Data gaps in evidence-based research on small water enterprises in developing countries

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ABSTRACT

Small water enterprises (SWEs) are water delivery operations that predominantly provide water at the community level. SWEs operate beyond the reach of piped water systems, selling water to households throughout the world. Their ubiquity in the developing world and access to vulnerable populations suggests that these small-scale water vendors may prove valuable in improving potable water availability. This paper assesses the current literature on SWEs to evaluate previous studies and determine gaps in the evidence base. Piped systems and point-of-use products were not included in this assessment. Results indicate that SWEs are active in urban, peri-urban and rural areas of Africa, Asia and Latin America. Benefits of SWEs include: no upfront connection fees; demand-driven and flexible to local conditions; and service to large populations without high costs of utility infrastructure. Disadvantages of SWEs include: higher charges for water per unit of volume compared with infrastructure-based utilities; lack of regulation; operation often outside legal structures; no water quality monitoring; increased potential for conflict with local utilities; and potential for extortion by local officials. No rigorous, evidence-based, peer-reviewed scientific studies that control for confounders examining the effectiveness of SWEs in providing potable water were identified.

Key words | community water, drinking water, independent water provider, private water vendor, small water enterprises, water kiosk

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INTRODUCTION

Small water enterprises (SWEs) have gained increasing attention over the last decade as governments, non-governmental organizations (NGOs) and global institutions search for mechanisms to increase access to potable water for approximately 1.1 billion people currently lacking safe drinking water (WHO/UNICEF/WSSCC 2000). These water providers often work where utilities have not been extended, cater to marginalized populations and utilize a wide range of methods to deliver water to their customers. It is hypothesized that in many developing cities more people are served each day by SWEs than by utilities (McGranahan *et al.* 2006). The market share of small-scale providers in developing countries is unknown but a study by Collignon and Vezina for the World Bank demonstrated that there is considerable variability between entrepreneurs, who are supplying water to 30–80% of the households in ten African cities (Collignon & Vezina 2000). A study by Conan for the Asian Development Bank (ADB) determined that the range of activity for SWEs was between 6% and 44% of the water market in eight Asian cities (Conan 2003). The Johns Hopkins University Center for Water and Health conducted an extensive literature assessment on SWEs to evaluate the contribution of these providers to the delivery of potable water, the diversity and distribution of SWE market implementation models and to determine the gaps in existing evidence of SWE effectiveness.

Access to safe drinking water is a global public health priority as indicated by Goal Seven of the United Nations (UN) Millennium Development Goals (MDGs), which aims to halve the proportion of people without access to

doi: 10.2166/wh.2009.213

sustainable safe drinking water by 2015 (UN 2000). One solution that has emerged as a potential mechanism towards achieving Goal Seven is providing drinking water sold by vendors at the community level or directly to households as opposed to water that is delivered through piped water supply systems. Although water supplied by small-scale water vendors is not included in internationally recognized definitions of safe drinking water, as this water is not considered to originate from 'protected' sources, their ubiquity in the developing world and their access to vulnerable populations suggests that small-scale water vendors may prove valuable in improving potable water availability (UN/UNESCO 2003).

Achievement of MDG Goal Seven will be difficult for numerous reasons. Many communities have never had access to public water infrastructure, particularly in Africa and Asia, and many existing piped water supply systems in low-income countries are falling into disrepair, forcing households to search out alternatives (Thompson *et al.* 2000; Lee & Schwab 2005). Urban and peri-urban populations continue to expand; an estimated 90% of the growth in global population between 2000 and 2025 is expected to occur in urban areas of least developed countries, according to a report from the Population Reference Bureau (Brockerhoff 2000). Additionally, expansion of water utilities is at risk according to a 2005 World Bank study which reported that government and private sector funding for major infrastructure investments in the water sector is being scaled back (Kariuki & Schwartz 2005). It is estimated that almost half of the urban and peri-urban areas in Africa are dependent on water sources other than public utilities (Collignon & Vezina 2000). Large-scale water systems take years to plan and build along with millions of dollars to fund. Thus, solutions to improving access to potable water by 2015 are predominantly focused on enhancing existing water sources and on methods to improve drinking water quality in a cost-effective manner.

The objectives of this landscape assessment were to assess the available literature on SWEs along with implementation methods and technologies used by small-scale providers to distribute potable drinking water to populations that are beyond the reach of existing improved water supplies. This assessment does not include piped or networked water supply systems nor does it focus on policy or governmental regulations. Additionally, this assessment will recommend a research agenda to advance knowledge on effective methods of potable water provision by SWEs.

METHODS

A broad review of the literature on SWE was conducted. Online searches for relevant literature were conducted through large search engines and topic-specific websites. Table 1 provides the list of sources searched for relevant documents and articles. Documents and articles were also obtained from researchers and organizations working in the field along with articles identified through reference lists from previously identified research papers.

Articles collected during the search were then screened for relevance. Any materials pertaining solely to tariffs, piped or networked systems, point-of-use water treatment, policy or regulations were excluded from the review unless they specifically detailed small-scale water providers. There was insufficient peer-reviewed literature on SWE use of

Table 1 | List of sources searched for relevant documents and articles

Search engines	Websites searched
Google	African Ministers' Council on Water
Google Scholar	African Development Bank
IngentaConnect	Asian Development Bank
PubMed	Blue Revolution Initiative
Scopus	Building Partnerships for Development in Water and Sanitation
	Eco-Asia Project
	International Rescue Committee
	Microfinance Gateway
	ScienceDirect
	South East Asian Water Utility Network
	United Nations Environment Programme
	United States Agency for International Development
	Water, Engineering and Development Centre, Loughborough University
	World Bank
	World Health Organization

rainwater harvesting for this process to be included. Additionally, this assessment did not address the ongoing debate within the water sector on water as an economic good versus basic entitlement (Allen *et al.* 2006).

There is no one universally accepted terminology describing the water providers evaluated in this assessment. Key words used during literature searches included: private water vendors, small-scale independent water providers, small water enterprises, small water entrepreneurs, small and medium entrepreneurs and small service providers. Throughout this document, these water providers will be referred to as SWEs.

Articles which met the selection criteria were then assessed in detail for the quality and characteristics of the study as well as the key findings of the research. Articles were categorized into four levels of relevance for this assessment (Table 2). The greatest weight of evidence was given to those documents in the first level with progressively less weight to the subsequent levels.

Data provided within articles and documents were also categorized using the following characteristics: population covered (urban, peri-urban, rural), vendor type (tankers, carters, water kiosks, carriers), financing model (micro-credit, micro-loan, micro-franchising) and water treatment technology (filtration, ultraviolet radiation, chlorine, reverse osmosis, solar, other).

RESULTS

One hundred and twenty documents were reviewed for this assessment and 62 of these documents were found to be relevant. Many of the documents excluded from the final analysis focused only on networked systems and, therefore, did not meet the inclusion criteria. The following sections provide data collected from review of the relevant documents.

Table 2 | Levels of relevance used to categorize articles

Level	Description
1	Independently peer-reviewed journal articles originating primarily from academic journals
2	Articles from national and international organizations that underwent internal peer review (i.e. within the organization that produced the document)
3	Conference proceedings from water-related meetings and symposia
4	Field reports or draft articles not yet in publication neither of which have undergone a peer-review process

Overview of SWE research

Recognition of the vast numbers of households in low-income countries which depend on SWEs has grown dramatically since the 1980s. One of the earlier studies to examine water vending was conducted by Zaroff & Okun (1984). Vendors were viewed as an interim solution before utilities were built or completed. The researchers noted that SWEs were most active in areas that had multiple barriers to piped systems or where the utility-supplied water was unsanitary or inconvenient. Barriers to constructing piped systems included terrain that was difficult to access with piping, high costs of utilities, squatter settlements that are not officially recognized, rural areas where housing is extremely spread out and peri-urban areas that spring up too quickly for utilities to keep pace (Zaroff & Okun 1984).

During the 1980s, as the International Drinking Water and Sanitation Decade progressed, much of the world's resources in the drinking water sector focused on subsidizing the construction of piped water supply systems in urban areas and the installation of handpumps in rural areas in an effort to supply adequate water to all people by the end of the decade (UN/UNESCO 2003). The construction of water utilities was supply-driven with subsidies for drinking water provided by the international community and national governments. As awareness of the small-scale water vending market grew, there was a concomitant shift in the literature to recognize the potential to improve access to drinking water supply through demand-driven water markets. By the end of the 1990s, a number of articles and reports had been produced by the World Bank detailing case studies of successful independent water suppliers which were found to be widespread in low-income countries (Cairncross 1992; Komives & Cowen 1998; Snell 1998; Solo 1998, 1999). In a literature review of non-state providers, Moran & Batley (2004) speak of this 'paradigm shift from supply-side to demand-side management' in the water sector having important implications for the way

private water vendors are viewed by governments. More and more governments are now recognizing, accepting and, in some cases, encouraging the critical role SWEs play in providing access to drinking water to some of the most vulnerable populations (Crane 1994; Moran & Batley 2004).

In many areas, the combination of public utility water and private vendors in urban areas has created a dual system of supplied water, as described by Moran & Batley (2004). The primary drinking water system is delivered to higher income households with connections to the formal, state-provided water supply at a single rate price which is too low to support expansion of the network. The secondary system is comprised of private water vendors charging higher prices per unit of water for the supply of variable quality water to newer, low-income households. These dual water supplies are found in numerous countries, where in many instances the utilities are unable to keep up with operations, maintenance and expansion demands because of the low, subsidized fees paid by households, resulting in increasing demand for private water vendors.

Owing to the lack of network water supply to marginalized populations, research has focused attention on alternative methods of water provision. The prevalence and importance of SWE have been well described in several large studies and reviews. These articles form the basis for much of the ongoing research into SWEs. Snell (1998) of the World Bank's Water and Sanitation Programme (WSP) provided an early overview of types of water vendor found throughout the developing world in, *Water and Sanitation Services for the Urban Poor. Small-scale Providers: Typology & Profiles*. Other key studies include the following: 'Small-scale entrepreneurs in the urban water and sanitation market', a broad summary of WSP research in urban Africa, Asia and Latin America (Solo 1999); *Independent Water and Sanitation Providers in African Cities,* a 10-country study in Africa by the World Bank's Collignon & Vezina (2000); *Independent Water Entrepreneurs in Latin America* (Solo 2003); *Asian Water Supplies,* a report to ADB (McIntosh 2003); and most recently a series of detailed field reports from the Water, Engineering and Development Centre (WEDC) at Loughborough University, UK (Gadir 2006; Materu & Mkanga 2006; Oenga & Kuria 2006; Sarpong & Abrampah 2006). Table 3 provides a summary of the key findings of these studies.

Types of vendor

The literature provides descriptions of a wide variety of SWEs; there is no one standard definition because of their informal and improvisational nature (Kariuki & Schwartz 2005). The services and distribution types of SWE can best be described using terms first used by World Bank studies, which divide water providers into three broad categories: wholesale vendors, distributing vendors and direct vendors (Collignon & Vezina 2000; McGranahan *et al.* 2006). Wholesale vendors may own a borehole or may buy water in bulk either from private borehole owners or from utility companies. These vendors own or rent tanker trucks with large capacity which allows them to then sell bulk quantities of water to small-scale vendors.

Distributing vendors go to the consumer, usually door-to-door, and make up the majority of the SWE (Collignon & Vezina 2000). The majority of distributing vendors are water carters who tend to be young, migrant men from rural areas who need little investment to get started. They carry the water in carts drawn by hand, animals, bicycles or motorbikes. Hand-carrying water vendors haul water in buckets or other smaller containers by hand, without carts or animals, and earn very small wages. Once abundant throughout many low-income cities, vendors hauling water by hand are declining in number as more use carts to haul the water (Collignon & Vezina 2000). Hand-carrying and hand-carted water vending tend to be the most physically taxing but are often among the most easily entered businesses requiring little funds for start-up. Distributing vendors typically sell water in volumes varying from cupfuls, bucketfuls or 20-litre jerrycans. Some vendors also distribute drinking water in single use disposable plastic sachets (Ampofo *et al.* 2007).

Tankers may also be used by distributing vendors, delivering water to wealthier households that have large storage tanks or to large facilities such as hotels or restaurants. Tankers are also used during festivals and special events such as weddings to supply large quantities of drinking water. Distributing vendors tend to charge the highest price since they provide the most customer service (e.g. delivering to the door) and serve peak demands for people who have little time for water collection or can pay for the convenience (Snell 1998).

Table 3 | Summary of key findings from large population-based studies and reviews involving SWEs

Title	Author and year	Population studied	Key findings
Water and Sanitation Services for the Urban Poor. Small-scale Providers: Typology & Profiles	Snell 1998	Africa, Asia, Latin America, Caribbean	Categorized small-scale water providers by method of delivery and services rendered Outlined key components of successful water providers Documented global importance of SWEs to drinking water supply
Small-scale entrepreneurs in the urban water and sanitation market	Solo 1999	Africa, Asia, Latin America	SWEs provide demand-driven business with strong customer service and flexible delivery Advocates the benefits of water vendor trade associations and vendor competition
Independent Water and Sanitation Providers in African Cities	Collignon & Vezina 2000	Africa	Competition critical to ensure fair pricing and efficient services SWE services respond to wide variety of customer water needs Official recognition of SWE needed
Independent Water Entrepreneurs in Latin America	Solo 2003	Latin America	Small-scale water providers may have lower costs than public utility-supplied water Government policy should recognize small-scale providers where they improve access to water for the poor
Asian Water Supplies: Reaching the Urban Poor	McIntosh 2003	Asia	SWE prevalence in urban areas: South Asia 5–10% Southeast Asia 20–45% Poor generally pay more for water Need for accountability, efficiency, transparency and equitability SWEs need access to financing
Small Water Enterprises in Africa – Tanzania	Materu & Mkanga 2006	Dar es Salaam	Focus of improvements should be on water quality and pricing Details benefits of water kiosks extending utility supply Community involvement in planning critical
Small Water Enterprises in Africa – Kenya	Oenga & Kuria 2006	Nairobi	Informal settlements rely on SWEs for water SWEs constrained by lack of recognition by authorities, operating costs, lack of capital base
Small Water Enterprises in Africa – Sudan	Gadir 2006	Khartoum	SWEs usually males Customers favourable toward SWEs Role of SWEs not acknowledged by government or utility
Small Water Enterprises in Africa – Ghana	Sarpong & Abrampah 2006	Accra	Utility water primary source of SWE water Key concerns include: water quality, pricing, water supply, financing, technology, recognition

Direct vendors have consumers come to them. Direct vendors also tend to charge mid-range prices and are in greatest demand where well water is of poor quality or is too expensive (Snell 1998). In many urban areas in low-income countries where utilities reach only a portion of the population, direct vendors can be dominated by households with piped water supply connections that resell the water to households without connections, thereby extending the reach of the public utility either legally or illegally. Water kiosks are another type of direct vendor commonly found in Africa and Asia (Kjellen & McGranahan 2006; McGranahan *et al.* 2006). There is a variety of kiosk models presented in the literature although a kiosk is generally described as a stationary water sales point with an operator who monitors the quantity – and in rare instances the quality – of water sold and collects payments. Kiosks may be divided into two categories based on water source: those that are extensions of public utilities and those that are erected from private or community-owned water sources. Kiosks are often used by the poorest households and allow the purchaser to control the volume of water purchased and total cost since the purchaser travels to the water and does not require additional services such as door-to-door delivery (Collignon & Vezina 2000).

Some 'kiosks' are solitary standposts with no treatment of the water, while other kiosks are more elaborate, having a shelter along with various types of water treatment devices. Water treatment ranges from simple cartridge filters or sand filters to more advanced systems such as UV lights, chlorination or reverse osmosis units (McIntosh 2003; McGranahan *et al.* 2006; Albert *et al.* 2008). Water may be sold from kiosks directly into water vessels brought by customers or in prepackaged containers supplied by the kiosk operator. A survey conducted in September 2007 by the Aquaya Institute and the Dian Desa Foundation in Yogyakarta, Central Java, also reported kiosks that provide washing stations for water containers to decrease the likelihood of contamination being introduced during transport and storage (Albert *et al.* 2008). Furthermore, while men dominate most of the SWE sector as carriers, carters and truckers, women may often be found as kiosk operators (McGranahan *et al.* 2006).

Recent studies have mentioned the expanding 'value-added water' available through bottled water (Conan 2003; Solo 2003). This water is usually treated and marketed as a safer alternative to other drinking water sources such as utility-supplied water, although the water is often bottled directly from the utility system without additional treatment. Bottled water has been found to be more expensive than other vended drinking water and is often seen as a status symbol, although few studies have compared bottled water with other vended water (WSP 1999). Additional types of vended water include water sachets and ice blocks which have been documented for sale in some African and Latin American cities (Solo 2003; Sarpong & Abrampah 2006; Okioga 2007). Water sachets are bags of water that may be filled and sealed in a factory or may be hand-filled. Typically 0.4 to 0.6 litre sachets have come under criticism in Ghana over the last few years as a large source of plastic waste. People buy them, drink the contents immediately and dispose of the bag on the ground (UN Office for the Coordination of Humanitarian Affairs 2003).

In most low-income countries, water collection is the work of women and children (UN/UNESCO 2003). It has been noted that the location and timing of water collection can be affected by concern for women's safety (Plummer 2002). Women and young girls are often at risk of harassment or rape when collecting water in remote places or outside of daylight hours (Fisher 2006; UNICEF 2006). In Muslim countries, especially where purdah (i.e. seclusion of women) is observed, women may not be allowed to collect water from communal sources for cultural reasons. Households will often opt for home delivery of water when feasible to avoid harassment of women and girls in public in regions where water collection puts them at heightened risk (Plummer 2002).

Key characteristics of SWEs

There are a number of general characteristics of SWEs which are commonly described in the literature. SWEs are found to operate in a wide variety of settings including urban, peri-urban and rural areas, particularly in informal settlements, in almost all low-income countries. Informal settlements are not officially or legally recognized, which

frequently precludes governmental utilities from delivering services. Examples can be found in the literature which detail SWEs functioning successfully in these settlements (Zaroff & Okun 1984; Solo 1999). It is estimated that, in many instances, informal settlements can make up to 50% of some urban and peri-urban populations (Plummer 2002). Multiple studies describe a leading benefit of SWEs to be their ability to adapt to local conditions and norms. In many instances SWEs are able to access even the most remote populations regardless of terrain, governmental boundaries, regulation, economic condition and population density. In contrast, utilities can become limited in their ability to expand in areas where the terrain becomes prohibitively expensive to traverse, the population density is low, and/or communities are not legally recognized (Solo 1999; Collignon & Vezina 2000; McIntosh 2003; Solo 2003; McGranahan *et al.* 2006).

Another commonly recognized benefit of SWEs is their ability to cater to poor households by allowing the intermittent purchase of water in quantities these households can afford. SWEs supply drinking water to all income levels but it is typically the low-income households that are most dependent on this source of water (Solo 1999).

While piped systems often require an upfront connection fee, SWEs require no large fee and have been found to allow flexibility of payment and even short-term credit to their customers (Collignon & Vezina 2000; Plummer 2002).

In some urban areas in Africa, there has been a documented rise in door-to-door delivery by water vendors who have purchased their supply from local vendors and resell to households. This phenomenon has come about as more household members work away from home leaving fewer people at home to haul water (Collignon & Vezina 2000). However, in almost all instances, the microbial and chemical quality of vended water is unknown and not monitored.

Regional differences in SWEs

The majority of documents available on small-scale, non-piped water vendors were produced by international organizations reporting on field activities in urban and peri-urban areas with a focus on Africa and Asia. A wide variety of SWE adaptations are spread broadly around the world, with very little substantial documentation of effectiveness of any one model.

Africa

In Africa Collignon & Vezina (2000) reported that over half the urban population depends on private water providers and estimate that private water providers account for about 1% of the active urban labour force in Africa. In a study comparing water supplies in 1967 with water supplies in the same urban East African sites 30 years later, researchers found a huge increase in water vending in low- and medium-income areas (Thompson *et al.* 2000). In these urban areas, kiosks had been created from privately bored wells and maintained positive customer relations because of their convenient locations, reliable supplies and perceived good water quality. A study of urban water supplies in Kenya reported that kiosks have improved access to drinking water for thousands of poor households that are not connected to utilities. The study found that 77% of kiosk users are poor while 5% of households with piped connections are poor. However, it was also found that kiosks were not a desirable solution for all users in comparison with piped networks owing to the cost, time spent on water collection and distance water needed to be carried (Gulyani *et al.* 2005).

Asia

McIntosh's overview of Asian water supplies reports that small water providers serve approximately 20–45% of households in Southeast Asia and 5–10% of households in South Asian cities. The report notes that countries with utilities providing good service and low connection fees have fewer SWEs (McIntosh 2003). Therefore, SWEs play a relatively minor role in South Asia, complementing free water available from standpipes mostly through tanker service when service quality is low or unreliable (Conan 2003; Kariuki & Schwartz 2005). Crane details the impact of deregulation in Jakarta which allowed households with water utility connections to resell municipal water (Crane 1994). He found a significant number of households switched from standpipes and vendors to resold municipal water after deregulation.

Latin America and the Caribbean

In Latin America and the Caribbean, water vendors tend to provide mostly piped water service to peri-urban, small town and rural populations (Kariuki & Schwartz 2005). Solo has written extensively on the water vending activities of *aguateros* and others, who construct small network systems to extend public utilities in unincorporated areas and whose activities have been documented in Peru, Honduras and Guatemala (Solo 1998, 1999, 2003). However, as previously mentioned, piped networks are not the focus of this assessment. Solo has also found that laws governing SWEs are quite diverse among Latin American countries; countries such as Peru and Colombia strongly encourage a private sector water service while in Bolivia the private water sector is highly regulated (Solo 2003). The legal status of SWEs can also be constrained by national rights, which often specify that the state has ownership and sovereign right to ground and surface water in most of South America (Solo 2003).

Other regions

Kariuki & Schwartz's literature review highlights regions in which water vending has not been well described but is thought to be active. These regions include some of the world's largest populations such as China, Russia, Brazil, Mexico, the Middle East, North Africa and Central Asia (Kariuki & Schwartz 2005).

Drinking water market and financing

Despite decades of subsidies for water utility systems, poor populations are currently paying for their water throughout the world and often paying more than affluent populations. There is an estimated US$20 billion annual household water market base among the 3.96 billion low-income consumers who live primarily in developing countries considered to be at the 'base of the pyramid' (Hammond *et al.* 2007) (see Table 4).

In much of the early SWE research, water vendors were thought to be exploiting vulnerable populations by charging extravagant prices where alternative water sources were scarce. Prices were reported to be up to 40 times that charged by water utilities in areas where the utility supplied the water which was then trucked or carted to neighbouring areas beyond the water lines (Zaroff & Okun 1984). Though still significant, recent evidence suggests much less disparity between the prices of vended water and utility-supplied water. Kariuki & Schwartz found that water collected from point sources and sold through SWEs cost up to 4.5 times utility water while water delivered door-to-door cost up to 12 times utility-supplied water (Kariuki & Schwartz 2005).

Table 4 | 'Base of the pyramid' annual household water market in US dollars (Hammond *et al.* 2007)

	Total estimated water market US$ (billions)	Total estimated population
Asia and Middle East	6.4	2.9 billion
Africa	5.7	486 million
Latin America	4.8	360 million
Eastern Europe	3.2	254 million
Total*	20	3.96 billion

*Columns do not add up to total because of rounding

Water vendors do not have access to the subsidies that support most water utility systems so it is not surprising that SWE's products are more expensive. Several articles account for the higher cost of vended water over utility-supplied water as due to the labour-intensive nature of water vending coupled with the added cost of vended water arising from the additional service of providing water in a variety of quantities without the advantages of economies of scale (Snell 1998; Solo 1999; McIntosh 2003). There have been efforts to regulate vended water but the evidence suggests the fixed-price approach is often not successful. Even where contracts have been arranged between water utilities and vendors to set a resale price of utility-derived water in order to ensure the subsidy is passed on to the customer, the actual resale price has been shown to be higher than the set price (Collignon & Vezina 2000).

SWEs provide a demand-driven water supply which allows basic water service to be sustainable without the input of subsidies. Private water vending is a competitive business in most areas and prices are set to cover costs (Solo 1999). At times when money is needed for their business, SWEs typically raise funds from informal sources to finance the purchase of equipment such as carts, trucks or kiosks.

The sources of financial support include personal savings, family members, community savings clubs, informal money lenders and loans from suppliers (Collignon & Vezina 2000).

Many of the articles reviewed for this assessment discussed the need for financial services to small local water vendors to expand access to potable water, but there was little evidence of effective utilization of microfinancing schemes (Snell 1998; Solo 1999; McIntosh 2003; Winpenny 2003; Mehta & Virjee 2003). Truckers are often the only type of water vendor able to access formal loan programmes, since there is a tangible asset to support the loan (Snell 1998). Other vendors often obtain credit through informal sources that may charge between 5 and 10% interest per month (ADB 2003). These water vendors are limited in their ability to expand or provide water treatment for their product by their lack of access to long-term credit or reasonable interest rates.

The Camdessus report recognized that microfinance schemes are 'relatively young' in sub-Saharan Africa in comparison with Asia and Latin America (Winpenny 2003). Mehta & Virjee (2003) further report that there are two main constraints to microfinancing in the water sector in sub-Saharan Africa: limited outreach and the lack of market-linked product development. A later report from 2007 reinforces the need for capacity-building in Kenya's microfinance sector to support the development of water vending initiatives even though Kenya has the largest level of microfinancing to the poor with about 30% penetration of poor populations (Mehta & Virjee 2007). Kiosk operators/owners are more likely to require access to capital than water carters owing to the higher start-up costs and maintenance requirements (Winpenny 2003). However, the lack of legal status for water vendors in many countries makes private investment difficult and increases the possibility of investments being expropriated (Collignon & Vezina 2000). Micro-franchising is also supported in theory as a valuable tool for expanding water supply through SWEs but there is no evidence of its effectiveness with non-piped water supplies (Van Ginneken *et al.* 2003).

The Solo (2003) World Bank report noted that several market-based approaches need to be used for water vendors to sustain their businesses and that strong relationships built between some SWEs and their customers were critical to the success of the small-scale water business. Successful market-based approaches to vending water respond to household ability to pay and include selling water in varying quantities and providing different levels of service, from distributing water at selected outlets within a community, to home delivery (Solo 2003). Additionally, to improve business, vendors should enhance customer loyalty through personal attention and even attempt to lock customers into supply contracts to ensure sustainability. The report concluded that creating a 'distinctive water' product would support a small-scale vendor's business. Marketing safe water has also been shown to improve water demand. Salter's research in Vietnam and Cambodia found the importance of marketing campaigns to heighten demand for improved water services, hygiene and technologies (Salter 2003). Salter (2003) describes an effective strategy used by International Development Enterprises (IDE) which targeted messages separately to men, women, boys and girls in order to promote healthy behaviours around water collection and usage. The marketing campaign resulted in a heightened demand for services and products. Over the course of the project, IDE supported the growth of marketing abilities within the private sector while gradually withdrawing its own marketing support.

The Asian Development Bank suggests caution when considering microfinancing schemes for SWEs (ADB 2003). In the Water for Life case studies, ADB recognized the importance of closely examining local conditions before implementing programmes, as supply, demand and water sources vary greatly from place to place. The ADB report stated that it is critical to understand the current small-scale market already in place before introducing or competing with local providers to reduce the potential for local conflict (ABD 2003).

Water quality

There has been minimal research regarding the microbiological and chemical quality of water sold through SWEs. Many articles reviewed for this assessment suggest that vended water tends to be of poor quality, but no published documents supported this conclusion with water analysis or other research results (Crane 1994; Albu & Njiru 2002; WSP 2005; Hammond *et al.* 2007). Two unpublished

studies were found which discuss water quality parameters; the first is a survey conducted by the Aquaya Institute and the Dian Desa Foundation in Yogyakarta, Central Java, in September 2007 (Albert *et al.* 2008), in which water samples from kiosks in Central Java were analysed and found to be delivering improved drinking water. The other unpublished study, from Ghana, compared factory-sealed water sachets with hand-packaged sachets and found the hand-packaged sachet water to have significantly more bacterial contamination (Okioga 2007). For SWEs that rely on buying water from utility systems, the quality of water later resold through kiosks, sachets or other outlets is dependent on the treatment and water pressure (i.e. to prevent pollutant intrusion) within the system along with the hygiene practices of the SWE (Collignon & Vezina 2000).

Consumer perception of vended water varies widely. In a study from urban Nigeria, consumers considered vended water to have better water quality and chose vended water for drinking and cooking while using water from other sources, such as hand-dug wells, surface water and rainwater, for cleaning. However, the Nigerian study did not include any water quality analysis to confirm this perception (Whittington *et al.* 1991). Whittington *et al.* also noted in their 1991 willingness-to-pay article that households typically felt that vended water was more reliable than utility-supplied water. In contrast, Solo reported on vended water in Argentina that was less expensive than utility supply but thought to be inferior because of the sulphur content that had not been removed (Solo 2003).

Addressing the water quality of vended water through SWEs presents a dilemma. SWEs are often not officially recognized or regulated, which allows them to operate outside legal requirements and without regard to the quality of the water they sell (Batley 2006). However, instituting water quality regulations that are in line with international standards has the potential to induce governmental fees and hardships on the providers and force many of the vendors out of business. Improving water quality will take a two-prong approach: a strong marketing campaign to ensure a demand for potable water along with effective capacity-building of SWEs to ensure ongoing water quality and hygiene.

DISCUSSION

Nearly 60% of the literature reviewed during the course of this research was from reports generated by international organizations. The World Bank has taken a lead in the research on SWEs, supporting over one-third of the documents assessed during this review. Other international organizations are also quite active in this field of research, especially the ADB and the United Kingdom's Department for International Development (DFID). However, SWE research is not well documented in independent, peer-reviewed journals. Of the 62 documents included in the final review, only 11 were from peer-reviewed journals. Documents and their supporting evidence from private enterprise (i.e. non-governmental organizations or for-profit companies) were much more difficult to access online or through personal contacts. The results of this assessment are affected by what is accessible primarily through the Internet and are therefore skewed towards the findings of international organizations.

The most recent literature tends to point towards kiosks as providing positive models of drinking water delivery systems in areas without access to piped water networks. Gulyani *et al.* (2005) provide a comprehensive overview of the kiosk system in use in urban Kenya. They found that, even in areas where utility-supplied water was available, both the poor and non-poor depend on kiosks as an important secondary source of water because of the inadequacy of the public utility or poor quality of free natural water sources (Gulyani *et al.* 2005). WEDC also provides detailed field research on kiosks through four case studies in urban areas of Africa. It defines kiosks as fixed installations connected to the utility system and its reports emphasize the need for good working relationships between kiosk operators and the utilities that provide the water (Gadir 2006; Materu & Mkanga 2006; Oenga & Kuria 2006; Sarpong & Abrampah 2006). WEDC also found that the kiosk's success depended on the level of competition, number and location of kiosk stations, the price of the water and the reliability of the kiosk's water supply (Smith 2006).

The inability of many utilities in developing countries to meet expanding water demands let alone routine operations and maintenance has led to an increased demand for SWEs (Moran & Batley 2004). Additionally, barriers to water

Table 5 | Potential SWE research topics

Study topic	Research question
Water quality	What is the effectiveness on household water quality of improving the quality of vendor's water supply?
Water quality	How does the SWE delivery method affect water quality?
Hygiene promotion	What is the impact of health communication messages on SWEs' hygiene behaviours and quality of their product?
Hygiene promotion	What is the impact of hygiene promotion on household behaviours and drinking water quality?
Health outcomes	Does improving the quality of the SWE's products and services improve household health outcomes, especially diarrhoea levels?
Community perception	How does the community perceive the quality of the SWE's product?
Financing	What effects do alternative forms of financing have on local water vending markets?
Financing	What SWE models are best positioned to scale up operations with access to capital?
Pricing	What is the willingness-to-pay in vulnerable populations?
Pricing	How do vulnerable populations value the product and service benefits provided by SWEs (e.g. safety, purification, convenience, improved taste and refreshment)?
Market models	What are the costs for each component of the value chain in different SME market models? Which of these can be leveraged to scale up provision of safe, affordable water?
Marketing	What is the impact of SWE demand generation/marketing programmes on choice of household drinking water?
Water quantity	What are the effects in the quantity of water collected per person per day with improved SWE services?

access often associated with utilities such as upfront connection fees and the difficulties associated with piped network expansion (i.e. costs, engineering demands and time) are minimized with SWEs, further suggesting the potential of SWEs to reach vulnerable populations more quickly than piped networks.

The possibility of unintended consequences in expanding SWEs is another important aspect to be considered before implementing projects related to SWEs. 'Rent extraction' or unofficial taxes demanded by local public and private officials to allow vendors to operate have been documented in some low-income regions (Lovei & Whittington 1993). Another concern is vendor reports of conflicts with water utilities or regulatory frameworks which are unprepared to work with small-scale providers and perceive them as competitors (Solo 2003; Njiru 2004). There is an inherent difficulty in trying to reconcile informal, private water vendors with formal governmental or large-scale donors (Sansom 2006). It is necessary to understand the existing role of institutional arrangements between SWE and the government before intervening in the drinking water sector (Snell 1998; Mitlin 2002; McIntosh 2003; McGranahan *et al.* 2006). For example, in some countries there may be government regulations that must be met or permission obtained from authorities to withdraw groundwater. In most African and South American countries, the water is legally owned by the state or government (Collignon & Vezina 2000; Solo 2003).

Vendor associations may provide a bridge between the different structural entities. Regional associations of small-scale water entrepreneurs have been shown to encourage cooperation among vendors, facilitate dialogue with utilities, support a sharing of knowledge and improvements, and potentially reduce 'rent-seeking' behaviour (Collignon & Vezina 2000; Moran & Batley 2004; WSP 2005). Multiple studies recommend official recognition of SWEs and their associations by government entities to improve reliability and water quality (Collignon & Vezina 2000; McIntosh 2003; Solo 2003; WSP 2005).

CONCLUSION

SWEs provide a critical daily basic service by ensuring access to drinking water. Currently available literature reports a number of strengths in the SWE models, especially their flexibility and responsiveness to customers in some of the world's most inaccessible regions. However the quality and affordability of the water supplied by these vendors continue to be unknown and evidence of their effectiveness in improving health outcomes for the populations they serve is missing. There is ample evidence that poor households are currently paying for water and that in many instances the water's quality is questionable. Kariuki & Schwartz (2005) conclude that much of the existing literature consists of opinion based on case studies rather than data collection. Mitlin (2002) also points out that, despite much interest in the private sector involvement in small-scale water supply, there is little evidence of the effects of these involvements with respect to price and extension of services.

Understanding the values consumers place on benefits delivered by SWEs beyond water quality is also necessary to better tailor targeted product and service offerings that realize broad consumer acceptance. To accomplish this, it is important that researchers contribute to an ongoing understanding of the benefits and risks of safe water provision focusing on how consumers value the various attributes and the benefits of SWE water provision.

Similarly, there is a need to understand the market drivers including consumer demand, pricing and profit structure for each component of SWE water provision. This will help identify best practices and opportunities to optimize operations, marketing, funding and pricing programmes. In addition to identifying promising opportunities, these insights will help to inform policy makers about the potential viability and acceptability of alternative approaches in order to have the largest impact on beneficiary populations.

There is a clear need for rigorous evidence on the effectiveness of SWE models designed to deliver potable water through implementation of randomized, controlled studies of SWEs. These studies should include not only delivery of safe water but also evaluation of market effectiveness and appropriate business models. There are many aspects of SWEs that require field-based, community-level research (Table 5). To date most of the available reports are not peer reviewed and lack the rigour of systematic data gathering. Although market demands will continue to drive SWE development, ideal systems or models may be delayed or undeveloped if evidence-based analysis in this critical area of public health is not conducted.

ACKNOWLEDGEMENTS

This study was supported in part by a grant to KJS from the Osprey Foundation of Maryland.

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