-sided)
Which of the following is true about water and health? Answer: Clean and Safe water is Drinkable	290 (77.5%)	188 (78.7%)	179 (74.9%)	**0.298**
What is water pollution? Answer: Makes the water unclean and unsafe to use	239 (63.9%)	152 (63.6%)	154 (64.4%)	**0.911**
Water pollution makes water.. Answer: Unsafe, Unhealthy, Unclean to use	220 (58.8%)	139 (58.2%)	166 (69.4%)	**< 0.001*** **
When can germs be found in drinking water? Answer: Disposing chemicals and human droppings in the water supply	201 (53.7%)	123 (51.5%)	151 (63.2%)	**< 0.001*** **
What is a waterborne disease? Answer: An illness due to infection caused by germs found in the water	283 (75.7%)	181 (75.7%)	185 (77.4%)	**0.671**
How can waterborne diseases like Cholera be avoided? Answer: By protecting drinking water quality before problems occur; always drinking clean water; avoiding causing water pollution	197 (52.7%)	118 (49.4%)	144 (60.3%)	**0.003** **
How can water pollution be avoided? Answer: Not littering next to the water supply; not dumping human waste in the water supply; not dumping chemicals into water drainages	255 (68.2%)	160 (66.9%)	182 (76.2%)	**0.004** **
How can we save water? Answer: Using only the amount you need; not wasting water; always turning off the tap after usage or collection of water	232 (62.0%)	142 (59.4%)	169 (70.7%)	**< 0.001*** **
Mean ± s.e.		**62.9 ± 3.9%**	**69.6 ± 3.8%**	**0.009** **

** = significant at 1%; *** = significant at 0.1%
Pre-intervention: Number of participants who answered the questions correctly during the pre-intervention quiz
Post-intervention: Number of participants who answered the questions correctly during the post-intervention quiz
Frequency: Number of participants who answered the question correctly.

The intervention resulted in a significant increase in correct responses (at the 0.1 % level of significance) to Questions 3 (“What effect does water pollution have on the water?”), 4 (“When can germs be found in drinking water?”) and 8 (“How can we save water?“) (p-value < 0.001 in each case). There are also significant increases in correct responses (at the 1% level of significance) to Questions 6

(“How can waterborne diseases like Cholera be avoided?“) and 7 (“How can water pollution be avoided?“) (*p*-value =0.003 and 0.004, respectively). Only Questions 1, 2 and 5 show no significant improvement in correct answers after the intervention (*p*-values = 0.298, 0.911, and 0.671, respectively). In fact, Question1 shows a decline in the number of correct responses after the intervention. The overall scores of participants in the pre- and post-tests are also significantly different at the 1% level of significance (*p*-value =0.009).

The results show significant gender differences in the pre-intervention mean percentage scores (at the 1 % level of significance), but no significant differences in the post-intervention mean scores (pre: Male: 56.6 ± 2.8 %, Female: 68.5 ± 2.7 %, *p*-value = 0.003; post: Male: 65.6 ± 2.8 %, Female: 73.1 ± 2.7 %; *p*-value = 0.053). Within the individual gender groups, only the males show significant improvement in their pre- and post-intervention mean scores at the 5% level of significance (*p*-value = 0.027). No significant differences are seen in the mean percentage scores between participants from government and independent schools before the intervention, but significant differences at the 1 % level of significance are observed after the intervention (pre: Government: 62.2 ± 2.2%, Independent: 66.0 ± 4.5%; p-value =0.444; post: Government: 67.4 ± 2.1%, Independent: 78.5 ± 4.4%; p=0.008). When analysing the school types separately, participants who attended or had attended independent schools show a significant improvement (at the 5% level of significance) between their pre- and post-intervention mean percentage scores (p-value =0.024).

There are significant differences (at the 0.1% level of significance) in both the pre- and post-intervention mean percentage scores between the different age groups. The mean ± standard error % scores of the participants in the age groups are: ’11 to 13 years’ (pre: 51.6 ± 3.7 %; post: 56.4 ± 3.7 %), ‘14 to 16 years’ (pre: 60.1 ± 2.9 %; post: 70.4 ± 2.9 %), ‘17 to 19 years’ (pre: 77.0 ± 3.7 %; post: 80.5 ± 3.7 %), and ‘over 20’ (pre: 71.4 ± 7.8%; post: 73.2 ± 7.7%) (ANOVA: pre: F=8.479, df =3, 235, *p*-value < 0.001; post: F=7.27, df =3, 235, *p*-value < 0.001). It should be noted that the mean percentage scores for the “over 20” group are lower than those for the “17 to 19” year olds, both before and after the intervention. Within the individual age groups, only the “14 to 16” age group shows significant improvement (at the 5% level of significance) in the pre- and post-intervention mean scores (*p*-value = 0.013).

The computerized quiz was successful in raising awareness of water conservation, causes of water pollution and the prevention of water pollution, especially among the young attendees at SciFest. The health promotion activity may serve as means of addressing the waterborne disease outbreak which still pose a great concern in developing countries such as South Africa (WHO, 2014). The participation of 374 participants in the quiz has resulted in initiating awareness and advocacy on environmental health issues. It is vital to target the youth especially the school learners as they will hopefully take on a proactive individual and societal role to conserve water. It is reinforced by UN Children’s Fund (UNICEF) that childhood and adolescent interventions can have a lasting effect on intellectual capacity, personality, and social behavior; because children are very receptive, adaptive and therefore are the hope for a safe and clean environment in the future (Young, 1996). Due to the urban-rural divide that reveals the limited access to information in developing countries, it is essential to design and implement health promotion activities and events to and for the youth, and the community as a whole, especially to the population residing in rural areas.

Rhodes University is based in Grahamstown, and is a semi urban area in the second poorest province of South Africa with certain unique advantages of being a University town where as a part of community engagement and social responsiveness the University supports service-learning activities. The activities included in the program include indirect and direct service to the community. An example of the indirect service which is supported by Rhodes University include Community Experience Programme developed in the Pharmacy Practice course where Pharmacy students interview and assist patients suffering from chronic conditions such as Asthma, Hypertension and Diabetes, who visit the public health care facilities. The indirect service may also aim at a research question; finding, gathering, analyzing, and reporting information or conducting environmental or other tests, or conducting experiments. Of the total number of participants, 346 participants (92.5 %) were 11 to 19 years old, which was the target group for the health promotion. It is encouraging to acknowledge that 89.3 % of the participants attended or had attended school in Eastern Cape and 78.1 % of the participants attended or had attended government schools. This indicates that most government schools allowed their learners to have the SciFest experience. Most of the participants who were government school attendees said and showed they had minimal or no exposure to computers, but showed interest and were willing to fully participate in the quiz regardless. The simplicity of the instructions of using only three indicated and marked keys on the computer keyboard with aid from the pharmacy students facilitating the process alongside the IsiXhosa interpreter may have encouraged and motivated the participants which had no exposure to the computers. Children can generally muster on their own or with little help from the facilitator or an adult, when given time and basic materials (Young, 1996).

The first assessment of the participants' knowledge was to determine whether the participants knew what the effect of unsafe and unclean water is. Of these, 85.8 % of the participants answered correctly. The participants showed reasonable prior knowledge of what water pollution is, how it can be avoided, and the related risks of using unclean water, as the overall percentage score 64.1 %. No significant difference in mean percentage scores between government and independent school attendees was noted in the pre-intervention questions; but there was a significant difference in the post-intervention questions among the participants who attended or had attended independent schools. The UN children's Fund promotes and helps governments implement a range or low-cost sanitation, water and hand-washing facilities and helps improve sanitation and promote hygiene (proper hand-washing, among others) in schools. [21]

There was a significant increase in the number of participants who answered the questions correctly during the post-intervention quiz compared to the pre-intervention quiz. The significant increase only applies to the questions from question 2 to question 8. It is very encouraging to note that the intervention improved the understanding and knowledge of the participants about water conservation, the causes of water pollution, and how waterborne diseases can be avoided; which in turn increased the number of questions answered correctly in the post-intervention quiz. There was also a decline in the number of correct responses after the intervention, from 78.7 % in the pre-intervention questions to 74.9 % in the post-intervention questions. The participants might have misunderstood the question after the intervention; the question was "which of the following is true and water and health". Due to the fact that most participants were taught English as the second additional language, this might have created uncertainty when reading the question after the intervention. It may also be due to the reason that the children's motivation is internal, therefore they become confused in their actions and thoughts when answering the quiz post-intervention (UN Economic and Social Council, 2015).

To further increase awareness of water pollution and the causes of water pollution, including water conservation; a variety of continuous health promotion should be carried out in specific areas. To carry out the health promotion activity quiz which is fun and interactive proved to be a very effective learning tool in areas where the target audience is young. In developing countries such as South Africa where 95% of the population has access to safe drinkable water (WHO 2014), targeting the youth may be very important to reduce the waterborne diseases transmission. Limitations included having only two weeks to develop the quiz, conduct the pilot study and make the relevant changes in time for

SciFest due to the Rhodes University start of term and SciFest exhibition gap. The post-intervention questions were not always completed by the participants due to other commitments arranged by the learners' facilitators which included attending other workshops, departure times and others. The participants interacted with the posters only if they were unwilling to participate in the quiz therefore the success of the additional educational interventions was not evident or recorded in the results. The environment was not controlled as SciFest as the exhibition was open for everyone including the teachers and parents hence difficult to control the attendees to the exhibition. Some of the participants found it very difficult to read the questions but were willing to participate regardless, might be because of the excitement to use the computers. The health promotion was only done during SciFest and therefore the implementation of the knowledge acquired is not monitored.

Second intervention

Results from the H_2S kit sampling of the microbial water quality are summarised in Table 2. The results are presented using the traffic light system as proposed by Nhokodi et al. (2016). In this system, five kits are taken at a particular sampling site on a particular sampling occasion and those kits were then incubated for 72 hours as outlined by Tandlich et al. (2012, 2014). If five kits remained negative after the incubation period, then a kit rating of 0 was assigned to the particular sample result and the water from that source was considered free of faecal contamination (Nhokodi et al., 2016). If one to four kits were positive for faecal contamination after the incubation period, then a kit rating of 1 was assigned to the particular sample result and the water from that source was suspected to be faecally contaminated (Nhokodi et al., 2016). If one to four kits were positive for faecal contamination after the incubation period, then a kit rating of 2 was assigned to the particular sample result and the water from that source was suspected to be faecally contaminated (Nhokodi et al., 2016).

Table 2. Sampling results of the assessment of microbial water quality using the kit between July and September 2017.

Sampling site	Sampling 1	Sampling 2	Sampling 3	Sampling 4
Hamilton rainwater tank	2	2	1	2
Joe Slovo dormitory rainwater tank	2	2	2	2
Environmental Learning Research Centre	2	2	1	1
Deionised water 1 fed with rainwater	1	2	1	1
Deionised water 2 fed with rainwater	2	2	0	0
Municipal tap 1	0	0	0	0
Municipal tap 2	0	0	0	0

Sixty percent of all rainwater samples had a kit rating of 2 and 10 % of rainwater samples were free of faecal contamination. Thus the average kit score was equal to 1.5 ± 0.7, while the average kit rating for the municipal water was equal to 0. One hundred percent of the municipal water samples were free of faecal contamination. These two values were statistically and significantly different at 5 % level of significance (Mann-Whitney test using the https://www.socscistatistics.com/tests/mannwhitney/Default2.aspx calculator, $U = 8$, $U_{critical} = 47$, p-value = 0.00014). Therefore the rainwater samples were on average either suspected of being faecally contamination or were definitely microbially contaminated. This is in line with the previous findings on microbial rainwater quality at Rhodes University have been reported before (Tandlich et al., 2012, 2014). The current results indicate regular microbial testing of rainwater quality must be conducted every two weeks and the water outage section of the Rhodes University Emergency Management plan must be modified to mandate this (Tandlich et al., 2013). The kit testing is currently being run on Rhodes University campus based on the environmental representatives who are in each student dormitory on campus are trained to perform the kit testing. The data is collected and problem communicated via a dedicated WhatsApp platform and results are communicated to the relevant stakeholders at Rhodes University.

Conclusions

The current paper describes two of the ongoing initiatives by the author team to facilitate community-based education and water quality testing initiatives in Makhanda and at Rhodes University in South Africa. On the first intervention, although the SciFest quiz participants had prior knowledge about water conservation, water pollution and the treatment of contaminated water before consumption, the educational intervention and interaction resulted in an increase in knowledge among participants. Even though the intervention resulted in positive outcomes, further intervention and applications that include continuous access to relevant information, are needed to bring about sustained knowledge and lifestyle modification with respect to water conservation and pollution. All the tanks that were sampled were fully functional, however regular assessment needs to be done to ensure they are functioning well. In case of a water crisis the inhabitants of Rhodes University should be notified of the quality of these tanks. Further investigation on quality of the tanks with bleaching needs to be done, to see if the water would be drinkable. The Emergency Management Plan is a well thought plan as it aims to provide a safe environment at the university. It shows that the university is aware of emergencies/disasters can take place at any time thus it has noted that quick response to these emergencies is of high importance. However it also needs to be critically evaluated to ensure that these emergency plans won't lead to further damage of the population.

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