

EVALUATION OF A UTILIZED DOMESTICATED WATER TRANSPORT AND STORAGE DEVICE IN KENYA

Water transport and storage using a water backpack

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ABSTRACT

Water is essential for sustainable development. In Kenya, 43% of the population does not have access to clean water. To fetch water, women are sometimes required to walk long distances using jerry cans. Use of the jerry can has been associated with musculoskeletal pains and microbial contaminations. The water backpack has been designed as a suitable alternative to the use of jerry cans. This study was conducted to assess the extent of proper utilisation of the backpacks previously distributed in Embu, Machakos, Kilifi (Watamu) and Kiambu (Limuru) counties of Kenya. Observation and structured questionnaires were used to collect data. Study participants consisted of 403 volunteers selected randomly from the study locations. Data was analysed using R?? and descriptive statistics were used to present the data. From the study, 86% of all study participants demonstrated proper usage of the water backpack. In addition there was a significant association between the use of the backpack and various water treatment methods. In Machakos and Kilifi counties, over 67% reported a marked reduction of musculoskeletal pains associated with use of the water backpack. In conclusion, there was strong evidence of many health and related benefits associated with proper usage of the water backpacks in the counties.

INTRODUCTION

Water is life and it is at the core of any development. It is a finite resource under a growing pressure

of demand. According to United Nations Water Development Report 2015 (WWAP, 2015), 748 million people today still do not have access to an improved source of drinking water. This situation is bound to get worse since the demand for water in manufacturing is expected to increase by 400 per cent between 2000 and 2050 globally. In Africa, only 5% of potential water resources are developed. There are a myriad of challenges with access to water in Africa as articulated at the 9th African Union General Assembly of the African Ministers Council of Water (AMCOW) in 2014. These include water infrastructure deficit, protection of the sanctity of the water sources and resources, water governance and management systems, water supply and distribution, financing and a lack of knowledge, and water information (WWAP, 2015). For instance, compared to North America's average per capita water storage of 6,000 m³, Africa has measly average per capita water storage of 200 m³. Poor water and sanitation facilities in Africa have resulted in waterborne illnesses. For instance, diarrhea is the third biggest killer of children under five in Sub-Saharan Africa.

In Kenya, 43% of the population has no access to clean water (Marshall, 2011). The water scarcity in Kenya has been attributed to global warming (leading to years of recurrent droughts), challenges with water management, low investment in the water sector, contamination of available water resources and an increase in demand for water due to the population growth and industrialisation.

Some communities in water-stressed regions are forced to migrate when there is drought in order to find water. Migration has led to conflict. It also leads to school-going children dropping out of school, affecting their education (Marshall, 2011). On the other hand, in the rural areas of Kenya, communities tend to settle within proximity of water sources. Kenya's rural population has a much lower access rate to clean water at 49% as compared to their urban counterparts at 85%. However, access to safe water by the urban poor is as low as 20% (Moraa et al., 2012). The devolved system of governance is expected to reverse this trend. It is therefore common to find that the only available water sources in rural areas are a distance away. To access water for daily use therefore, members of these communities have to trek long distances. It is mostly women and school-going girls who bear the responsibility of fetching water.

For a long time, the ubiquitous water transportation and storage container in Africa has been the twenty (20) litre jerry cans. The jerry can is fraught with several challenges. One, it is extremely difficult to clean the inside of the jerry can and therefore there is a likelihood that this results in an accumulation of grime, a possible breeding ground of disease-causing microorganisms. Secondly, most of the jerry cans are sourced from chemical industries. Some of the chemical residues persist in the cans and may not be removed by a simple wash. Users of these jerry cans therefore stand the risk of ingesting harmful compounds that may percolate slowly from these cans. On the other hand, these jerry cans are hard and when filled with 20 litres may hurt the user, especially if travelling for a long distance. Anecdotal reports indicate that long usage of the jerry cans can result in back pain and severe discomfort. Some innovations have been developed to assuage the challenges of the jerry cans. For example the WaterWheel, a 50-litre water transportation and storage container that doubles up as a wheel is rolled



Map of Kenya showing the counties where this study was carried out

by the user hence easing the burden of carrying water on the back or head. The WaterWheel is proposed to retail at \$30 each, a cost that is already too high. In addition, it is challenging to use this contraption in steep terrain. During the wet season, it may be difficult and risky to use.

The packH2O, a water backpack developed by Greif, is another innovation designed to ease the burden of carrying household water from an access point to home. It was designed to imitate a standard backpack and has a 20-litre water carrying capacity. It contains a removable plastic liner that, after use, is easily cleaned and can be sanitised with exposure to sunlight. It also comes with a spout for dispensing water and a puncture-resistant outer shell. Since the backpack is lightweight and collapsible, it has been found to be easy to store and transport.



Image: Staff from Partners for Care (PFC) conducting training on the use of the water backpack at Ishiara village, Machakos County. Photo courtesy of PFC.

The water backpack was first used in Haiti after the earthquake. Since 2013, the pack has been introduced in Kenya through Partners for Care (PFC), a non-governmental organisation (NGO).

The backpacks were given as a donation and the users were taken through a short training session that highlighted the proper utilisation of the pack, treatment of water and cleaning procedure. This study was therefore carried out to determine the utilisation of the water backpack as an alternative water transportation and storage device.

METHOD

Study Design, Area and Population

An evaluation study was adopted in Embu, Machakos, Kilifi and Kiambu counties of Kenya to determine the extent of proper use of the water backpack. The study was carried out on October and November, 2015 in Kiambu County, Machakos County, Watamu in Kilifi County and Limuru in Kiambu County. The population distribution in Embu, Machakos, Kiambu and Kilifi counties are 543,221, 1,099,000, 1,623,000 and 1,110,000 persons, respectively. According to the 2013 County Report by Kenya National Bureau of Statistics, 63% of residents in Machakos County (KNBS & SID, 2013a) rely on unimproved sources of water compared to 36% in

Kilifi County (KNBS & SID, 2013b), 25% in Kiambu County (KNBS & SID, 2013c) and 51% in Embu County (KNBS & SID, 2013d).

Sample Size Determination

The minimum sample size n was determined using the following formula,

$$x = Z(c/100)^2 r(100-r)$$

$$n = N x / ((N-1)E^2 + x)$$

where N is the population size, r is the fraction of responses that you are interested in, and $Z(c/100)$ is the critical value for the confidence level c , 1.96 at 95% confidence level

(www.raosoft.com/samplesize.html).

Data Collection Techniques

Data was collected using structured questionnaires which were administered by research assistants as well as through observation.

Data Handling and Analysis

Microsoft Excel was used to generate histograms and tables and R statistical package was used for further inferential statistical analysis and generation of correlograms.

Ethical Clearance

Free and informed consent of the participants was obtained and the study protocol was approved by the Mount Kenya University Ethics Review Committee (MKU-ERC), Kenya, Protocol number MKU/ERC/0037 on 3 August, 2015.

RESULTS & DISCUSSION

Water Backpacks Distributed in the Study Area

The total number of households in the four study areas was approximately 730,000. Between 2012 and 2014, a total number of 10,680 water backpacks were distributed to Embu (3,000 packs, Aug. 2014), Kiambu (Limuru area) (4,100 packs, Dec. 2012 - Mar. 2013), Machakos (2,080 packs, Mar. 2013) and Kilifi (Watamu area) (1,500 packs, Sept. 2014). Each household received one water backpack. All the recipients were trained on how to use the water backpack. In addition, they were trained on how to treat the water, clean the water backpack, and the sterilisation procedures for the liner.

Socio-demographic Characteristics

A total of 403 participants (Embu, 100; Kiambu, 102; Machakos, 101 and Kilifi, 100) took part in the study. Majority of the participants, 66%, were aged 20-50 years, 25% were aged between 51 and 70 years while only 2% were below 20 years old. Of the total participants, 308 (76%) were females with age ranging from 15 to 105 years (mean age 43 years) and 95 (24%) were males, aged between 13 to 100 years (mean age 44 years). Majority of the homesteads (54%) had between 5 and 10 family members in the four study areas. Kilifi County however had 20% homesteads with between 11 and 30 family members and an average homestead of 8 members. The gender ratio varied with 80% women in Embu County, 78% women in Machakos County, 66% women in Kilifi County and 80% women in Kiambu County. Figure 1 shows educational characteristics of the study participants. The educational background of the study participants varied, ranging from illiterate to tertiary education. The participants with no formal education were as follows: 17% in Embu County, 13% in Machakos County, 37% in Kilifi County and 20% in Kiambu County. Half the participants had a primary level of education while 22% had secondary and tertiary level of education.

Water Sources

In this study, the source of water is important since the water backpacks are meant to improve transportation of water as well as to act as a storage facility. In Embu County, 58% of the respondents reported piped water as their source of water for domestic use while 26% of respondents fetched their water from the river. In Machakos County, 88% of the respondents relied solely on water from the river and only 9% had piped water and water reservoir tanks as their source of water for domestic use. In Kilifi County on the other hand, 92% of the respondents obtained their water from water tanks, borehole or piped sources. The situation in Kiambu County was close to that of Embu County since 78% of the participants reported to rely on piped water as the source of water for their domestic use, while



Image: Staff from Partners for Care (PFC) conducting training on the correct use of the water backpack at Ndeiya Health Center, Kiambu County. Photo courtesy of PFC.

14% collected water from water reservoir tanks within their compounds. It is worth noting that piped water generally referred to public taps.

Water Transportation

In Embu County, 63% of the respondents used jerry cans and buckets to fetch water while 35% of the respondents used water backpacks together with jerry cans to fetch water. In Machakos County, 87% of the respondents used water backpacks together with jerry cans and buckets to fetch water. Only 13% of the respondents relied on jerry cans and buckets to fetch water. In Kilifi County, 91% of the respondents used water backpacks together with jerry cans and buckets to fetch water. Kiambu County had half the respondents using the water backpacks together with jerry cans and buckets to fetch water. It was noteworthy that in Machakos County, those who used the water backpack to transport water significantly, $P = 0.037$, treated their water. In Kilifi County, it was noted that use of water backpacks to transport water significantly, $P = 0.003$, depended on the family size with increase in family size resulting to less usage of the backpack in water transportation (see figure 2). This can be attributed to the use of the backpack for storage especially in large households. It was also noted that there was a tendency to use the backpack together with other water carrying containers.

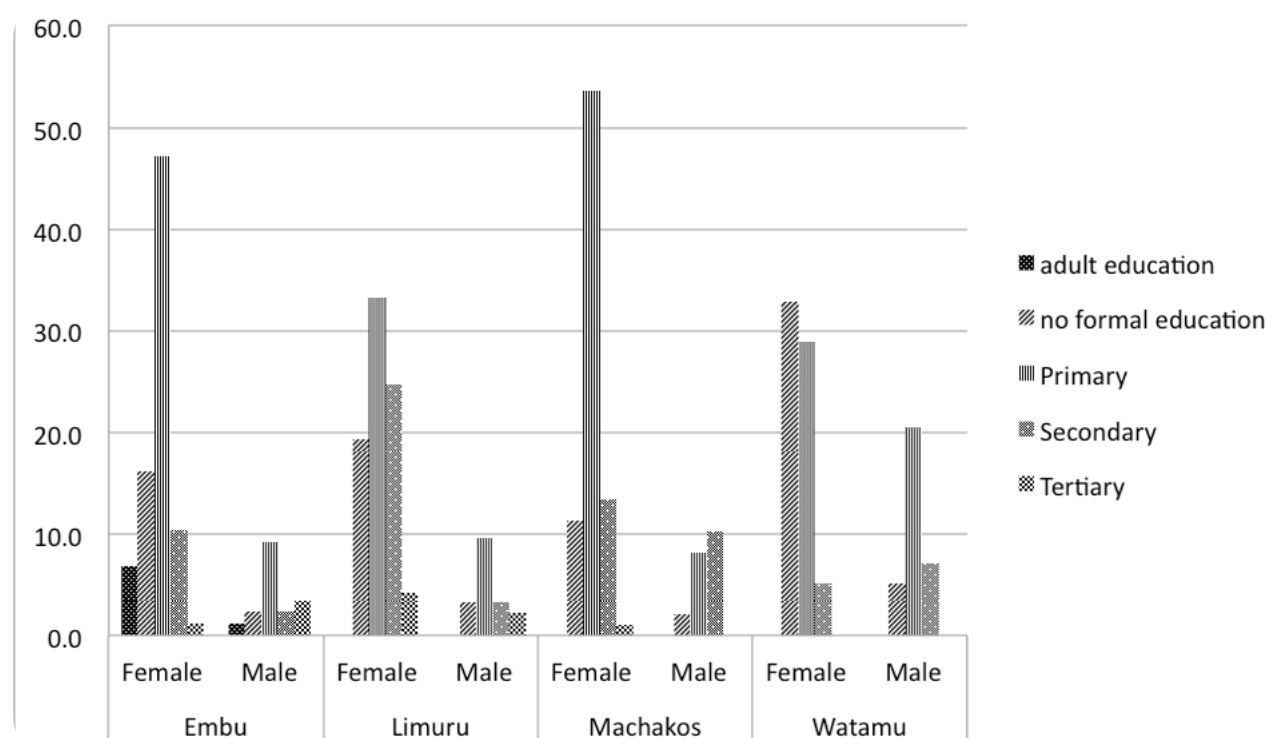


Figure 1. Education level of the study participants

Water Storage

On the question of water storage, 84% of the respondents in Embu county stored water using the water backpack together with plastic jerry cans, buckets and plastic storage water tanks. On the other hand, 60% of the respondents from Machakos County used the water backpack exclusively for water storage purposes while 31% used the water backpack together with jerry cans and water tanks. In Kilifi County, 92% of respondents used the water backpack together with jerry cans, buckets and water tanks to store their water. In Kiambu County, an overwhelming 99% of the respondents used the water backpack together with jerry cans, buckets and water tanks. Of this number, 37% of the respondents used the water backpack exclusively to store water. Notably, there was a significant correlation that those who used the water backpack to transport water also used it for its storage purposes in Kiambu County ($P = 0.029$), and Machakos County ($P = 0.167$). It is apparent that one water backpack per household was less than sufficient to address the water storage requirements of households with an average of six members.

Water Collection Distance

In Machakos County, 56% of the respondents took more than two hours to make a round trip to the water source. This is almost twice the number of respondents from Embu County (32%) who take more than two hours to fetch water and compares closely to the percentage of respondents from Kilifi County (59%). Kiambu County had the least percentage of respondents (8%) who took at least two hours to fetch water. In Embu County, the findings indicate a high significant relationship between water collection distance and reported pain ($P = 0.00000376$, Correlation coefficient = 0.4499788) which was reported to have reduced significantly following the introduction of the water backpack ($P = 0.0000856$, Correlation coefficient = 0.39998588) (see figure 2).

Frequency of Water Collection

Over 95% of respondents from Machakos, Kiambu & Kilifi County fetch water daily, as do 87% respondents from Embu County. Eighty-eight per cent of the respondents from Machakos County fetch water more than twice daily as do 74% respondents from Kilifi County, 84% respondents from Embu County and 89% respondents from Limuru County.

Notably, use of the backpack to carry water in Embu County correlated significantly with increased daily water collection frequency possibly due to the excitement of using the pack ($P = 0.000141$). Interestingly, it was noted that those who used the water backpack to store water showed a significant reduction in water collection frequency ($P = 0.0341$, Correlation coefficient = -0.21536674) possibly because the users preferred to use the backpack in water collection.

Incidents of Water Spillage from the Water Backpack

This study reported very few cases of water spills in respondents using the water backpacks. For instance, less than 10% respondents from Machakos, Embu and Kiambu Counties reported cases of water spills (see figure 3). However, 28% of the respondents from Kilifi County reported cases of water spillage.

It was noted that this was due to poor folding technique and overfilling the water backpack. In Kilifi County spillage was most significantly associated with improper use ($P < 0.000001$, Correlation coefficient = 0.664703012). Considering that Kilifi County had over 37% illiteracy level, a further training in proper use of the backpack is recommended in the area. There were no reported cases of water spills due to torn water backpacks.

Observation of the Proper Use of the Water Backpack

It was observed that on average 86% of all study participants demonstrated proper use of the water backpack with respondents from Machakos County demonstrating the lowest percentage (72%) and Kiambu County demonstrating the highest percentage (98%). There is a noticeable high acceptance and proper use of the water backpack by the community. During the study, other than to transport and store water, the data collectors did not observe any other undesirable use of the backpack in the study region.

Cleaning of the Water Backpack Liner

From the study, over 97% of the participants reported to be cleaning the water pack liner. The frequency was either every time water is used up, weekly, bi-weekly or monthly. Notably, 62% of all participants cleaned the liner every time the water was used up and only 2% of the respondents, mostly from Embu County, reported to have never cleaned up the liner (see figure 4). About 68% of the respondents used both wiping and sun drying methods to clean the liner. A small number of the respondents used either wiping (24%, mostly in Kiambu County) or sun-drying (6%, mostly in Embu County) alone to clean the water backpack liners. Interestingly, there was a significant, correlation between use of backpack to carry water in Kiambu County and failure to clean its liner ($P = 0.006$).

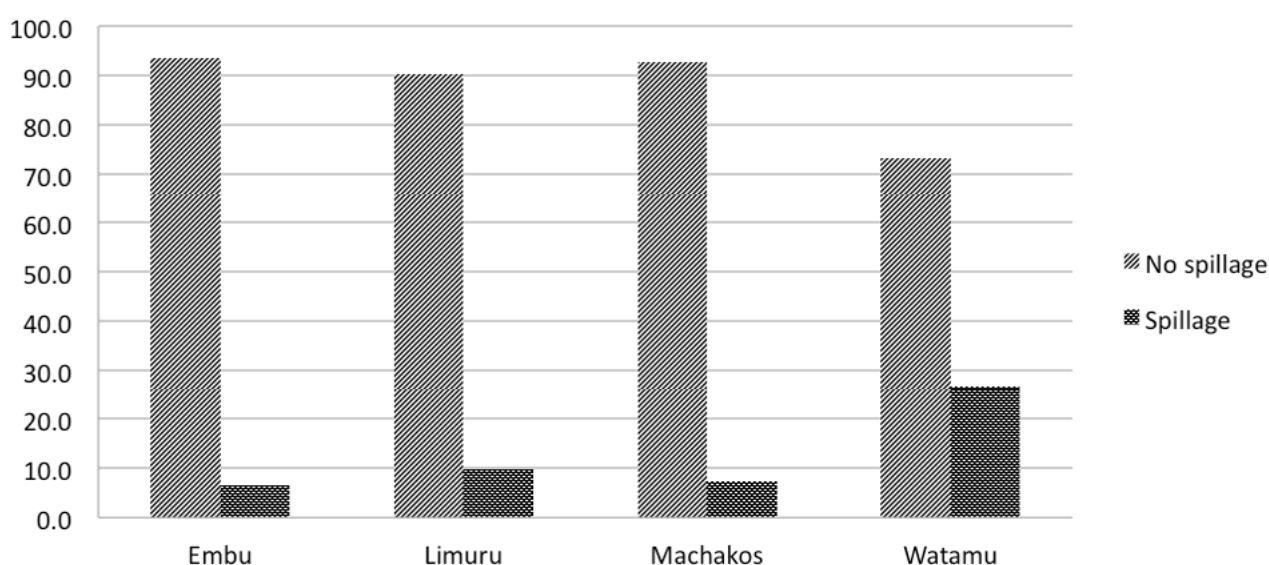


Figure 3. Incidents of water spillage from the water backpacks

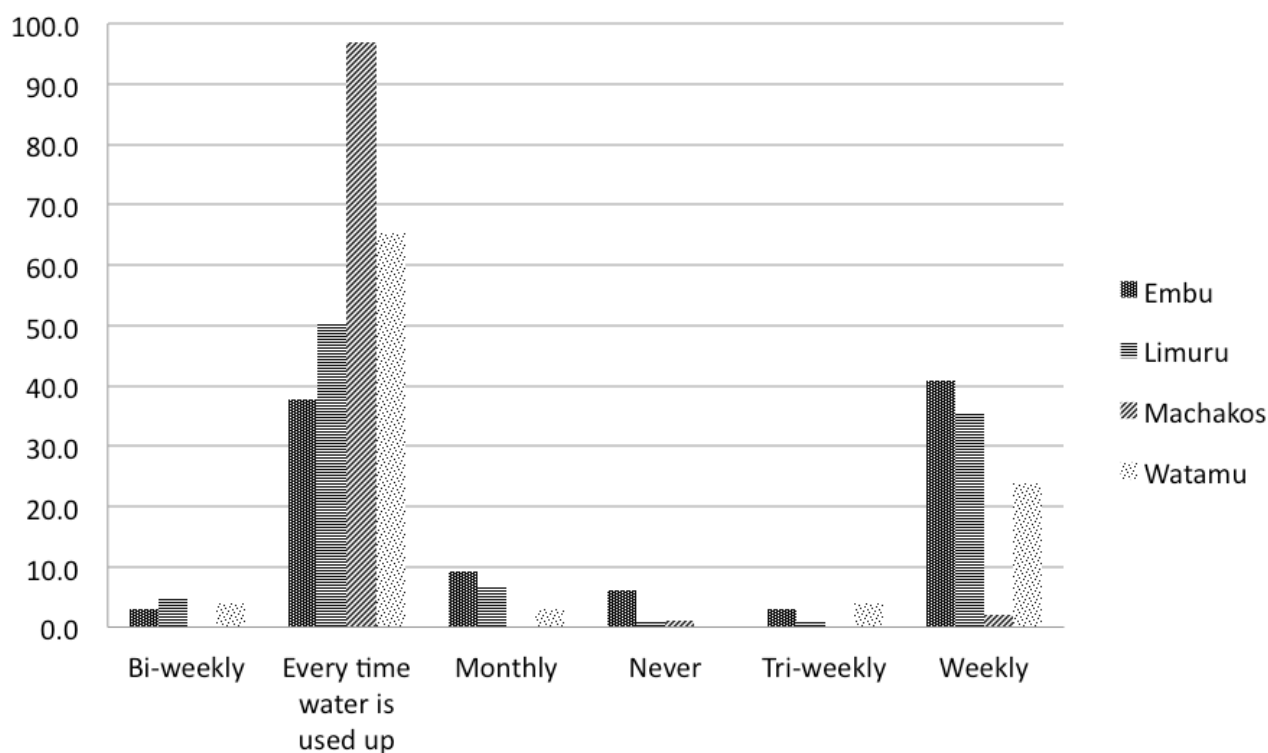


Figure 4. Water backpack liner cleaning frequency

Water Treatment Methods

Over 91% of the respondents in the four Counties treat their water. The treatment methods used across the Counties were boiling (33%), water guard (44%), a combination of water guard and PuR (57%) and filtration (3%). Embu and Limuru Counties preferred boiling treatment method at 44% and 59%, respectively. Machakos County overwhelmingly used the water guard at 86% whereas in Kilifi County, water guard (53%) and a combination of water guard and PuR (53%) was preferred. Those who did not treat had different reasons for not doing it. Some believed that the piped water was safe (Embu and Limuru County), did not have money, or did not have time. It was noted that use of the water backpack in Embu County and Kiambu County led to a significant increase in the use of water treatment methods with ($P = 0.013$ and 0.040 , respectively).

Back and Neck Pains

When asked whether the respondents have experienced back and neck pains while using the jerry cans, 77% of all the respondents answered yes. In Machakos and Kilifi

County, over 98% of the respondents have experienced back and neck pains that they associate with the use of jerry cans. The percentage was slightly lower in Embu (59%) and Kiambu (54%) Counties. When asked if there has been a reduction of pain since they started using the water backpack, 67% of the respondents answered in the affirmative. 81% of these were from Machakos County, 90% from Kilifi County, while only 49% and 51% of the respondents from Embu and Kiambu Counties respectively answered this question in the affirmative (see figure 5).

CONCLUSION

There is overwhelming evidence that there is proper usage of the backpacks. It was also noted that the water backpack has resulted in creating awareness on use of water treatment methods leading to safe drinking water in the study regions. This was clearly stated by many residents who noted a reduction in waterborne diseases since the introduction of the packs. We plan to coordinate a further study to verify this claim from the health facilities within the region.

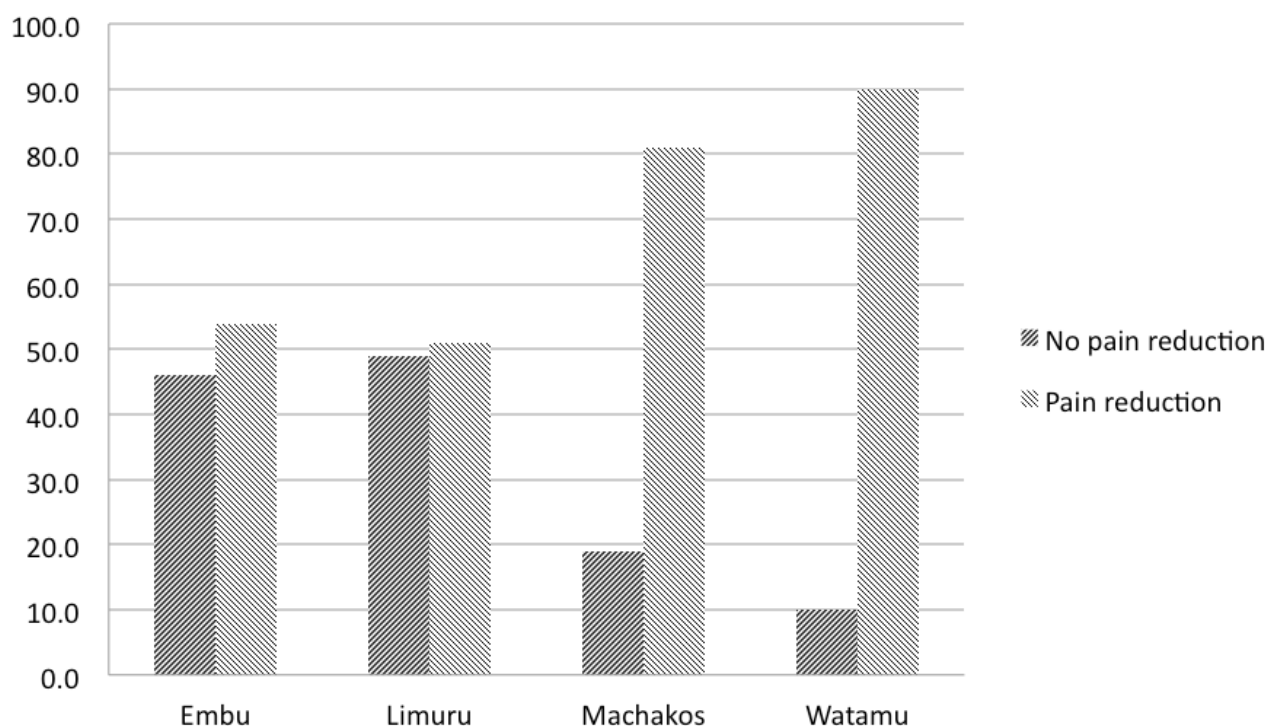


Figure 5. Rates of back and neck pain reduction after use of the water backpacks

The significant reduction in musculoskeletal injury following the introduction of the packs means that the women fetching water using the backpacks are healthier and can engage in other socio-economic activities. In addition, it was observed that use of the backpack made fetching water a good and decent experience. There was overwhelming evidence that additional water backpacks are necessary in the region. Most of the households had an average of six members and this necessitated fetching more than 40 gallons of water daily. There was therefore a tendency of using jerry cans to ferry water and water backpacks to store water since each household was only given one backpack. Residents also suggested that large sized water backpacks be provided for the purpose of water storage.

MEMORABLE QUOTES FROM THE RESPONDENTS

"Easy to carry! I am happy. Please, I would want more water backpacks."

"I am happy and this pack helps me to help my wife carry the pack. Thank you and God bless."

"Thank you for the water pack. It has prevented my children from getting waterborne diseases."

"My children used to be very sick with waterborne diseases, now it's no more. I am thankful for the water backpack."

Positive correlation is represented by blue shading while negative correlation is represented by red. The level of correlation significance is represented by the size of the circle.

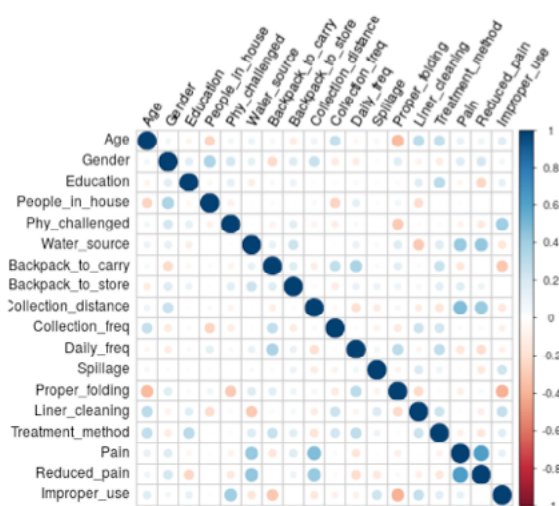
Conflict of Interest

The authors declare no conflict of interest in carrying out the research.

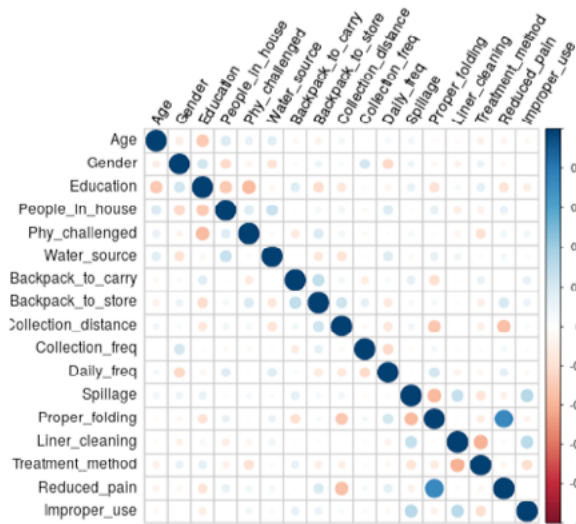
ACKNOWLEDGEMENTS

The authors acknowledge Mount Kenya University management for supporting execution and publication of this research. The contributions of Partners for Care (PFC) in distribution of the water backpack and assistance during data collection is highly appreciated. Lastly, the authors wish to acknowledge the support given by the county governments of Embu, Kilifi, Kiambu and Machakos.

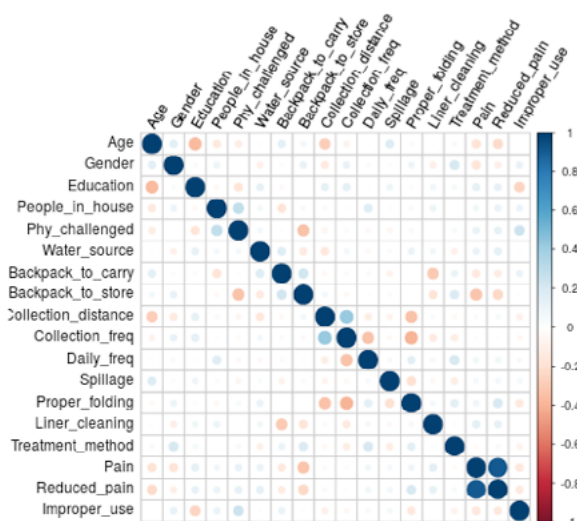
Embu



Machakos



Kiambu



Kilifi

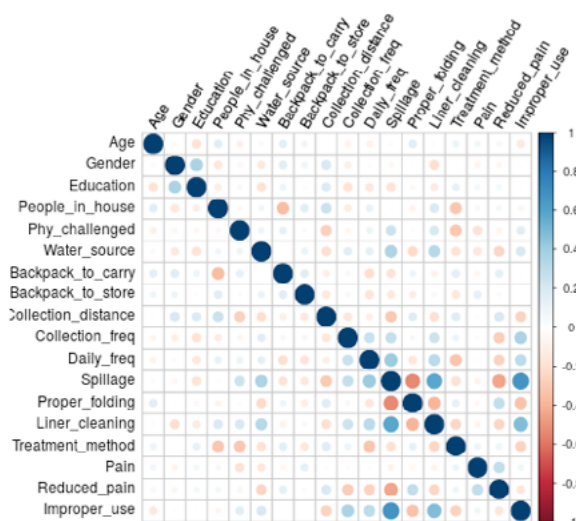


Figure 2. Correlograms showing different associations in the study

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