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Use, adoption and effectiveness of tippy-tap handwashing station in promoting hand hygiene practices in a resource-limited setting: A systematic review

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Abstract

Background A low cost and simple handwashing and enabling technology such as tippy-taps may provide adequate water sources, handwashing stations and motivation for people to prioritise handwashing. This systematic review aimed to establish the use, benefits, adoption and effectiveness of enabling technology; tippy-tap handwashing station, in resource-limited settings.

Methods We systematically searched for articles in the PubMed, EMBASE, PsycINFO, AMED, CINAHL, DOAJ and Google Scholar databases using a search strategy as predefined in the protocol registered with the PROSPERO database. Data were extracted and the quality of studies was appraised by the Mixed Method Appraisal Tool.

Results Twenty articles met the eligibility criteria. The use of tippy-taps for handwashing by household members or school children was reported by authors of 16 studies, and it ranged from 2.7% to 80%. The availability of tippy-taps increased handwashing and use of soap among participants. Furthermore, the majority of people who were oriented to tippy-taps or recruited to tippy-tap studies built their tippy-tap stations even after the promotional activities or programs ended. In one study, tippy-taps were found to be effective in preventing episodes of stomach pain among participants.

Conclusion Tippy-tap handwashing station could help in promoting handwashing practice in resource constraint settings. Future studies are needed to evaluate the effectiveness of tippy-tap hand washing station on preventing water and hygiene-related infections.

Background

The United Nations International Children's Emergency Fund (UNICEF) estimate that 884 million people in the world lack access to basic drinking water supply services [1]. The majority of these people live in rural areas of low and middle-income countries [1]. Lack of improved water sources in these areas is problematic not only to the households but also to the public facilities such as hospitals and schools [2]. The World Health Organisation (WHO) stated that 38% of healthcare facilities lack an improved water source, 19% lack improved sanitation, and 35% lack water and soap for handwashing in developing countries [2]. In addition, more than half of all primary schools in developing countries do not have adequate water facilities and nearly two-thirds lack adequate sanitation [1]. Where water or water stations are not readily available, neglecting hand washing is not uncommon. Failure to wash hands after visiting the toilet, before eating and feeding a child, before and after preparing food, and after changing and cleaning up a child who has used a toilet, increases the risk of contracting or spreading diarrheal and respiratory-related diseases [2, 3]). The World Vision International reported that inadequacy of water supply, sanitation and hygiene cause death of a child every minute, 80% of childhood diseases, 272 million days of school absenteeism and other health condition in the general population such as diarrhoea and respiratory disorders [4].

Although lack of resources and modern technology are commonly associated with the inadequate handwashing stations, low cost and simple handwashing and technology such as tippy-taps may provide adequate water sources, stations and motivation for people to prioritise handwashing [5]. Tippy-taps are simple and economic handwashing stations, made with locally available materials including plastic containers, jerry cans or gourds, and do not depend on a piped water supply [5]. Biran [6]describes a tippy-tap as 'a device consisting of a small (three or five-litre) jerry can be filled with water and suspended from a wooden frame. A string is attached to the neck of the jerry can that can be tied to a piece of wood at ground level. Pressing on this piece of wood with the foot, tips the jerry can to release a stream of water through a small hole. Soap is suspended from the frame beside the jerry can," (See Figs. 1 and 2). Furthermore, tippy-taps are very affordable, easy to construct, use very little water, easier to use and only soap is touched, thereby making handwashing very hygienic because it avoids contamination of the jerry can, unlike the real tap [6]. Tippy-taps could be a technology of choice for reducing diarrheal and respiratory disorders and deaths that are associated with inadequate water stations and hand hygiene practices, taking into account that handwashing education alone is not enough, but partly depends on the availability of other resources such as handwashing station, water and soap [7]. This systematic review was, therefore, conducted to establish the use, adoption and effectiveness of enabling technology: tippy-tap handwashing

Source: UNICEF/Zambia/2012/Asindua. Source: Mark Tiele Westra

The first tippy-tap was constructed by Dr Jim Watt and Jackson Masawi of the Salvation Army in Chiweshe, Zimbabwe, and was called the Mukombe in the 1980s. The Mukombe is a type of gourd or calabash, which is used as the can [6].Since then, many different versions of tippy-taps have emerged in different parts of the world, depending on the availability of the local materials [6].Tippy-taps can help to reduce the factors that hinder handwashing practice such as unavailability of handwashing station, water and soap [7]. The number of child deaths could be cut dramatically if a low-cost and simple handwashing program was widely promoted and used.

Tippy-taps are simple, economical (US$0–4) handwashing stations constructed from commonly available materials in underdeveloped rural areas [8]. In addition, tippy-taps are suitable for use in water-scarce resource places, because it uses only 40–50 ml of water per hand wash on average compared with 500–600 ml of water used in other methods of handwashing [8]. Furthermore, tippy-taps can help increase handwashing behaviour in schools because it is appealing to children since it is funny and easy to use [6]. Tippy-tap is possibly the best known low cost enabling technology for handwashing [6]. The UNICEF and Water Aid encourage and recommend the use of tippy-taps in schools and family houses next to the latrine [8]. Currently, tippy-taps are commonly used in some parts of Uganda, India, Mozambique, Tanzania and Zambia.

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Enabling technology is one of the factors that externally influence individual's probability to accomplish a behaviour [6]. The aim of this systematic review, therefore, was to gather, consolidate and quantify the

evidence of the use, benefits, adoption and effectiveness of tippy-tap handwashing station in promoting hand hygiene practices in resource-limited settings. Promotion of handwashing behaviour was the main outcome measure of concern in this systematic review. The questions that were addressed by this review are: 1) How does the use of tippy-tap handwashing stations promote hand hygiene practices in a resource-limited setting? 2) How effective are tippy-taps in promoting hand hygiene and reducing water and hygiene-related infections?

Methodology

Protocol

This review was guided by the acceptable best practice developed by the PROSPERO and COCHRANE for systematic search and selection of articles. The protocol was published in the PROSPERO database with registration number CRD42017074331 [9]. Details on the protocol have been published elsewhere In addition, a PRISMA flow diagram was used in this study to elaborate on the number of articles retrieved, retained, excluded and reasons for every action. A Mixed-Method Appraisal Tool (MMAT) was specifically used to appraise studies.

Inclusion criteria

The inclusion criteria for articles under review were: (1) studies that used tippy-tap hand washing station as a handwashing facility regardless of the design; (2) Studies that were published in peer-reviewed journals from the inception of databases to 2019.

Exclusion criteria

Papers written in languages other than English and papers with studies conducted in developed countries were excluded

Information Source /Search strategy

The following database sources were used to gather the required information; PubMed, EMBASE, PsycINFO, AMED, CINAHL, DOAJ and Google Scholar. Mesh terms were used during searching for the articles to ensure accuracy. Besides Mesh terms, keywords were also combined using Boolean operations OR and AND. Efforts were made to identify both published and unpublished interventional studies by manually checking the reference list of the articles that met the inclusion criteria. Hand searching in the key journals was also done. The search period for the research articles in the mentioned databases was from the inception of the databases to July 2019. The key search words used were: Tippy-taps, enabling technology, handwashing station, handwashing behaviour, diarrhoea, respiratory infection, increase handwashing behaviour (see Table1).

Study Selection

Identified titles from the databases were extracted and imported to Endnote X7 Reference Management System. Thereafter, duplicates were removed. The abstracts of the retained titles were retrieved and manually assessed for potential eligibility. Full articles were retrieved for the retained abstracts and these were thoroughly assessed manually for eligibility. Assessing eligibility for the articles was done independently by two reviewers using the predefined inclusion and exclusion criteria. Any disagreement between the two reviewers over the eligibility of particular studies were resolved through discussion with a third reviewer.

Data Collection Process

The process of data extraction started with database search of relevant articles using search terms while following the PRISMA guidelines (see Figure 1). A standardised form was used to extract data from the included studies for assessment of the study quality and evidence synthesis. The details included: author, year of study, type of participants, age, setting, country, sample size, study design, and methods, study purpose and objectives, study outcome measures. All relevant information was extracted from each study, summarised and documented (see Table 2). Two reviewers extracted data independently; discrepancies were identified and resolved through discussion with a third author. Missing data were requested from the corresponding authors of the study.

Search outcome

The search yielded a total of 4094 titles of articles of which 4021 were excluded in a preliminary assessment stage because they were duplicates or were based on different study areas. Seventy-three titles were retained, and their full articles were retrieved and assessed by two authors for eligibility. The third author validated the eligibility of the articles for inclusion in the review. From this assessment, only 20 articles met the inclusion criteria. Fifty-three articles were excluded from this systematic review because they did not meet the eligibility criteria (see Figure 1).

Risk of bias/quality appraisal

Quality of the design and reporting system were the main focus at this stage. Three review authors independently assessed the risk of bias in the included studies. The MMAT [10] was used to critically appraise the twenty studies included in the review. MMAT is a validated checklist used to appraise the quality of studies included in any systematic review with a quantitative, qualitative and mixed methods approach [11-13]. The MMAT has two general screening questions applicable to all study designs: 1) Are there clear qualitative and quantitative research questions or objectives, or is there a clear mixed-methods' question or objective? 2) Do the collected data address the research question or objective? The MMAT appraises the following study methodologies and designs: qualitative, quantitative randomised controlled, quantitative non-randomized, quantitative descriptive and mixed methods study designs. The tool is divided into five components and each component is designed to assess the quality of the specific

study design. These components are qualitative, quantitative randomised controlled, quantitative non-randomized, quantitative descriptive, and mixed methods studies. All components are numbered and each section has three to four assessment criteria. These criteria are given numbers using a multilevel numbering system, (first and second levels). For example, appraising a study with a qualitative design will use a qualitative component that has four quality assessment criteria numbered as follows 1.1, 1.2, 1.3 & 1.4. All components have four criteria except the mixed methods designs assessment criteria, which has three parts only [5.1, 5.1 & 5.3] [10]. Each criterion equals 25% if the assessment response is 'Yes', and zero if the response is 'No'. A summation of the responses is the total score of the quality of the study in per cent. In the assessment component for mixed methods, 25% is given by default and is summed up with other scores from the criteria under this component. Overall, the higher the score, the better the quality of the study. MMAT was chosen to appraise studies in this review because it can simultaneously appraise studies of different designs, which suits the diversity of study designs included in this systematic review.

Synthesis of Results

The review gathered, consolidated and quantified the evidence of the use, benefits, adoption and effectiveness of tippy-tap handwashing station in promoting hand hygiene practices in resource-limited settings. The main category of the analysis was based on the promotion of handwashing behaviour by using tippy-tap. Under this category, the reviewers came up with three subcategories, namely: effectiveness of tippy-tap, use and benefits of tippy-tap in promoting hand hygiene, and adoption of tippy-tap. Content analysis was carried out to synthesise the extracted data and similar information was grouped (see Table 2). Findings were presented in narrative form as shown below.

Results

Quality appraisal

Based on MMAT, eight studies scored 100% [14-21]; ten studies scored 75% [22-31] and two studies scored 50% [6, 32]. With an average MMAT score of 82.5% across the included studies, the studies are considered to be of high quality. Based on the quality of articles included in this review, the resulting synthesis can be relied upon to inform the education, practice, and policy regarding use, adoption and effectiveness of tippy-tap handwashing station in promoting hand hygiene practices in a resource-limited setting.

Study characteristics

The history of tippy-tap dates back to 1980s [6], the first peer-reviewed article was published in 1986 by Hurtado and colleagues. Thereafter, a gap ensued until 2011 when Biran and colleagues published the next paper on tippy-tap. In addition, applying filters in the search strategy did not include limiting the inception year for published articles, which may suggest that tippy-tap enabling technology is relatively a new concept in research area especially on the promotion of handwashing practice. The latest articles in

this field were published in 2019 [17, 29]. All studies in this review but one (n=18) were conducted between 2011 and 2019. Nine of the total articles reviewed were conducted within the last two years of conducting this systematic review.

Six studies were conducted in Uganda [6, 21, 26, 28, 30, 31], two in Ethiopia [18, 24], and two in Tanzania [14, 20]. Furthemore, one study was conducted in each of the following countries: Zambia [16], Zimbabwe [27], Kenya [23], Nigeria [22], Haiti [19], Malawi [17], Ghana [15] and Sierra Leone ([32]. The studies were conducted in communities either in a school or household setting (See table 2).

Six studies included in this review utilised qualitative design [6, 16, 21, 25, 27, 32]. Elleven studies used quantitative designs [14, 15, 18-21, 23, 24, 26, 29, 30].Three studies used mixed methods [17, 22, 28]. Data in the qualitative studies was collected through focus group interviews, semi-structured questionnaire and in-depth interviews. Those that used quantitative design utilised quasi-experiment, pre-post survey, cross-sectional survey and cluster randomised trials study approaches (see table 2).

Study participants

Regardless of study design and demographic characteristics of participants, studies that used tippy-tap handwashing station were included in this review, if they were published in a peer-reviewed journal and reported in English. In addition, there was no age specification for the participants involved in the studies that were included in this review. The youngest participants were infants less than eight months old in a study conducted by Mbuya et al. (2015). The oldest age was 40 years in a study by D Singh, R Cumming, N Mohajer and J Negin [21]. The number of participants in each study varied from five schools in a study by S Bresee, B Caruso, J Sales, J Lupele and M Freeman [16] to 2,875 households in a study by A Mwakitalima, K Massa, A Seleman and T Kassile [20].

Presentation of results

Studies included in this review were analysed based on the following three outcomes: the use and benefit of tippy-tap in promoting hand hygiene; adoption of tippy-tap and its associated hand hygiene resources, and the effectiveness of tippy-tap. These sub-categories were generated from the objective of the study. The presentation and interpretation of the results follow these categories as narrated below.

Use and benefits of tippy-tap in promoting hand hygiene

The use of tippy-taps for handwashing among household members or school children was reported by authors of 16 studies conducted in Nigeria, Haiti, Malawi, Ghana, India, Tanzania, Uganda, Sierra Leone, Kenya and Ethiopia [6, 14, 15, 17-20, 22-26, 28-30, 32]. The use of tippy-tap among the participants in the 16 studies ranged from 2.7% [26] to 80 % [14].

With regard to the benefits of using tippy-taps, authors of three studies [6, 24, 30] reported an increase in handwashing practice by participants after being exposed to tippy-tap. In one randomised controlled trial in Uganda, the researchers reported an increased estimate in the proportion of students reporting ‘always’

or ‘often’ washing their hands at school from 3.5% at baseline to 100.0% at follow-up (t=19.54, P<0.05, 95% CI 1.21– 1.68) in the intervention schools [replicated in control schools by Times 3 (t=12.92, P<0.05, 95% CI 1.48–2.45] [30]. In the same study, it was observed that the proportion of students ‘always’ washing their hands after using the toilet increased from 5.5% to 65.0% (t=14.61, P<0.05, 95% CI 1.02–1.58) in the intervention schools, while in the control schools washing hands after using the toilet among students increased from 3.6% to 79.3% (t=13.21, P<0.05, 95% CI 1.16–1.90) by Time [30].

In addition, tippy-taps increased use of soap by students in the intervention schools from 13.5% to 84.5% (t=5.64, P<0.05, 95% CI 0.29–1.04); handwashing from 5.5% to 93.0% (t=9.84, P<0.05, 95% CI 0.98–1.91) and handwashing after using the toilet from 5.5% to 65.0% (t=14.61, P<0.05, 95% CI 1.02–1.58) [30]. Similarly, A Biran [6] found that tippy-taps increased handwashing after latrine use by providing convenient soap and water, and by acting as a salient cue to handwashing. Although quantitative data on handwashing rates were not collected, participants in households with tippy-taps believed that their post-latrine handwashing rates had increased as a result of the tippy-taps [6]. Pre- and post-data analysis on self-reported handwashing revealed that the population-tailored interventions, especially the tippy-tap-promotion, performed better than the standard education intervention . In a study conducted [24] by Christensen in 2016, the use of tippy-tap was measured through the availability of handwashing resources (soap and water) at the tippy-tap station. Christensen found that enumerator-observed indicators of use, were still high (72–85% for having both soap and water present at tippy-tap station) [23]. In an Indian qualitative study, most participants reported using tippy-tap because of its benefits [25]. The participants reported that hand washing using tippy-tap requires less water and soap compared to the usual method of handwashing [25].

The economic benefits of tippy-taps were reported by the authors of a Nigerian study [22]. The installation of tippy-taps in small scale business facilities by women who were involved in selling food items led to an increase in the number of customers, which resulted in more sales and profits.

Adoption of tippy-tap and its associated hand hygiene resources

Authors of six studies assessed the adoption of tippy-taps by households [6, 16, 21, 23, 24, 31]. In a study conducted by Christensen (2016), the intervention households were significantly more likely to have a place for handwashing (71–85 percentage point increases) with soap available (49–66 percentage point increases) than controls. These authors also noted an increase of 86% in having a dedicated location for tippy-taps. Similarly, in another study, teachers educated school going children on tippy-tap as a handwashing station [16]. Although these children were not directly asked to construct tippy-tap, they all managed to attempt building one or influence their parents to assist them . Their parents trusted the information received from their children . The tippy-taps were also found to be attractive, easy to use and helpful in fostering the habit of handwashing among children [16].

Signh et al. [31] engaged the community in a hand hygiene promotion program. At one year follow-up, the researchers noted a 47% installation of functioning tippy-taps in the intervention villages compared to 35% in the control villages ($p < 0.002$) [31]. There was a large increase in the number of tippy-taps that

were built in the community from 4.7% of homes at baseline to 47% of homes after the intervention, which was undertaken by community members after being shown by the community health volunteers (CHVs) (. The CHVs implemented what they learnt during the training and were role models to other community members . Furthermore, there was a great improvement in owning tippy-taps by CHVs from 1% at baseline to 84% after interventions [31]. Another significant evidence of adoption of tippy-taps was observed in a study where all study households built tippy-taps within two weeks of counselling [27]. After one year of tippy-tap promotion, 80% of the households still had a tippy-tap installed, with evidence of use (water in the container and on the ground around the device). Similar results were observed in a study by Contzen et al., (2015) nearly 100% of the households followed the promotion and invested material and time to construct for themselves a tippy-tap. In the same study, all participants in the intervention group constructed tippy-taps and about 83% of these were still operational three months after termination of the interventions [24].

Although there is limited awareness on tippy-tap, having knowledge about tippy-tap did not result in immediate construction of the station [6, 16]. Some were thought to have constructed a tippy-tap because they were asked to do so, or they anticipated that the researcher would be visiting them regularly to evaluate the adoption of the technology [6]. Some participants constructed tippy-tap as a result of campaigns and fear of fines from community leaders, while others were reluctant to construct a tippy-tap because they thought that the enabling technology looked childish or was not attractive [6].

Effectiveness of tippy-tap

Incidence of diarrhoea

Out of twenty articles under review, only one study [30] had an incidence of diarrhoea as an outcome measure. The study was conducted in a school setting in Uganda and aimed at measuring the efficacy of a tippy-tap-based handwashing programme in promoting handwashing rates in elementary schools in rural Uganda. Zhang et al. (2013) used the pre-and post-intervention surveys in which four intervention schools were given tippy-taps, soap and educational materials, while four control schools initially received only educational materials. At each school, one classroom was selected randomly (lottery draw), and 25 boys and 25 girls (Grades 2–5) were selected from that classroom using a systematic random sampling design (every third girl and boy). Proxy data on the incidence of diarrhoeal disease was indicated by the number of students reporting stomach pain episodes in the previous month. The authors of the study found that in the intervention schools, the percentage of students reporting no stomach pain episodes increased from 7.0% at baseline to 80.0% after the intervention (t=10.84, P<0.05, 95% CI 0.92–1.68) [30]. However, no proxy data was provided on the trend of diarrhoea in the control group.

Discussion

The aim of this systematic review was to assess the use, benefits, adoption and effectiveness of tippy-tap handwashing station in resource-limited settings. A total of twenty articles were identified and reviewed. The findings of our systematic review show that the availability of tippy-taps increased handwashing and use of soap among participants. Furthermore, the majority of people who were oriented to tippy-taps or recruited to tippy-tap studies built their tippy-tap stations even after the end of promotional activities or programs. In one study, tippy-taps were found to be effective in preventing stomach pain episodes among participants [30].

There is sufficient evidence that hand washing is a single most important intervention for preventing diarrhoeal and respiratory infections yet the rate of handwashing in resource-limited settings is very low [3, 33–35]. The findings of this review have shown that tippy-taps have a great potential to improve the health outcomes of people as it increases handwashing and use of soap, which are crucial in breaking the transmission cycle of infections. Tippy-taps are commonly constructed near the toilet so that people can easily wash their hands after using the toilet. Studies have shown that convenient hand washing station increases handwashing and reduces microorganisms from the fingertips [36, 37]. In addition, tippy-taps are easy and cheap to construct as they are made from locally available resources. The tippy-tap technology is one of the interventions that people working in the field should promote in resource-limited settings where the majority of people fetch water from community boreholes or wells which are far from their houses.

A tippy-tap is one of the cost-effective handwashing stations that can easily be embraced by the community because it is made from locally available resources [5, 8]. The findings of this study have revealed that tippy-taps have a higher likelihood of sustainability. Majority of the participants who constructed their tippy-taps were still using them even after the end of interventions or promotional programs [6, 21, 24, 27, 30]. There was good adoption of the tippy-tap more generally as evidenced by the construction of tippy-taps; availability of water in the tippy-tap and on the floor around the tippy-tap; the existence of tippy-tap three months and one year after the termination of the program and availability of handwashing soap on the tippy-tap. This trend may signify that there is a high likelihood of adoption of the enabling technology in resource-limited settings. It is, therefore, important for public health workers and policymakers to incorporate and encourage the use of tippy-tap in resource-limited settings where it is expensive to construct handwashing sinks. It is also crucial to provide education regulary about tippy-taps to people in the communities to motivate them to use or adopt tippy-taps.

Although more than three decades have passed since the first tippy-tap was constructed, the findings of our systematic review show that there is still limited data regarding its use and effectiveness. Only a few studies have specifically evaluated tippy-tap as an intervention. Out of the seven studies included in this study, only three were experimental studies [23, 24, 30]. Out of these three experimental studies, only one [30]specifically evaluated the effectiveness of the tippy-tap in preventing stomach pain episodes. In the other two studies [23, 24], tippy-taps were part of a combined water and hygiene interventions that were evaluated together. While Zhang and colleagues (2013) reported that tippy-taps were effective in reducing stomach pains episodes among the participants in the treatment group, the study lacked information

regarding blinding of participants and measures of fidelity. The findings should, therefore, be interpreted with caution as it is difficult to rule out the risk of bias. Notwithstanding these limitations, all the studies except two, scored high (≥ 75%) on quality appraisal using MMAT with eight articles scoring 100%. This entails that the majority of the studies included in this review were of moderate or strong quality.

The findings of this review draw attention to the need to establish the effectiveness of tippy-taps on preventing ailments associated with unhygienic practices. Future well-designed randomised controlled trials with rigorous methodology are warranted to evaluate the effectiveness of this intervention in preventing infection in a resource-limited setting. Although schools are places where children spend much of their time, interact with others and easily get or transmit infections, only four studies [15, 16, 28, 30] included in this review had schools as a study setting. Future studies conducted in school settings are therefore necessary.

Conclusion

Tippy-taps have great potential to improve health outcomes of people living in resource-limited settings where waterborne diseases are common. However, with limited data, it is difficult to ascertain how common tippy-taps are within the community or how effective they are in reducing infections associated with poor hand hygiene. More prevalence and experimental studies are warranted to provide a good understanding of the use, adoption and effectiveness of tippy-taps. To the best of the authors' knowledge, this is the first systematic review to assess the use, adoption and effectiveness of tippy-tap handwashing station in promoting hand hygiene practices in a resource-limited setting.

Declarations

Competing interests

The authors declare no competing interests.

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Availability of data and material

The data and all supporting materials used in our manuscript are freely available to any scientist wishing to use them without breaching.

Author contribution

Design of the literature review: BCM, FWK & MZ

Protocol writing and publication in PROSPERO: BCM, FWK & MZ

Literature search: BCM, FWK & MZ

Data analysis: BCM, FWK & MZ

Manuscript writing: BCM, FWK & MZ

Critical revision or important intellectual content: BCM, FWK & MZ

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Figures



Figure 1

A boy washing hands using tippy-tap. SOURCE: UNICEF/Zambia/2012/Asindua



Figure 2

An examples of a tippy-tap Source: Mark Tiele Westra

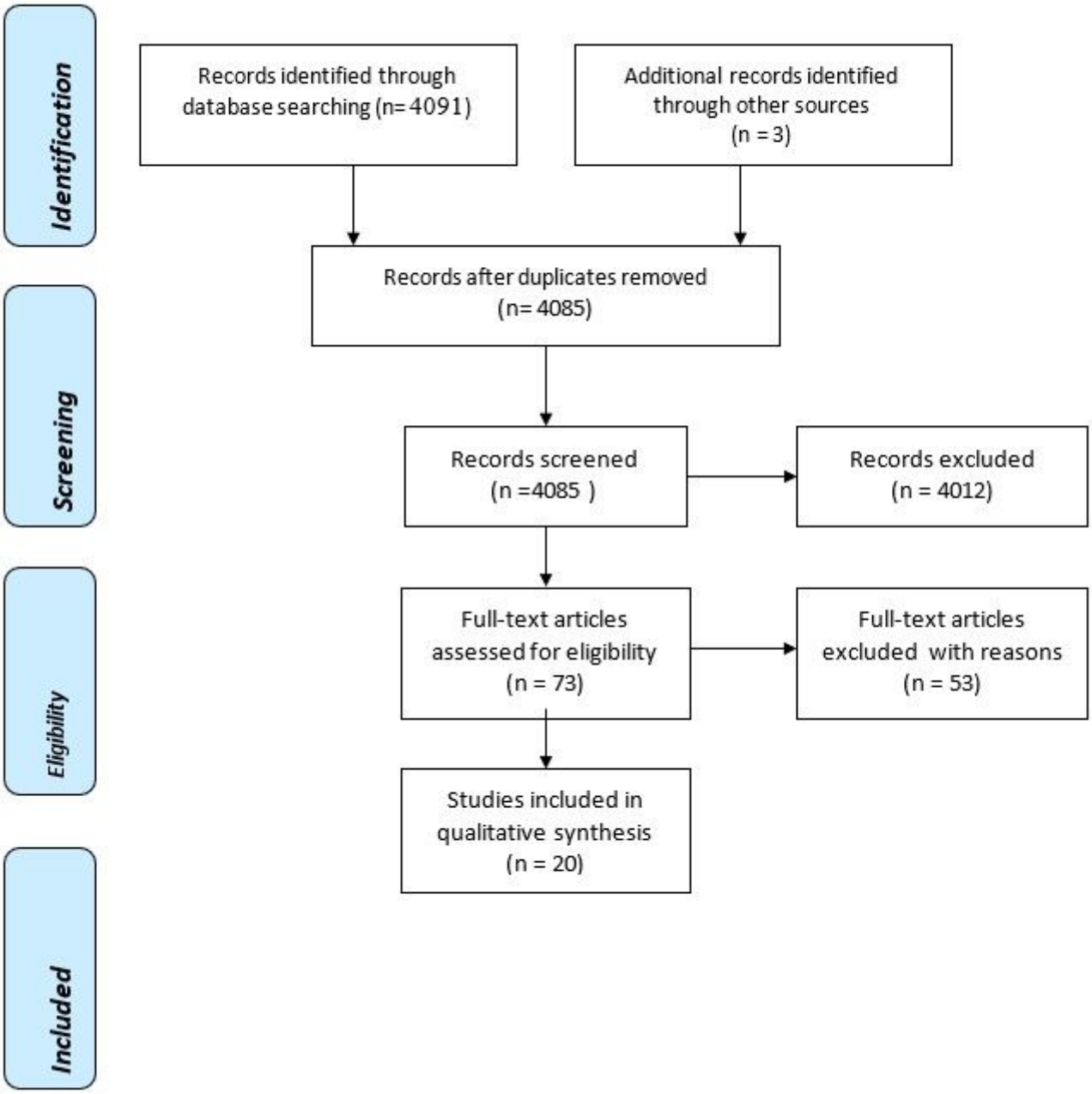


Figure 3

PRISMA Flow Diagram