International Journal of Environmental Health Research

ISSN: 0960-3123 (Print) 1369-1619 (Online) Journal homepage: http://www.tandfonline.com/loi/cije20

21st century research in urban WASH and health in sub-Saharan Africa: methods and outcomes in transition

Eve Mackinnon, Richard Ayah, Richard Taylor, Michael Owor, John Ssempebwa, I Daniel Olago, Robinah Kubalako, Anta Tal Dia, Cheikh Gaye, Luiza C. Campos & Edward Fottrell

INTERNATIONAL JOURNAL OF ENVIRONMENTAL HEALTH RESEARCH
https://doi.org/10.1080/09603123.2018.1550193

Taylor & Francis
Taylor & Francis Group

ARTICLE

OPEN ACCESS Check for updates

21st century research in urban WASH and health in sub-Saharan Africa: methods and outcomes in transition

Eve Mackinnon [a], Richard Ayah [b], Richard Taylor [c], Michael Owor [d], John Ssempebwa [e], I Daniel Olago [b], Robinah Kubalako [e], Anta Tal Dia [f], Cheikh Gaye [f], Luiza C. Campos [a] and Edward Fottrell [g]

[a]Civil, Environmental and Geomatic Engineering, University College London, London, United Kingdom of Great Britain and Northern Ireland; [b]Faculty of Science Engineering and Health, Daystar University Nairobi, Nairobi, Kenya; [c]Department of Geography, University College London, London, United Kingdom of Great Britain and Northern Ireland; [d]Department of Geology and Petroleum Studies, Makerere University, Kampala, Uganda; [e]College of Agricultural and Environmental Sciences, Makerere University, Kampala, Uganda; [f]Department of Geology, FST, Universite Cheikh Anta Diop, Dakar, Senegal; [g]University College, London Institute of Global Health, London, United Kingdom of Great Britain and Northern Ireland

ABSTRACT

Tackling global inequalities in access to Water, Sanitation and Hygiene (WASH) remains an urgent issue – 58% of annual diarrhoeal deaths are caused by inadequate WASH provision. A global context of increasing urbanisation, changing demographics and health transitions demands an understanding and impact of WASH on a broad set of health outcomes. We examine the literature, in terms of health outcomes, considering WASH access and interventions in urban sub-Saharan Africa from 2000 to 2017. Our review of studies which evaluate the effectiveness of specific WASH interventions, reveals an emphasis of WASH research on acute communicable diseases, particularly diarrhoeal diseases. In contrast, chronic communicable and non-communicable health outcomes were notable gaps in the literature as well as a lack of focus on cross-cutting issues, such as ageing, well-being and gender equality. We recommend a broader focus of WASH research and interventions in urban Africa to better reflect the demographic and health transitions happening.

Abbreviations: CBA: Controlled Before and After; GSD: Government Service Delivery; IWDSSD: International Drinking-Water, Supply and Sanitation Decade (IDWSSD); KAP: Knowledge, Attitudes and Practices; IBD: Irritable Bowel Diseases; MDG: Millennium Development Goals; NTD: Neglected Tropical Diseases; PSSD: Private Sector Service Delivery; SDG: Sustainable Development Goals; SSA: Sub Saharan Africa; SODIS: Solar Disinfection System; STH: Soil Transmitted Helminths; RCT: Randomised Control Trial; WASH: Water Sanitation and Hygiene; WHO: World Health Organization

ARTICLE HISTORY
Received 8 June 2018
Accepted 15 November 2018

KEYWORDS
Water-borne diseases; sanitation; health outcomes; urbanisation; hygiene

Introduction

Water, Sanitation and Hygiene (WASH) refers to three core components; access and availability to water, adequate sanitation, and hygiene, grouped together due to their inter-dependent nature. WASH positively impacts a number of key resources essential for development and has been a priority on the development agenda for the last 50 years. The International Drinking-Water,

CONTACT Eve Mackinnon eve.mackinnon.15@ucl.ac.uk Civil, Environmental and Geomatic Engineering, University College London, London WC1E 6BT, United Kingdom of Great Britain and Northern Ireland

Supply and Sanitation Decade (IDWSSD) of the 1980s initiated these efforts (Esrey et al. 1991), and was followed by targets set under the Millennium Development Goals (MDGs) from 2000 to 2015 to increase access to WASH. The United Nations' Sustainable Development Goals (SDGs) have renewed and expanded these targets, including SDG 6, to 'ensure availability and sustainable management of water and sanitation for all (including hygiene)' and secures WASH as a priority development issue from 2015 to 2030, a period which will also be characterised by global transitions in climate, demographics, health and urbanisation (DESA/UN 2016).

Despite the importance of WASH contributing to a broad range of desirable social, economic and environmental outcomes, a narrower set of specific health outcomes is typically associated with WASH interventions and variables. This focus is related to the fact that a large number of infectious diseases are associated with human excreta and fecal pathogens (Feachem et al. 1983); an association supported on the basis of biological plausibility of fecal-oral disease and environmental transmissions routes (Curtis 2000). Tackling these outcomes through improved WASH remains relevant; the World Health Organization (WHO) estimated inadequate WASH provision caused 58% of the 842,000 annual diarrheal deaths in 2012 (WHO 2014) and there is a large body of evidence that describes relationships between inadequate WASH provision and the incidence of diarrheal diseases (Prüss-üstün et al. 2004) and other infectious diseases (Bain et al. 2014; Crocker and Bartram 2016).

The MDG targets for access to drinking water were largely achieved globally but this indicator does not adequately address aspects of water quality, quantity and sustainable access which are fundamental to human health outcomes. Moreover, these global averages mask spatial inequities between and within nations. The region of sub-Saharan Africa (SSA) did not meet the MDG target for access to an improved water supply, achieving 68% relative to 91% globally. In urban SSA, access to piped water during the MDG period decreased from 43 to 34% (WHO/UNICEF 2015). Even less progress was achieved in terms of sanitation under the MDGs. An estimated 2.4 billion people globally still lacked access to adequate sanitation in 2015, and access in urban SSA to 'improved sanitation' stagnated at 43% whilst absolute numbers of people practicing open defecation increased by 26% from 16 to 25 million (WHO/UNICEF 2015; Hopewell and Graham 2014).

SSA is the most rapidly transitioning region in the world. By 2050, the urban population is expected to rise from 414 million to 1.2 billion (UN 2011) with most urban growth expected in urban slums or informal settlements. This urban population growth risks eroding progress in WASH, meaning urban dwellers will remain vulnerable to exposure to fecal pathogens and other harmful organisms through unprotected drinking water sources, use of unimproved sanitation and unsatisfactory post-exposure hand hygiene practices (World Health Organization 2014). Indeed, stagnation of under-five mortality rates in urban SSA has been observed since 2008, rates in some urban areas are again increasing (Garenne 2010) and fecal exposure still accounts for approximately 10–15% of all deaths in this age group (Julian 2016). Non-fatal, low-level exposure to fecal pathogens is also associated with environmental enteropathy causing malnutrition, stunting and poor cognitive development (Julian. 2016 https://www.tandf.co.uk//journals/authors/style/reference/tf_CSE.pdf), with lasting consequences on lifelong health and chronic disease risk (Wells 2016). These emerging, longer-term and complex disease pathways call for a broad understanding of WASH and human health and intervention effectiveness across the life course, focused not just on disease outcomes but also on aspects of ageing, well-being, dignity and respect, gender equality, and income generation, for example.

A multi-disciplinary team of hydrogeologists, engineers, microbiologists and epidemiologists under the *AfriWatSan* project seeks to explore the nature and dynamics of groundwater in urban SSA and potential contamination from local sanitation systems and associated health risks. In this paper, we critically review research into health outcomes associated with WASH in urban SSA in the 21st century in order to identify gaps in the research and direct future interventions. Specifically, we review health, hygiene and behavioural outcomes that have been examined in association with WASH exposures in SSA. We then examine specific health-focused interventions and the evidence of their effectiveness in urban SSA this century. In so doing, we highlight an unfinished agenda in terms of WASH and infectious diseases, emphasise the need to broaden the scope of research to chronic infectious and non-communicable diseases, and propose the use of more rigorous intervention designs and evaluations linked to theories of change that acknowledge the individual, social and ecological determinants of health.

Methodology

Literature was searched using OVID PubMed (Medline) electronic databases. Six separate search strings were combined so that only studies which were relevant to all six search enquires were included. These were (1) Urban Population, (2) Urban Health, (3) Africa, (4) Drinking Water, (5) Sanitation and (6) Hygiene. For each search term two types of searches were conducted: the first search employed a 'Mapped to Subject Headings' (MeSH) search whereas the second used a key word search within the title and abstract fields of the academic databases.

All papers published in the English language between January 2000 and March 2017 were included since the lead author is an native English speaker without adequate skills for review in foreign language. The 2000 publication cut-off was chosen to limit research to that published this century and to coincide with the MDG-era and beyond. References were downloaded in Mendeley referencing software program and duplicates removed. After excluding duplicates, potentially relevant titles were screened so that only original papers (not reviews) that explicitly addressed a human health outcome linked to WASH in urban sub-Saharan Africa were retained.

There were two objectives of the literature review. The first was to map the health outcome focus of WASH research. To do so, we reviewed the abstracts (or entire articles when further clarification was necessary) of papers retrieved from the literature search. The health outcomes were described according to 10 predefined groupings and based on principles of distinguishing between conditions with broadly similar preventative and health service implications (Table 1). Hygiene and sanitation related behavioural outcomes were included as a separate category since although not strictly a health outcome, they are frequently the focus of WASH interventions and are known, modifiable determinant of health outcomes (De Buck et al. 2016).

The second objective, was to review health-focussed WASH interventions and evidence of their effectiveness in urban SSA this century. Therefore we only retained papers for further review if they described an intervention or interventions and evaluated their impact on tangible health outcomes including behavioural outcomes. Observational studies (i.e. those where exposure to a WASH intervention was not controlled by the implementers or researchers) were excluded from the review of intervention effectiveness due to difficulties in attributing observed changes in health

Table 1. Health outcomes categories with principal examples of diseases in each category.

	Health Outcomes (with principal examples)
1	**Acute infections** (Diarrhea diseases (Hepatitis A and E, Polio, Cholera, Salmonella, Typhoid, Helibacteryi, Dysentery), Skin infections)
2	**Vector Related** (Malaria/Dengue/Yellow Fever)
3	**Neglected Tropical Diseases** (Intestinal parasites including schistoschimiases, Soil Transmitted Helminths and Trachoma)
4	**Other** (Toxocara Canis Infection, Hepatitis C)
5	**Inorganic** (Chemical toxicity and Dental Caries)
6	**Nutrition** (Undernutrition)
7	**Chronic Communicable** (HIV, Tuberculosis)
8	**Chronic Non-Communicable** (Hypertension, Cancer, Asthma, Allergies, Epilepsy, Diabetes)
9	**Cross cutting** (Old Age, Female Health and Menstrual Hygiene, Mental Health, Quality of life and Well-being, Protection and Safety (Sexual Violence))
10	**Hygiene-Related Outcomes (**Handwashing rates and Knowledge, Attitudes and Practices related to handwashing and hygiene)

outcomes from potential confounding factors or secular trends. We grouped the intervention studies into one of three predetermined categories to represent different socio-ecological levels of action: (1) technical, relating to engineered strategies such as the type of handwashing dispenser or water treatment technologies; (2) contextual, referring physical and institutional drivers of WASH and its health impacts, such as subsidies or costs (Galgani et al. 2014); and (3) socio-behavioural, including individual and community-level WASH initiatives that influence health (Dreibelbis et al. 2013).

Results

We identified 941 papers that met our search terms, 11 duplicates were removed. Following review of the titles, 524 papers were excluded as they did not meet initial inclusion criteria (Figure 1). Abstract review of the remaining 406 resulted in the rejection of 170 studies which focussed on analysis of urban water quality and environmental contamination but did not include a measurable health outcome (Table 1) or evaluate associated health risks. Thus a total of 236 papers were retained and reviewed to describe the health outcome focus of WASH research addressing the primary objective. Dealing with the second objective, only those articles that applied experimental or quasi-experimental methods to evaluate the effectiveness of a WASH intervention or interventions in terms of a health outcome were retained – a total of just seven papers.

Mapping of health outcomes

The following section summarises the health outcome focus of WASH research in urban Africa since 2000. Forty different countries were represented in this research although almost one third of the studies were based in just three countries – Nigeria, Kenya and Ghana – whilst ten sub-Saharan countries accounted for 58% of the studies (Figure 2). 56% of included studies explicitly categorised their research setting as 'urban', 18% referred to 'slum', 'peri-urban' and 'informal settlement' populations and 26% of studies compared

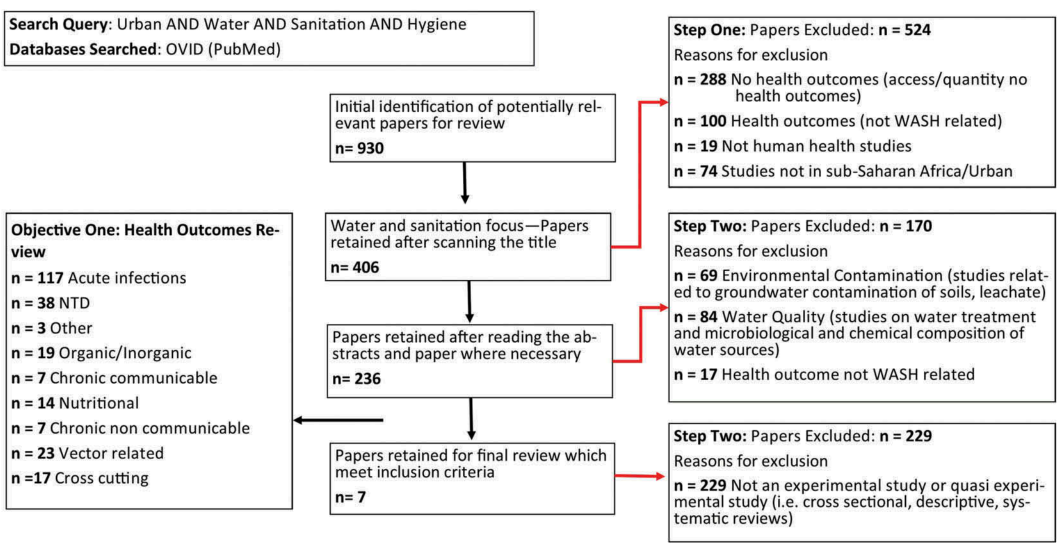

Figure 1. Methodological procedural steps in the literature review.

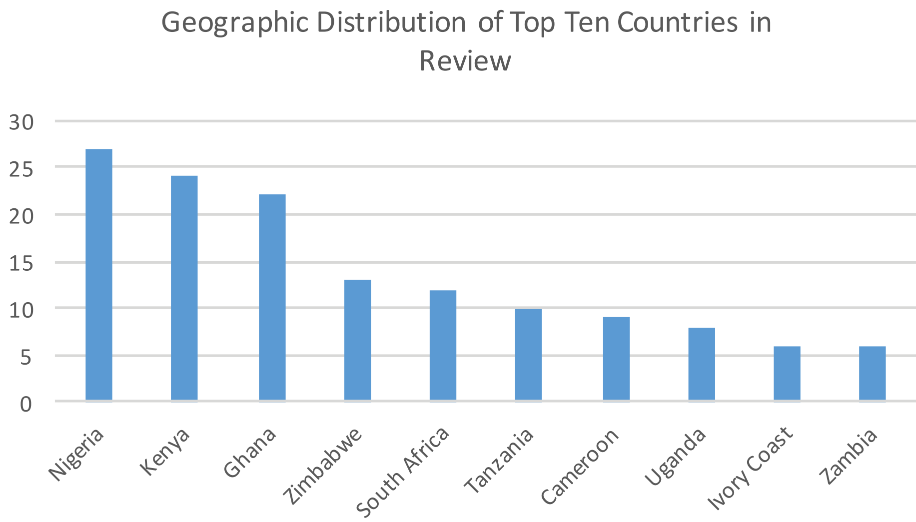

Figure 2. Proportion of health-focussed urban African WASH research in the top 10 Countries, which account for 50% of all studies.

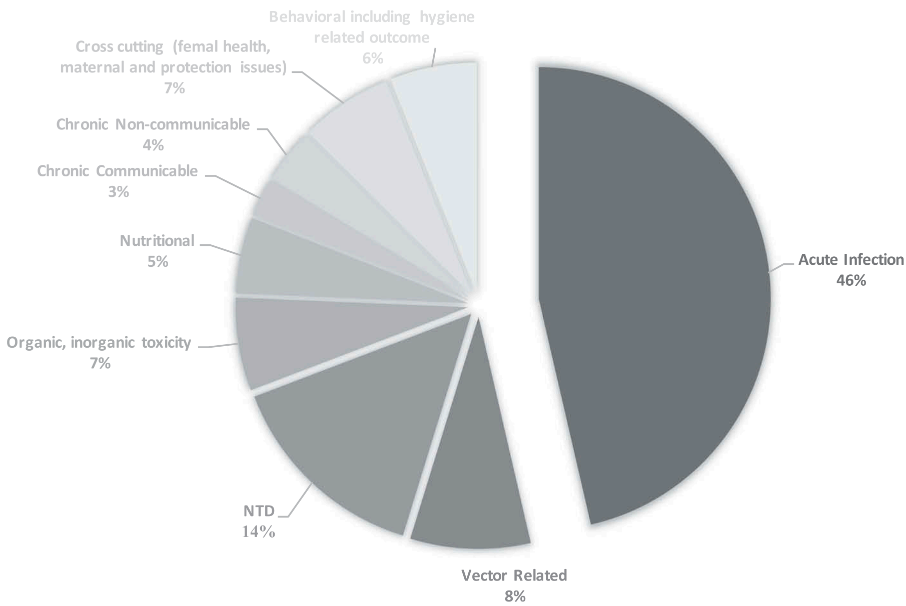

Figure 3. Distribution of urban SSA health-focussed WASH research by health outcome.

rural and urban contexts. School-based studies constituted 12% of the included literature. Figure 3 shows the proportion of WASH studies by reported health outcomes. Acute infections, vector borne diseases and neglected tropical diseases (NTDs) account for almost four fifths of studies, with under 3 and 4% addressing chronic non-communicable diseases and communicable diseases, respectively.

Acute infections

Acute infectious diseases account for the vast majority of health-focussed WASH studies (*n* = 122). The majority of these studies used observational study designs and applied multivariate regression models to examine associations between WASH variables and acute diarrhoeal outcomes and/or enteric infections, controlling for broad cultural, social and economic variables. A few studies used Quantitative Microbial Risk Assessment to model health risks to specific microbial contamination (Macassa et al. 2004; Labite et al. 2010).

Seventy-five studies focussed on diarrhoeal disease including studies of enteric infections through prevalence of disease agents such as rotavirus, Shigella, cryptosporidium and salmonella as pathogens causing diarrhoeal diseases (Ali et al. 2005; Morse et al. 2007; Ankarklev et al. 2012; Dos Santos et al. 2015). Other acute infectious disease outcomes included within this category were *Toxocara canis* infection (*n* = 2) (Liao et al. 2010; Gyang et al. 2015), Herpes virus (*n* = 1) (Hazel et al. 2015) and Zoonotic diseases (*n* = 1)(Kagira and Kanyari 2010).

Twenty-seven studies focussed on cholera and its transmission in urban SSA settings. Epidemiological studies used unmatched case-control designs and ecological analyses using spatial mapping of outbreaks against the variability of (protective) factors in contracting the infection. Contaminated water from wells, street vendors, and the breakdown of municipal water supplies, were associated with the risk of cholera whereas handwashing with soap was a protective factor. Studies link cholera incidence with environmental WASH factors such as elevation, insufficient drainage or waste dumps (Osei and Duker 2008; Schaetti et al. 2010; Luque Fernandez et al. 2012) and also couple the risk of poor sanitation with climate factors (e.g. increased rainfall) (Sasaki et al. 2009; Jutla et al. 2015).

Vector-borne diseases

Vector-related health outcomes (*n* = 22), including malaria, dengue fever, yellow fever and lymphatic filariasis (LF) were studied in relation to WASH variables typically using cross-sectional surveys or clinical case-control designs. Occurrence of vector-related diseases was strongly associated with proximity to vector-breeding sites, including of urban agriculture (Afrane et al. 2004; Wang et al. 2005; Matthys et al. 2006; Weeks et al. 2009). Seidahmed and colleagues described seasonality and differences in population water consumption patterns as drivers of dengue incidence in eastern Sudan (Seidahmed et al. 2012). Several papers also highlighted the contribution of social behaviours to vector-borne disease prevalence in certain contexts, including use of bed nets, health-seeking behaviours,[1] and prevention (Baragatti et al. 2009; Ndo et al. 2011; Adedotun et al. 2010).

Neglected tropical diseases

Neglected tropical diseases (NTDs) are a diverse sub-group of communicable diseases that prevail in tropical and sub-tropical conditions and disproportionately affect populations living in poverty and, as such, are largely attributable to poor access to safe water or sanitation and poor hygiene conditions (Feasey et al. 2010). A total of 38 papers researched NTDs and WASH factors in urban SSA contexts. These included infections from Soil Transmitted Helminths (STH) including intestinal parasites such as Schistosomiasis and Ascaris and vector-transmitted diseases such as Trachoma. The study design typically used cross-sectional or case-control data that described the prevalence of STH in populations exposed to different WASH variables.

Inorganic/toxicity

Inorganic health outcomes refer to studies of toxic effects of inorganic and chemical compounds ingested primarily through drinking water. Despite a considerable body of literature evaluating chemical composition of water sources, few studies directly linked exposure to health outcomes in urban SSA. The majority of studies (7) presented evidence of presence and prevalance of dental caries with excessive fluoride in drinking water or water sources and the impact of water fluoridation (Wongdem et al. 2000; Awadia et al. 2002; Fantaye et al. 2003; Re et al. 2011; Gbadebo 2012; Kroon and Van Wyk 2012; Ayele et al. 2013).

One study employed health risk assessments to calculate levels of heavy metal contamination of vegetables, water and soil above WHO guidelines; subsequent exposure frequency was associated with health risk (Bempah and Ewusi 2016). Elevated concentrations of nitrate and chloride in groundwater above WHO guidelines was linked to on-site sanitation in urban centres (Wright et al. 2013). A high mean nitrate concentration of 31 mg/L reported in groundwater sources was predicted to be associated with thyroid and cancer risks (Njeze et al. 2014) though direct measurement of this association and health outcomes is lacking in urban SSA. One study found presence of urinary mercury as evidence for inorganic mercury absorption in exposed populations (associated with airborne exposure pathways) although no long-term health impacts were investigated in this study (Dalvie and Ehrlich 2006). High concentrations of dissolved substances contributed to elevated health risks, referred to as heart and kidney problems especially for those living with heart conditions, whereas excessive iodine was associated with goitre (Medani et al. 2013; Amogne et al. 2015).

Nutrition

Eight out of the 14 nutrition-focused WASH studies investigated the prevalence of malnutrition in infants and children under five in day care and pre-school environments (Abidoye and Ihebuzor 2001; Abate et al. 2000; Masibo and Makoka 2012; Mduma et al. 2014, Mwase et al. 2016). The studies used cross-sectional study designs and multivariate regression analysis to unpack associations between social and household factors (including WASH indicators) and nutritional status, determined using anthropometric measures of weight-for-age and height-for-age z-scores and body mass index (Pongou et al. 2006; Djimeu 2014). A small-scale pilot study by Mwase and colleagues in day care centres in Nairobi, Kenya found 40% of children undernourished and associated this result with non-responsive care practices and poor hygiene practices (Mwase et al. 2016).

Chronic communicable infections

Six studies, predominately cross-sectional observational studies, investigated the additional WASH needs among people living with HIV and AIDS. HIV status exacerbates the health burden of poor WASH in cities and reduces the effectiveness of certain treatment for STH (Adams et al. 2006; Yallew et al. 2012). Among children under two years, increased diarrhoea prevalence was associated with children whose mothers were HIV positive whilst breast feeding was a protective factor (Peletz et al. 2011). A study by Breton et al. (2007) found differing prevalance of Microsporidiosis; an opportunistic intestinal infection that causes diarrhea and wasting, linked to immune status of HIV positive individuals in urban settings compared to non-selected rural individuals (Breton et al. 2007). Dodor et al. (2009) looked at tuberculosis, which showed that specific food and safety practices enforced by ill-informed health professionals influenced community perceptions relative to risks of TB transmission via a food and hygiene route, increasing stigmatisation of individuals with the disease (Dodor et al. 2009).

Chronic non-communicable diseases

Chronic non-communicable diseases, including hypertension, diabetes, cardiovascular disease and cancer, represent an increasing burden of disease throughout Africa and particularly in urban areas (Maher et al. 2010; Dalal et al. 2011). However, there is a dearth of research into the risks, consequences and interactions between WASH and non-communicable diseases. Two studies review respiratory and allergic atopy (Steinman et al. 2003; Nicolaou et al. 2005). At the same time, the emerging 'hygiene hypothesis' suggests that improved sanitary conditions may increase incidence of autoimmune and atopic conditions, specifically discussed in relation to Inflammatory Bowel Disease (Chu et al. 2013). Four studies review hypertension and socio-economic factors including WASH determinants. Damorou et al. (2008) found no WASH association in their cross-sectional field study in Togo. In comparison, Griffiths et al. (2012) showed that early-life measures of water and sanitation facilities were significantly associated with systolic blood pressure at 16 years though confounding bias limits the interpretation of this result. Increased prevalence of hypertension in urban areas in Guinea observed by Balde et al. (2006) point to the over-arching role of socio-economic factors (Balde et al. 2006; Fourcade et al. 2007; Damorou et al. 2008; Griffiths et al. 2012). Just two WASH studies in urban SSA considered cancer risks related to WASH factors (Njeze et al. 2014; Bempah and Ewusi 2016), referred to in the previous section regarding inorganic and toxicity reviews. One study considering people living with epilepsy (PWE) and WASH access as part of a broader review of social function found that 95% of PWE did not encounter any difficulties in social functioning (including access to WASH). This percentage was higher in urban compared to rural areas but the study also highlights the lack of reporting and consideration of WASH access for people living with physical disabilities (Birbeck and Kalichi 2003).

Behaviours

Sixteen studies focused on personal and/or food hygiene and/or specific handwashing behaviours. Several studies examined the associations between targeted interventions and Knowledge, Attitudes and Practices (KAP) of food hygiene and handling practices (Mensah et al. 2002; Jagals et al. 2004; Amoah et al. 2007; Chukwuocha et al. 2009; Donkor 2009; Isara and Isah 2009; Mohamed et al. 2014; Okojie and Isah 2014). One study concerned the cost effectiveness of interventions associated with hand hygiene (Borghi et al. 2002), whilst six studies looked at effectiveness of interventions on behavioural outcomes (Davis et al. 2011; Davis et al. 2013; Lang 2012; Pickering et al. 2014; Tumwebaze and Mosler 2014, 2015; Ejemot-Nwadiaro et al. 2015), Davis et al. (2011) and Tumwebaze et al. (2015) were related to objective two and are included in the forthcoming discussion. Effective interventions on short term health and hygiene impacts are reported, yet it is acknowledged that changing deep-seated personal behaviour is challenging (Jagals et al. 2004). Other observational studies did not report any significant associations between interventions and changes in KAP related to hygiene behaviours (Chukwuocha et al. 2009; Donkor 2009).

Cross-cutting

Thirteen papers consider aspects of maternal, female and adolescent girls' health and protection in terms of WASH. Women are found to be more vulnerable to the health impacts of WASH (Stockman et al. 2007; Olusanya and Ofovwe 2010; Wilunda et al. 2013; Corburn and Hildebrand 2015; Peletz et al. 2016). No access to household sanitation was associated with elevated risk of anaemia in adolescent girls (Ondimu 2000) and anaemia is also associated with high rates of stunting and thinness and is a leading cause of morbidity and mortality in pregnant and post-partum women (Teji et al. 2016; Ondimu 2000; Wilunda et al. 2013). Only one paper modelled the risk of sexual violence linked to poor access to sanitation (Gonsalves et al. 2015); no empirical studies of this were found. Likewise, one study found that sanitary pad interventions resulted in significantly less abseentism from school (Montgomery et al. 2012). Three papers in the review consider general aspects of well-being and associated WASH indicators. Surveys explored self-rated health status and found multiple factors associated with determinants (Cau et al. 2016), while social capital, including WASH access, was identified as a stressor effect on mental health (Greif and Nii-Amoo Dodoo 2015). Sanitation and over-crowding were also related to health issues in a qualitative photo voice study, however, the study reported that health was not a priority concern among the urban young (Mmari et al. 2014).

Health-focussed WASH interventions and evaluations

Seven experimental or quasi-experimental studies evaluated the effectiveness of WASH interventions on health outcomes in urban SSA since 2000 (Table 2). Four studies used an individual or cluster randomised controlled trial design to evaluate impact (Du Preez et al. 2011; Davis et al. 2013; Tumwebaze and Mosler 2015; Bohnert et al. 2016), one used randomisation to allocate clusters to one of four interventions, without a control comparison group (Davis et al. 2011), one applied a non-randomised controlled, quasi-experimental design (Montgomery et al. 2012), and one simply applied a pre- and post-intervention survey to assess intervention impact over time (Ryman et al. 2012). All interventions under evaluation used information and education strategies to promote particular behaviours. The study by Tumwebaze and Mosler (2015) is notable for explicitly addressing shared responsibility and community-level action and hygienic behaviours whereas the other studies largely focussed on individual- or household-level behaviours. Five studies supplemented information with technical interventions of varying degrees of sophistication, ranging from basic hygiene kits to solar technology and sanitation services (Bohnert et al. 2016; Du Preez et al. 2011; Davis et al. 2013; Montgomery et al. 2012; Ryman et al. 2012). No included studies explicitly addressed contextual drivers of WASH such as governmental, institutional, private or public sector factors.

The health outcomes of focus of most studies included hygiene behaviours including water treatment behaviours (Bohnert et al. 2016; Davis et al. 2011, 2013; Ryman et al. 2012; Tumwebaze and Mosler 2015), though Bohnert et al. (2016) and Davis et al. (2013) also assessed exposure to faecal contamination and self-reported diarrhoea morbidity, respectively. The primary outcome in the randomised controlled trial by Du Preez et al. (2011) was self-reported diarrhoeal disease incidence, though objective measures of child growth were also included. Montgomery et al. (2012) focussed on school abseentism associated with menstrual periods on the assumption that this was indicative of overall well-being.

Evidence of intervention impact on health outcomes

Du Preez et al. (2011) measured diarrhoeal incidence rate ratios (IRR) and growth differences among children using solar disinfection (SODIS) of drinking water compared to those maintaining usual practice. Their findings showed a statistically significant (P < 0.001) reduction of dysentery (IRR = 0.56 (CI 95% 0.40–0.79)) and non-dysentery diarrhoea (IRR = 0.55 (95% CI 0.42–0.73) among those drinking solar disinfected water relative to control children. These findings must be interpreted with caution considering the necessarily unblinded study design and the self-reporting of the primary outcome of dysentery and diarrhoea. Nevertheless, the fact that source water quality did not differ between study arms but that solar disinfected water had lower bacterial levels strengthens the argument that observed differences in disease incidence may be causally related to the intervention. Du Preez et al. (2011) present statistically significant (P = 0.031) evidence that the median height-for-age increased among intervention children over a one-year period (95% CI 0.7–1.6 cm); this observation was in line with that expected for

Table 2. Health focussed WASH intervention evaluation studies included in this review.

Study	Author	Type of Intervention	Evaluation Method	Description of Intervention	Health Outcome(s) Assessed
2	Davis et al. 2011.	Social	Cluster randomised experimental cohort study without control whereby 20 clusters of 10–30 houses with resident children under 5 years were divided into four cohorts, each receiving one of four intervention packages. Outcomes were measures through in-depth survey interviews at four time points which recorded self-reported behaviour changes.	All households received information on strategies to reduce water and sanitation-related illness. Three of the household cohorts also received either: (1) water quality test results; (2) hand-rinse test results; (3) water quality and hand rinse test results.	Knowledge and behaviours related to hand hygiene and water treatment.
3	Du Preez et al. 2011.	Social and Technical	Randomised Controlled Trial with randomisation at the household level and measurement of outcomes through self-recorded diarrhoeal episodes over a period of up to 17 months and anthropometry at three time points.	Intervention households were trained to use Solar Disinfection (SODIS) of drinking water for provision of water to children residing in the household. Control households were instructed to maintain usual practices.	Dysentery and non-dysentery diarrhoeal incidence among children aged 6–60 months over a period of up to 17 months; height and weight.
6	Ryman, T.K. et al., 2012.	Social and Technical	A pre- and post-intervention survey was conducted within two urban clinics, nested within a larger evaluation in Kenya to assess changes in hygiene knowledge and self-reported and observed practices,	Distribution of hygiene education and hygiene kits to caregivers during clinic vaccination visits.	Household water treatment practices and ability of caregivers to hand WASH correctly. The level of microbial contamination of water and hands.
4	Montgomery et al. (2012)	Social	Three-arm non-randomised controlled trial whereby 120 school girls between the ages of 12–18 were randomised to one of three levels of treatment and their school attendance was assessed over one school year.	Girls were randomised to receive either: (1) menstrual hygiene education; (2) menstrual hygiene education plus sanitary pads; (3) no intervention.	School attendance (absenteeism) as proxy indicator for well-being.
5	Davis et al. 2013.	Social and Technical	Three-arm cluster randomised controlled trial in six schools with before and after collection of self-reported data on hand cleaning behaviour, school absenteeism and 24-hour symptom recall including diarrhoea, observed rhinorrhoea, as well as observation data on hand Washing practices after toilet use and before lunch.	Intervention arms received teacher training sessions in hygiene plus installation of either soap or sanitiser dispensers. Control schools did not receive training or hygiene kits.	Self-reported symptom recall of diarrhoea; observed rhinorrhoea; absenteeism; hand cleaning rates after toilet use and before eating.

(*Continued*)

Table 2. (Continued).

Study	Author	Type of Intervention	Evaluation Method	Description of Intervention	Health Outcome(s) Assessed
7	Tumwebaze and Mosler 2015.	Social	A cluster randomised controlled trial whereby users of shared toilets were randomised to one of three exposure groups and interviewed before and after exposure to assess changes in outcome measures.	Users were randomised to receive either: (1) a discussion intervention facilitated by a local leader to talk about shared use and cleanliness of shared facilities; (2) a discussion intervention plus a public commitment related to the maintenance and use of the shared facilities; or (3) no intervention.	Hygienic behaviours related to shared toilets.
1	Bohnert et al. (2016)	Social & Technical	Cluster randomised controlled trial in 20 schools with comparisons of outcomes at two time points during intervention delivery.	10 intervention schools received a Private Sanitation Service Delivery latrine using urine diversion dry toilets with waste collection plus a hygiene curriculum; 10 control schools received the Government Standard Delivery of ventilated improved pit latrines or sewered cistern-flush toilets connected to septic tanks.	Hand Washing behaviour (assessed through observation); *E. coli* contamination from toilet environment (measures through surface swabs) *and E. coli* contamination of hands (assessed through hand rinses of random samples of school children).

significant reductions in dysentery and non-dysentery diarrhoea. No statistically significant increases were found regarding median weight-for-age measurements. These results are interpreted by the authors to demonstrate the effect of SODIS on childhood anthropometry. However, the specific analytical approach used for this outcome is complex, comparability in anthropometric parameters between arms at baseline is not reported, and Du Preez et al. (2011) acknowledge the possibility that the anthropometric growth impact may be a false-positive finding.

Davis et al. (2013) compared the use and promotion of hand sanitiser or soap with controls in a three-arm cluster randomised trial in Nairobi. They found that observed rhinorrhoea was significantly reduced in intervention schools compared to control schools (risk ratio (95% confidence interval = 0.77 (0.62–0.95)). Children in sanitiser intervention schools were twice as likely to clean their hands after the toilet than control school children (prevalence ratio (95% CI) 2.2 (1.2–4.3)) and no difference in hand cleaning was observed between soap schools and control schools (1.0 (0.3–3.8)), although unreliable water availability in soap schools was noted as a possible explanation for this. Although no difference in the reporting of diarrhoeal episodes was observed, children in sanitiser schools were approximately 50% less likely (0.51 (0.31–0.71)) to report having missed a day at school due to illness in the week prior to data capture compared to control children (Davis et al. 2013). Davis et al. (2013) report important process data which helps to explain observed usage patterns of sanitiser and soap interventions, including aspects of novelty, convenience and preferences. The authors conclude that an improved technical facility – in the form of sanitiser – contributed to an 'enabling environment' for handwashing which led to more effective behaviour changes and consequently improved health outcomes more than handwashing with soap and just information alone. These conclusions and claims of causality may be overstated, however, and the observed positive effects of hand sanitisers must be interpreted with consideration of the unblinded, self-reported limitations of the study design.

Bohnert et al. (2016) measured a number of variables such as toilet maintenance and cleanliness, activation for handwashing rates among school children and environmental exposure of toilet surfaces and hand contamination, using *E. coli* as a proxy for fecal contamination. The study compared urine-diversion (dry) toilets delivered by private sector sanitation delivery (PSSD) to Government Standard Delivery (GSD) of ventilated pit latrines or flush toilets in public schools in Nairobi. The PSSD intervention was accompanied by a hygiene curriculum. Sampling methods used in the study are unclear and difficulties in implementation, particularly in terms of construction or rehabilitation of ventilated pit latrines or flush toilets in the 'control' GSD arm are notable. Overall, the study showed no significant difference in hand contamination between school children at PSSD or GSD schools; 79 and 78% respectively ($P = 0.73$) nor were there differences between sanitation modalities in the percentages of students practicing handwashing with soap by the end of the intervention. It was found that *E.coli* concentration on toilet surfaces in the PSSD study arm decreased longitudinally over the period of a day, whilst in GSD the converse was found. The increase in *E. coli* contamination is linked to increased usage despite continued cleaning. Despite a lack of robust evidence presenting clear benefits of one modality over another, Bohnert et al. (2016) argue that the establishing of the feasibility of providing a lower-cost, private sanitation service similar to that provided by the government is an important finding.

Montgomery et al. (2012) conducted a small-scale randomised controlled trial to assess the effects of menstrual education with or without provision of sanitary pads on school attendance among teenage girls in Ghana. Their findings demonstrated that provision of pads with education significantly ($P < 0.001$) improved school attendance among girls (lambda 0.824, $F = 3.760$), with potential wide-reaching effects on health and wellbeing. A reduction in social stigma and better knowledge about how to manage cloth for periods was considered to be responsible for this reduction (Montgomery et al. 2012), since five months of intervention puberty education alone resulted in similar levels of school attendance. However, lack of randomisation means that potential confounding effects may provide alternative explanations for the observed study results.

Further, the relatively small-scale, pilot nature of the study limits generalisability of findings while short follow-up means that the longer-term effects of the interventions are unknown. Acknowledging these facts, Montgomery et al. (2012) argue for a more rigorous cluster randomised controlled study to assess effectiveness.

Two studies focussed exclusively on socio-behavioural interventions (Davis et al. 2011; Tumwebaze and Mosler 2015). Davis et al. (2011) compared and evaluated the impact of strategies to promote health and hygiene education to randomised groups of households receiving one of four informational intervention packages (see Table 2). Follow-up of household cohorts to assess changes in knowledge and behaviours related to water treatment and hand hygiene showed a general improvement across all groups assessed during both follow up visits. The number of water treatment methods mentioned by respondents and the mean daily handwashing rate increased significantly from baseline levels across the full sample during follow-up visits, although absolute differences were quite small. The increase in reported handwashing was greatest among participants receiving only the hygine information intervention compared to those receiveing the information intervention plus data on their household's water and/or hand rinse test results. The information only cohort also exhibited a reduction of 0.29 log CFU/2 hands of *E. coli* on hands from baseline levels, which was 0.36 log CFU greater than the information plus water quality cohort ($P = 0.04$) and 0.37 log CFU greater than information plus water quality and hand-rinse data cohort ($P = 0.05$). Overall, the utility of using water quality and hand rinse test results to motivate improved WASH behaviours has not been well established as Davis et al.'s study showed no evidence of added benefit beyond that achieved through information-giving strategies alone.

The contribution of this study is also greatly limited by: (1) imbalances between exposure groups at baseline in terms of religion and certain hygienic practices; (2) the high risk of social desirability bias in the self-reported behavioural outcomes and methodological limitations in the analysis, including no apparent adjustment for the clustered survey design; and (3) multiple-outcome testing and numerous sub-group analyses. Further, even if observed improvements in knowledge and behaviour across all groups reflects real change, whether this translates to improved health outcomes is unknown, as this was not an outcome of the study.

The impact of a behavioural intervention using group discussion and public pledges on cleaning behaviour determinants in communal toilets was reported by Tumwebaze and Mosler (2015) which employs a cluster randomised controlled trial design. They found that the intervention comprising discussions about the toilet cleaning experience and a public commitment to participate in shared cleaning (by way of public pledge and signing a commitment form) resulted in a significant ($P < 0.05$) difference in self-reported cleaning three times higher in intervention groups compared to control groups. Non-response bias and social desirability bias are important limitations of this study, although not explicitly described or analysed as such by Tumwebaze and Mosler (2015). The findings therefore do not greatly improve understanding of the effectiveness of the intervention and, as in similar behaviour-focussed studies, it is impossible to determine whether observed improvements in self-reported behaviours translate to objective measures of improved health outcomes.

Ryman et al. (2012) compared two distribution strategies in urban and rural communities to deliver hygiene messages to caregivers during vaccination visits. The first strategy used community health workers (CHW) taken from the local community and the second used nurses. Hygiene outcomes were assessed using indicators including knowledge and awareness of household water treatment, chlorine residual and handwashing practices relative to the impact of the two strategies and comparing urban and rural differences.

All intervention arms resulted in similar, significant increases for hygiene knowledge and behaviour indicators. Knowledge regarding correct water treatment and handwashing increased post intervention across all distribution sites, without substantial differences between interventions types. Correct water treatment knowledge was higher at follow up 75.8% (CI 68.9–81.5) in urban arms compared to rural arms 69.5% (CI 63.5–74.9). However, the water quality (indicated by chlorine residual) declined in comparison to baseline levels, although the difference was not significant ($P > 0.20$), suggesting a social desirability bias may have influenced responses. Factors suggested to account for this included the use of clay pots, length of time, and rapid breakdown of chlorine. It was noted that microbial assessment would have been a more reliable indicator of water quality, but was less cost effective. A very high baseline regarding hygiene use and awareness reduced the ability to record significant impacts of the hygiene interventions in this study and, overall, the authors' claim that hygiene messaging contributes to reductions in diarrhea related morbidities in the intervention group is not supported by the data shown. Ryman et al. (2012) conclude that community members are well positioned and effective agents to disseminate hygiene messages, and that further studies should consider evaluating the success of integration of CHW in health interventions.

Discussion

Our review is the first comprehensive, health-outcome focussed review of WASH research and intervention evaluations in urban SSA this century. Using a carefully planned search strategy and well-defined inclusion criteria we are confident that we have captured the majority of research within this field since 2000. The review is limited by the exclusion of non-English texts which means our findings are likely to under-represent research conducted in Francophone, Lusophone and other non-Anglophone contexts. Restriction of our review to literature published since the beginning of this century was both practical and meaningful in terms of describing activities and evidence generated during and since the MDG-era. This date restriction, however, means that much important work conducted prior to 2000, and particularly during the IDWSSD of the 1980s is beyond our scope.

Health outcome focus of WASH research

The first objective of this review was to map the health outcomes that have been the focus of WASH studies in urban SSA in the 21st century – note that we did not set out to critically appraise or summarise the findings of these studies. To meet our objective, we reviewed paper abstracts on the assumption that key outcomes would be mentioned there. Whilst we did delve deeper into full paper reviews where abstracts were unclear, it is possible that we did not capture the full range of health outcomes that have been studied. Further, our grouping of health outcomes into broad categories of public health significance is likely to mask important heterogeneity between specific health outcome causes and effects.

Our review of literature on health-focussed WASH research revealed an overwhelming attention to acute infectious diseases, particularly diarrhoeal disease. This focus likely reflects the historical prioritisation of diarrhoea within the field of WASH as well as the contemporary and persistent burden of diarrhoeal diseases and their consequences within the urban African context (Liu et al. 2015). Whilst further descriptive studies of WASH and acute, particularly diarrhoeal infections may refine our understanding of disease aetiology in this context, they are unlikely to change anything fundamental. Rather, efforts need to be focussed on developing, implementing and evaluating effectiveness of specific WASH interventions to address these well-established health problems whilst increasing efforts to describe emerging and hereto under-researched health outcomes associated with WASH in an era of changing demographic and health profiles.

The literature describes a positive relationship between improved WASH and reduced disease burdens, notably diarrhoeal disease, which is supported by a number of global meta-analyses (Waddington 2009; Norman et al. 2010). The evidence also highlights that adverse health impacts linked to inadequate WASH tend to be exacerbated in urban, and particularly slum, populations (Graf et al. 2008; Oguntoke et al. 2009; Van de Poel et al. 2009; Breiman et al. 2012; Dos Santos et al. 2015; Gruebner et al. 2015; Tsiko 2015). Given, the growing numbers of individuals in urban areas already living with chronic conditions, be they infectious or non-communicable, we highlight an important gap in the research beyond manifestations of diarrhoea episodes and their consequences.

Research questions related to the role of sub-clinical infections caused by poor access to WASH in urban Africa and associations with child growth and development as well as the cumulative and lasting effects of poor WASH exposures, including life-term risk for chronic metabolic non-communicable diseases, now warrant further investigation. Broader conceptualisations of WASH and health, including aspects of protection or safety (particularly gender related) are also much needed. As research into WASH in urban Africa continues into the 21st century, perspectives on gender, age and equity must be emphasised. This not only means inclusion of health outcomes specific to vulnerable populations, but also consideration of the social and environmental aspects that interact with WASH and its effects on health.

Health impacts of WASH interventions

In addressing our second objective – to describe and review the health-focused interventions and the evidence of effectiveness in urban SSA this century – we reviewed full papers and provided a critical appraisal of the evidence. Our inclusion criteria in addressing this objective was more restrictive, requiring experimental or quasi-experimental design whereby exposure to a WASH intervention was allocated by the researchers in order to assess impact on health outcomes. As such, literature that investigated associations between WASH interventions or exposures and health outcomes from purely observational designs were excluded.

Only seven papers met the inclusion criteria and presented experimental evidence of the effectiveness of WASH interventions on health outcomes in urban Africa. All of the studies reviewed, with the exception of menstrual hygiene, reflected the dominance of health evaluations associated with acute infections, predominately diarrheal diseases. Moreover, all of these studies were hampered by methodological limitations of bias, confounding and/or the effect of chance. Firstly, the reliance on self-reported outcomes or directly observed behaviours (Table 2: # 1,3,5,7) influenced results due to social desirability, recall, reporting and observer bias, especially given the impracticality of blinding participants to intervention exposure or the general objectives of the study. Secondly confounding factors, are a considerable limitation in non-randomised evaluations and even randomised studies (Schimdt and Norman 2011) where baseline imbalances between intervention and control arms are not accounted or adjusted for in analyses. Finally, the identification of effects due to chance remains a possibility in studies that test for multiple outcomes without appropriate adjustments, as in the study by Davis et al. (2011).

Understanding the impact of technical interventions was hampered by implementation problems in the studies by Davis et al. (2013) and Bohnert et al. (2016), reflecting the complexity of such interventions and their evaluation. However, elements of process evaluation were included in both studies which helped explain their observed findings. The inclusion of process evaluation and implementation science techniques to document, analyse and describe the context, delivery and receipt of interventions is used in pragmatic trials of complex interventions in real world settings (Craig et al. 2008), and is important in understanding the implementation and effectiveness (or lack of effectiveness) of interventions and their longer-term sustainability and scalability.

The use of ‘theories of change’ to better define causal mechanisms are de riguer in many areas of public health intervention development and evaluation but were largely absent from the WASH literature we reviewed. With the exception of Tumwebaze and Mosler (2015) and Montgomery et al. (2012), the reviewed intervention studies do not explicitly apply theories to their intervention design, evaluation approach or interpretation of findings. Instead, studies tend to focus on specific causal pathways between intervention and outcome without acknowledging the multitude of factors that may interact with and influence this pathway at the individual, household, community, organisational, political and environmental level.

The majority (98%) of health-focused WASH intervention papers did not meet our review inclusion criteria as they relied on observational or ecological designs to evaluate the health impacts of WASH interventions. Such study designs are less able to account for confounding factors in associations between exposures and health outcomes and their use may be considered a weakness in the body of WASH intervention evidence . Schmidt and Norman (2011) declared that the potential challenges in accounting for confounders, '*virtually precludes using conventional ecological analysis for the evaluation of WASH interventions*' (Schmidt and Norman 2011, p. 7).

Reasons for the lack of experimental study design within the field of WASH in urban Africa need to be explored. We posit that disciplinary differences may partly account for this situation. The use of Randomised Control Trials (RCTs) is highly regarded within the fields of medicine and public health due to the RCT's ability to reduce confounding effects and, if blinded, reduce bias and maximise confidence in causal associations between intervention exposures and health outcomes. However, RCTs are often expensive and require specific technical expertise. Furthermore, there are important ethical and practical limitations of experimental and quasi-experimental designs within the context of WASH research in urban Africa. To justify the use of most experimental designs there must be equipoise – genuine uncertainty about the benefit of the intervention being tested. This uncertainty is often absent in WASH interventions, particularly well-established technical and contextual strategies such as provision of piped water into households or sewerage provision. Moreover, the randomisation of most large scale WASH interventions is often not politically, financially or logistically acceptable which means that RCTs are probably not the 'gold standard' for many WASH evaluations (Schmidt and Norman 2011). Acceptable alternatives to RCTs may include before and after concurrent control (BAC) studies that are less costly to run for health impact evaluations of WASH interventions. Similarly, more sophisticated experimental designs, such as stepped-wedge trials, can allow experimentation and rigorous evaluation of impact while ensuring the entire study population will ultimately receive interventions.

Conclusions

There is a need for greater attention to emerging health outcomes in WASH focussed research in urban Africa that reflects current and projected demographic shifts and health transitions. There is also a need for high quality development, implementation and evaluation of interventions that draws on the use of theories of change and robust methodologies already applied in other areas of public health.

Note

1. Whereby infected individuals seek medical care.

Funding

This work was supported by the Royal Society - DFID Africa Capacity Building Initiative [grant number AQ140023].

ORCID

Eve Mackinnon http://orcid.org/0000-0001-9181-7566
Edward Fottrell http://orcid.org/0000-0003-0518-7161

References

Abate G, Kogi-Makau W, Muroki NM. 2000. Health seeking and hygiene behaviours predict nutritional status of pre-school children in a slum area of Addis Ababa, Ethiopia. Ethiop Med J. 38(4):253–265. http://ovidsp.ovid.com/ovidweb.cgi?T=JS&PAGE=reference&D=med4&NEWS=N&AN=11125500.

Abidoye RO, Ihebuzor NN. 2001. Assessment of nutritional status using anthropometric methods on 1–4 year old children in an urban ghetto in Lagos, Nigeria. Nutr Health. 15(1):29–39. http://ovidsp.ovid.com/ovidweb.cgi?T=JS&PAGE=reference&D=med4&NEWS=N&AN=11403370.

Adams VJ, Markus MB, Kwitshana ZL, Dhansay MA, van der Merwe L, Walzl G, Fincham JE. 2006. Recall of intestinal helminthiasis by HIV-infected South Africans and avoidance of possible misinterpretation of egg excretion in worm/HIV co-infection analyses. BMC Infect Dis. 6:88. http://ovidsp.ovid.com/ovidweb.cgi?T=JS&PAGE=reference&D=med5&NEWS=N&AN=16725057.

Adedotun A.A, Morenikeji O. A Odaibo A. B. 2010. Knowledge, attitudes and practices about Malaria in an urban community in South-Western Nigeria. Journal of Vector Borne Diseases. 47(3):155–159.

Afrane YA, Klinkenberg E, Drechsel P, Owusu-Daaku K, Garms R, Kruppa T. 2004. Does irrigated urban agriculture influence the transmission of malaria in the city of Kumasi, Ghana? Acta Trop. 89(2):125–134. http://ovidsp.ovid.com/ovidweb.cgi?T=JS&PAGE=reference&D=med5&NEWS=N&AN=14732235.

Ali MB, Ghenghesh KS, Aissa RB, Abuhelfaia A, Dufani M. 2005. Etiology of childhood diarrhea in Zliten, Libya. Saudi Med J. 26(11):1759–1765. http://ovidsp.ovid.com/ovidweb.cgi?T=JS&PAGE=reference&D=med5&NEWS=N&AN=16311662.

Amoah P, Drechsel P, Abaidoo RC, Klutse A. 2007. Effectiveness of common and improved sanitary washing methods in selected cities of West Africa for the reduction of coliform bacteria and helminth eggs on vegetables. Trop Med Int Health. 12(Suppl 2):40–50. http://ovidsp.ovid.com/ovidweb.cgi?T=JS&PAGE=reference&D=med5&NEWS=N&AN=18005314.

Amogne WT, Gizaw M, Abera D. 2015. Physicochemical quality and health implications of bottled water brands sold in Ethiopia. J Egypt Public Health Assoc. 90(2):72–79. http://ovidsp.ovid.com/ovidweb.cgi?T=JS&PAGE=reference&D=medl&NEWS=N&AN=26154834.

Ankarklev J, Hestvik E, Lebbad M, Lindh J, Kaddu-Mulindwa DH, Andersson JO, Tylleskär T, Tumwine JK, Svärd SG, Elmendorf HG. 2012. Common coinfections of Giardia intestinalis and Helicobacter pylori in non-symptomatic Ugandan children. PLoS Negl Trop Dis. 6(8):e1780. http://ovidsp.ovid.com/ovidweb.cgi?T=JS&PAGE=reference&D=med7&NEWS=N&AN=22953010.

Awadia AK, Birkeland J, Haugejorden O, Bjorvatn K. 2002. Caries experience and caries predictors–a study of Tanzanian children consuming drinking water with different fluoride concentrations. Clin Oral Investig. 6 (2):98–103. http://ovidsp.ovid.com/ovidweb.cgi?T=JS&PAGE=reference&D=med4&NEWS=N&AN=12166721.

Ayele FA, Taye BW, Ayele TA, Gelaye KA. 2013. Predictors of dental caries among children 7–14 years old in Northwest Ethiopia: a community based cross-sectional study. BMC Oral Health. 13:7. http://ovidsp.ovid.com/ovidweb.cgi?T=JS&PAGE=reference&D=medl&NEWS=N&AN=23331467.

Bain R, Cronk R, Hossain R, Bonjour S, Onda K, Wright J, Bartram J. 2014. Global assessment of exposure to faecal contamination through drinking water based on a systematic review. Medicine and International Health. 19 (8):917–927.

Balde MD, Balde NM, Kaba ML, Diallo I, Diallo MM, Kake A, Bah D, Camara A, Balde M. 2006. Hypertension: epidemiology and metabolic abnormalities in Foutah-Djallon in Guinea. Hypertension Arterielle: Epidemiologie Et Anomalies Metaboliques Au Foutah-Djallon En Guinee. 21(3):19–22. http://ovidsp.ovid.com/ovidweb.cgi?T=JS&PAGE=reference&D=med5&NEWS=N&AN=19435002.

Baragatti M, Fournet F, Henry, MC, Assi S, Ouedraogo H, Rogier C, Salem G. 2009. Social and environmental malaria risk factors in urban areas of Ouagadougou, Burkina Faso. Malar J. 8:13. http://ovidsp.ovid.com/ovidweb.cgi?T=JS&PAGE=reference&D=med6&NEWS=N&AN=19144144.

Bempah CK, Ewusi A. 2016. Heavy metals contamination and human health risk assessment around Obuasi gold mine in Ghana. Environ Monit Assess. 188(5):261. http://ovidsp.ovid.com/ovidweb.cgi?T=JS&PAGE=reference&D=medl&NEWS=N&AN=27037696.

Birbeck GL, Kalichi EMN. 2003. The functional status of people with epilepsy in rural sub-Saharan Africa. J Neurol Sci. 209(1–2):65–68. http://ovidsp.ovid.com/ovidweb.cgi?T=JS&PAGE=reference&D=med4&NEWS=N&AN=12686404.

Bohnert K, Chard AN, Mwaki A, Kirby AE, Muga R, Nagel CL, Thomas EA, Freeman MC. 2016. Comparing sanitation delivery modalities in urban informal settlement schools: a randomized trial in Nairobi, Kenya. Int J Environ Res Public Health. 13(12). http://ovidsp.ovid.com/ovidweb.cgi?T=JS&PAGE=reference&D=prem&NEWS=N&AN=27916914.

Borghi J, Guinness L, Ouedraogo J, Curtis V. 2002. Is hygiene promotion cost-effective? A case study in Burkina Faso. Trop Med Int Health. 7(11):960–969. http://ovidsp.ovid.com/ovidweb.cgi?T=JS&PAGE=reference&D=med4&NEWS=N&AN=12390603.

Breiman R. F, Cosmas L, Njuguna H, Audi A, Olack B, Ochieng J. B, Feikin D. R. 2012. Population-based incidence of typhoid fever in an urban informal settlement and a rural area in Kenya: implications for typhoid vaccine use in Africa. Plos One. 7(1):e29119.

Breton J, Bart-Delabesse E, Biligui S, Carbone A, Seiller X, Okome-Nkoumou M, Nzamba C, Kombila M, Accoceberry I, Thellier M. 2007. New highly divergent rRNA sequence among biodiverse genotypes of Enterocytozoon bieneusi strains isolated from humans in Gabon and Cameroon. J Clin Microbiol. 45 (8):2580–2589. http://ovidsp.ovid.com/ovidweb.cgi?T=JS&PAGE=reference&D=med5&NEWS=N&AN=17537939.

Cau BM, Falcao J, Arnaldo C. 2016. Determinants of poor self-rated health among adults in urban Mozambique. BMC Public Health. 16(1):856. http://ovidsp.ovid.com/ovidweb.cgi?T=JS&PAGE=reference&D=prem&NEWS=N&AN=27553080.

Chu KM, Watermeyer G, Shelly L, Janssen J, May TD, Brink K, Benefeld G, Li X. 2013. Childhood helminth exposure is protective against inflammatory bowel disease: a case control study in South Africa. Inflamm Bowel Dis. 19(3):614–620. http://ovidsp.ovid.com/ovidweb.cgi?T=JS&PAGE=reference&D=medl&NEWS=N&AN=23380935.

Chukwuocha UM, Dozie INS, Amadi AN, Nwankwo BO, Ukaga CN, Aguwa OC, Abanobi OC, Nwoke EA. 2009. The knowledge, attitude and practices of food handlers in food sanitation in a metropolis in south eastern Nigeria. East Afr J Public Health. 6(3):240–243. http://ovidsp.ovid.com/ovidweb.cgi?T=JS&PAGE=reference&D=med6&NEWS=N&AN=20803912.

Corburn J, Hildebrand C. 2015. Slum sanitation and the social determinants of women's health in Nairobi, Kenya. J Environ Public Health. 2015:1–6. http://ovidsp.ovid.com/ovidweb.cgi?T=JS&PAGE=reference&D=medl&NEWS=N&AN=26060499.

Craig P, Dieppe P, Macintyre S, Michie S, Nazareth I, Petticrew M. 2008. Developing and evaluating complex interventions: the new medical research council guidance. BMJ. 337(7676):979–983.

Crocker J, Bartram J. 2016. Interpreting the Global Enteric Multicenter Study (GEMS) Findings on Sanitation, Hygiene and Diarrhea. Plos Medicine. 13(5):2–5.

Curtis, V., Cairncross, S. and Yonli, R. (2000). Review: domestic hygiene and diarrhoea - pinpointing the problem. Trop. Medicine and International Health. 5(1):22–32

Dalal S, Beunza JJ, Volmink J, Adebamowo C, Bajunirwe F, Njelekela M, Mozaffarian D, Fawzi W, Willett W, Adami H-O, et al. 2011. Non-communicable diseases in sub-Saharan Africa: what we know now. Int J Epidemiol. 40(4):885–901.

Dalvie MA, Ehrlich R. 2006. Community mercury levels in the vicinity of peri-urban waste disposal sites and fossil fuel burning operations. Environ Int. 32(4):493–499. http://ovidsp.ovid.com/ovidweb.cgi?T=JS&PAGE=reference&D=med5&NEWS=N&AN=16434098.

Damorou F, Yayehd K, Pessinaba S, Baragou R, Soussou B. 2008. Ischemic cardiomyopathy in Lome: epidemiologic aspects and risk factors (study of 461 cases). Les cardiopathies ischemiques (CI) a Lome: aspects epidemiologiques et facteurs de risque (etude de 461 cas). 23(3):47–54. http://ovidsp.ovid.com/ovidweb.cgi?T=JS&PAGE=reference&D=med6&NEWS=N&AN=19617156.

Davis AJ, Scalmanini J, Pickering AJ, Okoth G, Ram PK, Blum AG, Breiman RF, Oyier B. 2013. Access to waterless hand sanitizer improves student hand hygiene behavior in primary schools in Nairobi, Kenya. Am J Trop Med Hyg. 89(3):411–418. http://ovidsp.ovid.com/ovidweb.cgi?T=JS&PAGE=reference&D=medl&NEWS=N&AN=23836575.

Davis J, Rogers K, Boehm AB, Mamuya S, Pickering AJ. 2011. The effects of informational interventions on household water management, hygiene behaviors, stored drinking water quality, and hand contamination in peri-urban Tanzania. Am J Trop Med Hyg. 84(2):184–191. http://ovidsp.ovid.com/ovidweb.cgi?T=JS&PAGE=reference&D=med7&NEWS=N&AN=21292883.

De Buck E, Van Remoortel H, Hannes K, Govender T, Naidoo S, Avau B, Musekiwa A, Lutje V, Cargo M, Mosler HJ, et al. 2016. Approaches to promote handwashing and sanitation behaviour change in low- and middle income countries: a mixed method systematic review. Campbell Syst Rev. (February 2013):1–46. http://www.campbellcollaboration.org/lib/project/366/.

DESA/UN. 2016. The Sustainable Development Goals Report 2016. New York (NY): UN Population Division of the Department of Economic and Social Affairs (DESA).

Djimeu EW. 2014. The impact of social action funds on child health in a conflict affected country: evidence from Angola. Soc Sci Med. 106:35–42. http://ovidsp.ovid.com/ovidweb.cgi?T=JS&PAGE=reference&D=medl&NEWS=N&AN=24530615.

Dodor EA, Kelly S, Neal K. 2009. Health professionals as stigmatisers of tuberculosis: insights from community members and patients with TB in an urban district in Ghana. Psychol Health Med. 14(3):301–310. http://ovidsp.ovid.com/ovidweb.cgi?T=JS&PAGE=reference&D=med6&NEWS=N&AN=19444708.

Donkor ES. 2009. Application of the WHO five keys of food safety to improve food handling practices of food vendors in a poor resource community in Ghana. East Afr J Public Health. 6(2):148–151. http://ovidsp.ovid.com/ovidweb.cgi?T=JS&PAGE=reference&D=med6&NEWS=N&AN=20000020.

Dos Santos S, Ouedraogo FDC, Soura AB. 2015. Water-related factors and childhood diarrhoea in African informal settlements. A cross-sectional study in Ouagadougou (Burkina Faso). J Water Health. 13(2):562–574. http://ovidsp.ovid.com/ovidweb.cgi?T=JS&PAGE=reference&D=medl&NEWS=N&AN=26042987.

Dreibelbis R, Winch PJ, Leontsini E, Hulland KR, Ram PK, Unicomb L, Luby SP. 2013. The integrated behavioural model for water, sanitation, and hygiene: a systematic review of behavioural models and a framework for designing and evaluating behaviour change interventions in infrastructure-restricted settings. BMC Public Health. 13(1).

Du Preez M, Conroy RM, Ligondo S, Hennessy J, Elmore-Meegan M, Soita A, McGuigan KG. 2011. Randomized intervention study of solar disinfection of drinking water in the prevention of dysentery in Kenyan children aged under 5 years. Environ Sci Technol. 45:9315–9323.

Ejemot-Nwadiaro RI, Ehiri JE, Arikpo D, Meremikwu MM, Critchley JA. 2015. Hand washing promotion for preventing diarrhoea. Cochrane Database Syst Rev. (9):CD004265. http://ovidsp.ovid.com/ovidweb.cgi?T=JS&PAGE=reference&D=medl&NEWS=N&AN=26346329.

Esrey S. A, Potash J. B, Roberts L, Shiff C. 1991. Reviews/Analyses Effects of improved water supply and sanitation on ascariasis. diarrhoea, dracunculiasis, hookworm Infection, schistosomiasis, and trachoma. Bull. of The WHO. 69(5):609–621.

Fantaye W, Anne A, Asgeir B, Melaku Z, Haymanot RT, Bjorvatn K. 2003. Perception of dental fluorosis among adolescents living in urban areas of Ethiopia. Ethiop Med J. 41(1):35–44. http://ovidsp.ovid.com/ovidweb.cgi?T=JS&PAGE=reference&D=med4&NEWS=N&AN=12764999.

Feacham R, Bradley D, Garelick H, Mara D. D. 1983. Sanitation and Disease: Health Aspects of Excreta and Wastewater Management. John Wiley and Sons.

Feasey N, Wansbrough-Jones M, Mabey DCW, Solomon AW. 2010. Neglected tropical diseases. Br Med Bull. 93 (1):179–200.

Fourcade L, Paule P, Mafart B. 2007. Arterial hypertension in sub-Saharan Africa. Update and perspectives. Hypertension arterielle en Afrique subsaharienne actualite et perspectives. 67(6):559–567. http://ovidsp.ovid.com/ovidweb.cgi?T=JS&PAGE=reference&D=med5&NEWS=N&AN=18300516.

Galgani P, van der Voet E, Korevaar G. 2014. Composting, anaerobic digestion and biochar production in Ghana. Environmental-economic assessment in the context of voluntary carbon markets. Waste Manag. 34(12):2454–2465. http://ovidsp.ovid.com/ovidweb.cgi?T=JS&PAGE=reference&D=medl&NEWS=N&AN=25204615.

Garenne M. 2010. Urbanisation and child health in resource poor settings with special reference to under-five mortality in Africa. Archives of Disease in Childhood. 95(6):464–468.

Gbadebo AM. 2012. Groundwater fluoride and dental fluorosis in southwestern Nigeria. Environ Geochem Health. 34(5):597–604. http://ovidsp.ovid.com/ovidweb.cgi?T=JS&PAGE=reference&D=med7&NEWS=N&AN=22539221.

Gonsalves GS, Kaplan EH, Paltiel AD. 2015. Reducing sexual violence by increasing the supply of toilets in Khayelitsha, South Africa: a mathematical model. PLoS ONE. 10(4):e0122244. http://ovidsp.ovid.com/ovidweb.cgi?T=JS&PAGE=reference&D=medl&NEWS=N&AN=25923105.

Graf, J., Meierhofer, R., Wegelin, M. and Mosler, H-J. 2008. Water disinfection and behaviour in an urban slum in Kenya: impact of childhood diarrhoea and influence of beliefs. International Journal of Env. Health Research. 18 (5): 335–355.

Greif MJ, Nii-Amoo Dodoo F. 2015. How community physical, structural, and social stressors relate to mental health in the urban slums of Accra, Ghana. Health Place. 33:57–66. http://ovidsp.ovid.com/ovidweb.cgi?T=JS&PAGE=reference&D=medl&NEWS=N&AN=25754264.

Griffiths PL, Sheppard ZA, Johnson W, Cameron N, Pettifor JM, Norris SA. 2012. Associations between household and neighbourhood socioeconomic status and systolic blood pressure among urban South African adolescents. J Biosoc Sci. 44(4):433–458. http://ovidsp.ovid.com/ovidweb.cgi?T=JS&PAGE=reference&D=med7&NEWS=N&AN=22490826.

Gruebner O, Lautenbach S, Khan M. M, Kipruto S, Epprecht M, Galea S. 2015. Place of residence moderates the risk of Infant Death in Kenya: Evidence from the most Recent Census 2009. Plos One. 10(10):e0139545.

Gyang PV, Akinwale OP, Lee YL, Chuang TW, Orok AB, Ajibaye O, Liao CW, Chen PC, Chou CM, Huang YC, et al. 2015. Seroprevalence, disease awareness, and risk factors for Toxocara canis infection among primary schoolchildren in Makoko, an urban slum community in Nigeria. Acta Trop. 146:135–140. http://ovidsp.ovid.com/ovidweb.cgi?T=JS&PAGE=reference&D=medl&NEWS=N&AN=25812836.

Hazel A, Foxman B, Low BS. 2015. Herpes simplex virus type 2 among mobile pastoralists in northwestern Namibia. Ann Hum Biol. 42(6):543–551. http://ovidsp.ovid.com/ovidweb.cgi?T=JS&PAGE=reference&D=medl&NEWS=N&AN=25387244.

Hopewell M. R, Graham J. P. 2014. Trends in access to water supply and sanitation in 31 major sub-Saharan African cities: an analysis of DHS data from 2000 to 2012. BMC Public Health. 14:208.

Isara AR, Isah EC. 2009. Knowledge and practice of food hygiene and safety among food handlers in fast food restaurants in Benin City, Edo State. Niger Postgrad Med J. 16(3):207–212. http://ovidsp.ovid.com/ovidweb.cgi?T=JS&PAGE=reference&D=med6&NEWS=N&AN=19767908.

Jagals P, Nala NP, Tsubane TJ, Moabi M, Motaung KC. 2004. Measuring changes in water-related health and hygiene practices by developing-community households. Water Sci Technol. 50(1):91–97. http://ovidsp.ovid.com/ovidweb.cgi?T=JS&PAGE=reference&D=med5&NEWS=N&AN=15318492.
Julian TR. 2016. Environmental transmission of diarrheal pathogens in low and middle income countries. Environ Sci: Processes Impacts. 18:944–955. http://xlink.rsc.org/?DOI=C6EM00222F.
Jutla A, Aldaach H, Billian H, Akanda A, Huq A, Colwell R, Schumann GJ-P. 2015. Satellite based assessment of hydroclimatic conditions related to cholera in Zimbabwe. PLoS ONE. 10(9):e0137828. http://ovidsp.ovid.com/ovidweb.cgi?T=JS&PAGE=reference&D=medl&NEWS=N&AN=26417994.
Kagira JM, Kanyari PWN. 2010. Occurrence of risk factors for zoonoses in Kisumu City, Kenya: a questionnaire survey. East Afr J Public Health. 7(1):1–4. http://ovidsp.ovid.com/ovidweb.cgi?T=JS&PAGE=reference&D=med6&NEWS=N&AN=21413564.
Kroon J, Van Wyk PJ. 2012. A retrospective view on the viability of water fluoridation in South Africa to prevent dental caries. Community Dent Oral Epidemiol. 40(5):441–450. http://ovidsp.ovid.com/ovidweb.cgi?T=JS&PAGE=reference&D=med7&NEWS=N&AN=22494006.
Labite H, Lunani I, van der Steen P, Vairavamoorthy K, Drechsel P, Lens P. 2010. Quantitative microbial risk analysis to evaluate health effects of interventions in the urban water system of Accra, Ghana. J Water Health. 8(3):417–430. http://ovidsp.ovid.com/ovidweb.cgi?T=JS&PAGE=reference&D=med6&NEWS=N&AN=20375471.
Lang M-C. 2012. Implementation of an evidence-based hand hygiene program in elementary schools in Ghana, as part of a City-to-City partnership between Ottawa public health and KEEA health directorate. Fam Community Health. 35(3):203–211. http://ovidsp.ovid.com/ovidweb.cgi?T=JS&PAGE=reference&D=med7&NEWS=N&AN=22617411.
Liao C-W, Sukati H, D'lamini P, Chou CM, Liu YH, Huang YC, Chung MH, Mtsetfwa JS, Jonato J, Chiu WT, et al. 2010. Seroprevalence of Toxocara canis infection among children in Swaziland, southern Africa. Ann Trop Med Parasitol. 104(1):73–80. http://ovidsp.ovid.com/ovidweb.cgi?T=JS&PAGE=reference&D=med6&NEWS=N&AN=20149294.
Liu L, Oza S, Hogan D, Perin J, Rudan I, Lawn JE, Cousens S, Mathers C, Black RE. 2015. Global, regional, and national causes of child mortality in 2000–13, with projections to inform post-2015 priorities: an updated systematic analysis. Lancet. 385(9966):430–440. [Accessed 2017 Aug 4]. http://linkinghub.elsevier.com/retrieve/pii/S0140673614616986.
Luque Fernandez MA, Schomaker M, Mason PR, Fesselet JF, Baudot Y, Boulle A, Maes P. 2012. Elevation and cholera: an epidemiological spatial analysis of the cholera epidemic in Harare, Zimbabwe, 2008–2009. BMC Public Health. 12:442. http://ovidsp.ovid.com/ovidweb.cgi?T=JS&PAGE=reference&D=med7&NEWS=N&AN=22708576.
Macassa G, Ghilagaber G, Bernhardt E, Burstrom B. 2004. Contribution of household environment factors to urban childhood mortality in Mozambique. East Afr Med J. 81(8):408–414. http://ovidsp.ovid.com/ovidweb.cgi?T=JS&PAGE=reference&D=med5&NEWS=N&AN=15622935.
Maher D, Smeeth L, Sekajugo J. 2010. Health transition in Africa: practical policy proposals for primary care. Bull World Health Organ. 88(12):943–948.
Masibo PK, Makoka D. 2012. Trends and determinants of undernutrition among young Kenyan children: Kenya demographic and health survey; 1993, 1998, 2003 and 2008–2009. Public Health Nutr. 15(9):1715–1727. http://ovidsp.ovid.com/ovidweb.cgi?T=JS&PAGE=reference&D=med7&NEWS=N&AN=22694984.
Matthys B, N'goran EK, Gosoniu L, Cissé G, Tschannen AB, Becket EG, Vounatsou P, Raso G, Utzinger J, Tanner M. 2006. Urban farming and malaria risk factors in a medium-sized town in Cote d'Ivoire. Am J Trop Med Hyg. 75(6):1223–1231. http://ovidsp.ovid.com/ovidweb.cgi?T=JS&PAGE=reference&D=med5&NEWS=N&AN=17172397.
Mduma ER, Gratz J, Patil C, Matson K, Dakay M, Liu S, Pascal J, McQuillin L, Mighay E, Hinken E, et al. 2014. The etiology, risk factors, and interactions of enteric infections and malnutrition and the consequences for child health and development study (MAL-ED): description of the Tanzanian site. Clin Infect Dis. 59(Suppl 4):S325–S330. http://ovidsp.ovid.com/ovidweb.cgi?T=JS&PAGE=reference&D=medl&NEWS=N&AN=25305305.
Medani AMMH, Elnour AA, Saeed AM. 2013. Excessive iodine intake, water chemicals and endemic goitre in a Sudanese coastal area. Public Health Nutr. 16(9):1586–1592. http://ovidsp.ovid.com/ovidweb.cgi?T=JS&PAGE=reference&D=medl&NEWS=N&AN=23206325.
Mensah P, Yeboah-Manu D, Owusu-Darko K, Ablordey A. 2002. Street foods in Accra, Ghana: how safe are they? Bull World Health Organ. 80(7):546–554. http://ovidsp.ovid.com/ovidweb.cgi?T=JS&PAGE=reference&D=med4&NEWS=N&AN=12163918.
Mmari K, Lantos H, Brahmbhatt H, Delany-Moretlwe S, Lou C, Acharya R, Sangowawa A. 2014. How adolescents perceive their communities: a qualitative study that explores the relationship between health and the physical environment. BMC Public Health. 14:349. http://ovidsp.ovid.com/ovidweb.cgi?T=JS&PAGE=reference&D=medl&NEWS=N&AN=24726018.
Mohamed AH, Dalal W, Nyoka R, Burke H, Ahmed J, Auko E, Shihaji W, Ndege I, Breiman RF, Eidex RB. 2014. Health care utilization for acute illnesses in an urban setting with a refugee population in Nairobi, Kenya: a cross-sectional survey. BMC Health Serv Res. 14:200. http://ovidsp.ovid.com/ovidweb.cgi?T=JS&PAGE=reference&D=medl&NEWS=N&AN=24885336.

Montgomery P, Ryus CR, Dolan CS, Dopson S, Scott LM, Baradaran HR. 2012. Sanitary pad interventions for girls' education in Ghana: a pilot study. PLoS ONE. 7(10):e48274. http://ovidsp.ovid.com/ovidweb.cgi?T=JS&PAGE=reference&D=med7&NEWS=N&AN=23118968.

Morse TD, Nichols RAB, Grimason AM, Campbell BM, Tembo KC, Smith HV. 2007. Incidence of cryptosporidiosis species in paediatric patients in Malawi. Epidemiol Infect. 135(8):1307–1315. http://ovidsp.ovid.com/ovidweb.cgi?T=JS&PAGE=reference&D=med5&NEWS=N&AN=17224087.

Mwase I, Mutoro A, Owino V, Garcia AL, Wright CM. 2016. Poor infant feeding practices and high prevalence of malnutrition in urban slum child care centres in Nairobi: a pilot study. J Trop Pediatr. 62(1):46–54. http://ovidsp.ovid.com/ovidweb.cgi?T=JS&PAGE=reference&D=medl&NEWS=N&AN=26507408.

Ndo C, Menze-Djantio B, Antonio-Nkondijo C. 2011. Awareness, attitudes and prevention of malaria in the cities of Douala and Yaounde (Cameroon). Parasites And Vectors. 4:181.

Nicolaou N, Siddique N, Custovic A. 2005. Allergic disease in urban and rural populations: increasing prevalence with increasing urbanization. Allergy. 60(11):1357–1360. http://ovidsp.ovid.com/ovidweb.cgi?T=JS&PAGE=reference&D=med5&NEWS=N&AN=16197466.

Njeze GE, Dilibe U, Ilo C. 2014. Nitrate and drinking water from private wells: will there be an epidemic of cancers of the digestive tract, urinary bladder and thyroid? Niger J Clin Pract. 17(2):178–182. http://ovidsp.ovid.com/ovidweb.cgi?T=JS&PAGE=reference&D=medl&NEWS=N&AN=24553028.

Norman R, Bradshaw D, Lewin S, Cairncross E, Nannan N, Vos T, Group S. A. 2010. Estimating the burden of disease attributable to four selected environmental risk factors in South Africa. Reviews on Environmental Health. 25(2):87–119.

Oguntoke O, Aboderin O. J, Bankole A. M. 2009. Association of water-borne diseases morbidity pattern and water quality in parts of Ibadan City, Nigeria. Tanzania Journal of Health Research. 11(4):189–195.

Okojie PW, Isah EC. 2014. Sanitary conditions of food vending sites and food handling practices of street food vendors in Benin City, Nigeria: implication for food hygiene and safety. J Environ Public Health. 2014:1–6. http://ovidsp.ovid.com/ovidweb.cgi?T=JS&PAGE=reference&D=medl&NEWS=N&AN=25258630.

Olusanya BO, Ofovwe GE. 2010. Predictors of preterm births and low birthweight in an inner-city hospital in sub-Saharan Africa. Matern Child Health J. 14(6):978–986. http://ovidsp.ovid.com/ovidweb.cgi?T=JS&PAGE=reference&D=med6&NEWS=N&AN=19795198.

Ondimu KN. 2000. Severe anaemia during pregnancy in Kisumu District of Kenya: prevalence and risk factors. Int J Health Care Qual Assur Inc Leadersh Health Serv. 13(5):230–235. http://ovidsp.ovid.com/ovidweb.cgi?T=JS&PAGE=reference&D=med4&NEWS=N&AN=11486678.

Osei FB, Duker AA. 2008. Spatial dependency of V. cholera prevalence on open space refuse dumps in Kumasi, Ghana: a spatial statistical modelling. Int J Health Geogr. 7:62. http://ovidsp.ovid.com/ovidweb.cgi?T=JS&PAGE=reference&D=med6&NEWS=N&AN=19087235.

Peletz R, Kumpel E, Bonham M, Rahman Z, Khush R. 2016. To what extent is drinking water tested in Sub-Saharan Africa? A comparative analysis of regulated water quality monitoring. Int J Environ Res Public Health. 13(3). http://ovidsp.ovid.com/ovidweb.cgi?T=JS&PAGE=reference&D=medl&NEWS=N&AN=26950135.

Peletz, R., Simuyando, M., Sarenje, K., Baisley, K., Kelly, P., Filteau, S. and Clasen, T. 2011. Drinking water quality, feeding practices, and diarrhoea among children under 2 years of HIV-positive mothers in peri-urban Zambia. The American Journal of Trop. Medicine and Hyg. 82 (5):312–326

Pickering AJ, Blum AG, Breiman RF, Ram PK, Davis J, Gupta V. 2014. Video surveillance captures student hand hygiene behavior, reactivity to observation, and peer influence in Kenyan primary schools. PLoS ONE. 9(3): e92571. http://ovidsp.ovid.com/ovidweb.cgi?T=JS&PAGE=reference&D=medl&NEWS=N&AN=24676389.

Pongou R, Ezzati M, Salomon JA. 2006. Household and community socioeconomic and environmental determinants of child nutritional status in Cameroon. BMC Public Health. 6:98. http://ovidsp.ovid.com/ovidweb.cgi?T=JS&PAGE=reference&D=med5&NEWS=N&AN=16618370.

Pruss-Ustun, A., Kay, D., Fewtrell, L., Bartram, J. Unsafe Water and Hygiene. 2004. In *Comparative Quantification of Health risks: Global and regional burden of disease attributable to selected major risk factors. volume 1*. World Health Organisation. p. 1321–1352.

Re V, Faye SC, Faye A, Faye S, Gaye CB, Sacchi E, Zuppi GM. 2011. Water quality decline in coastal aquifers under anthropic pressure: the case of a suburban area of Dakar (Senegal). Environ Monit Assess. 172(1–4):605–622. http://ovidsp.ovid.com/ovidweb.cgi?T=JS&PAGE=reference&D=med7&NEWS=N&AN=20300838.

Ryman T. K, Briere E. C, Cartwright E, Schlanger K, Wannemuehler K. A, Russo E. TWatkins M. L. 2012. Integration of routine vaccination and hygiene interventions: a comparison of 2 strategies in Kenya. The Journal of Infectious Diseases. 205:65–76.

Sasaki S, Suzuki H, Fujino Y, Kimura Y, Cheelo M. 2009. Impact of drainage networks on cholera outbreaks in Lusaka, Zambia. Am J Public Health. 99(11):1982–1987. http://ovidsp.ovid.com/ovidweb.cgi?T=JS&PAGE=reference&D=med6&NEWS=N&AN=19762668.

Schaetti C, Khatib AM, Ali SM, Hutubessy R, Chaignat C-L, Weiss MG. 2010. Social and cultural features of cholera and shigellosis in peri-urban and rural communities of Zanzibar. BMC Infect Dis. 10:339. http://ovidsp.ovid.com/ovidweb.cgi?T=JS&PAGE=reference&D=med6&NEWS=N&AN=21110853.

Schmidt WP, Norman G. 2011. Evaluating the health impact of urban WASH programmes: an affordable approach for enhancing effectiveness. Sanitation and Hygiene Applied Research for Equity (SHARE), London, UK.

Schmidt, W. P., Norman, G. and Water and Sanitation for the Urban Poor (WSUP). 2011. Evaluating the health impact of urban WASH programmes: an affordable approach for enhancing effectiveness: a discussion paper. Sanitation and Hygiene Applied Research for Equity. [accessed 2018 Nov 26]. www.ircwash.org/resources/evaluating-health-impact-urban-wash-programmes-affordable-approach-enhancing-effectiveness

Seidahmed OME, Hassan SA, Soghaier MA, Siam HAM, Ahmed FTA, Elkarsany MM, Sulaiman SM, Kading RC. 2012. Spatial and temporal patterns of dengue transmission along a Red Sea coastline: a longitudinal entomological and serological survey in Port Sudan city. PLoS Negl Trop Dis. 6(9):e1821. http://ovidsp.ovid.com/ovidweb.cgi?T=JS&PAGE=reference&D=med7&NEWS=N&AN=23029582.

Steinman HA, Donson H, Kawalski M, Toerien A, Potter PC. 2003. Bronchial hyper-responsiveness and atopy in urban, peri-urban and rural South African children. Pediatr Allergy Immunol. 14(5):383–393. http://ovidsp.ovid.com/ovidweb.cgi?T=JS&PAGE=reference&D=med4&NEWS=N&AN=14641609.

Stockman LJ, Fischer TK, Deming M, Ngwira B, Bowie C, Cunliffe N, Bresee J, Quick RE. 2007. Point-of-use water treatment and use among mothers in Malawi. Emerging Infect Dis. 13(7):1077–1080. http://ovidsp.ovid.com/ovidweb.cgi?T=JS&PAGE=reference&D=med5&NEWS=N&AN=18214185.

Teji K, Dessie Y, Assebe T, Abdo M. 2016. Anaemia and nutritional status of adolescent girls in Babile District, Eastern Ethiopia. The Pan African Medical Journal. 24:62.

Tsiko R. G. 2015. Bayesian spatial analysis of childhood diseases in Zimbabwe. BMC Public Health. 15:842.

Tumwebaze I. K, Mosler H J. 2015. Effectiveness of group discussions and commitment in improving cleaning behaviour of shared sanitation users in Kampala, Uganda slums. Social Sci. and Medicine. 147:72–79.

Tumwebaze IK, Mosler H-J. 2014. Shared toilet users' collective cleaning and determinant factors in Kampala slums, Uganda. BMC Public Health. 14:1260. http://ovidsp.ovid.com/ovidweb.cgi?T=JS&PAGE=reference&D=medl&NEWS=N&AN=25494556.

Tumwebaze IK, Mosler H-J. 2015. Effectiveness of group discussions and commitment in improving cleaning behaviour of shared sanitation users in Kampala, Uganda slums. Soc Sci Med. 147:72–79. http://ovidsp.ovid.com/ovidweb.cgi?T=JS&PAGE=reference&D=medl&NEWS=N&AN=26547047.

Van de Poel, E., O'Donnell, O. and Van Doorslaer, E. 2009. What explains the rural-urban gap in infant mortality: household or community characteristics? Demography, 46(4): 827–850.

Waddington H, Snilstveit B. 2009. Effectiveness and sustainability of water, sanitation and hygiene interventions in combating diarrhoea. Journal Of Development Effectiveness. 1(3):295–335.

Wang S-J, Lengeler C, Smith TA, Vounatsou P, Diadie DA, Pritroipa X, Convelbo N, Kientga M, Tanner M. 2005. Rapid urban malaria appraisal (RUMA) I: epidemiology of urban malaria in Ouagadougou. Malar J. 4:43. http://ovidsp.ovid.com/ovidweb.cgi?T=JS&PAGE=reference&D=med5&NEWS=N&AN=16168054.

Weeks J, Stoler J, Hill AG, Getis A. 2009. Distance threshold for the effect of urban agriculture on elevated self-reported malaria prevalence in Accra, Ghana. Am J Trop Med Hyg. 80(4):547–554. http://ovidsp.ovid.com/ovidweb.cgi?T=JS&PAGE=reference&D=med6&NEWS=N&AN=19346373.

Wells J. 2016. The metabolic ghettoan evolutionary perspective on nutrition, power relations and chronic disease. In the metabolic Ghetto: an evolutionary perspective on nutrition, power relations and chronic disease. Cambridge: Cambridge University Press; p. I–Ii.

Wilunda C, Massawe S, Jackson C. 2013. Determinants of moderate-to-severe anaemia among women of reproductive age in Tanzania: analysis of data from the 2010 Tanzania demographic and health survey. Trop Med Int Health. 18(12):1488–1497. http://ovidsp.ovid.com/ovidweb.cgi?T=JS&PAGE=reference&D=medl&NEWS=N&AN=24118432.

Wongdem JG, Aderinokun GA, Sridhar MK, Selkur S. 2000. Prevalence and distribution pattern of enamel fluorosis in Langtang town, Nigeria. Afr J Med Med Sci. 29(3–4):243–246. http://ovidsp.ovid.com/ovidweb.cgi?T=JS&PAGE=reference&D=med4&NEWS=N&AN=11713999.

[WHO/UNICEF] World Health Organisation/United Nations Childrens Fund. Joint Monitoring Programme for Water Supply and Sanitation. 2015. A Snaphot of Sanitation and Drinking Water in sub-Saharan Africa region.

Wright JA, Cronin A, Okotto-Okotto J, Yang H, Pedley S, Gundry SW. 2013. A spatial analysis of pit latrine density and groundwater source contamination. Environ Monit Assess. 185(5):4261–4272. http://ovidsp.ovid.com/ovidweb.cgi?T=JS&PAGE=reference&D=medl&NEWS=N&AN=22976120.

Yallew WW, Terefe MW, Herchline TE, Sharma HR, Bitew BD, Kifle MW, Tetemke DM, Tefera MA, Adane MM. 2012. Assessment of water, sanitation, and hygiene practice and associated factors among people living with HIV/AIDS home based care services in Gondar city, Ethiopia. BMC Public Health. 12:1057. http://ovidsp.ovid.com/ovidweb.cgi?T=JS&PAGE=reference&D=med7&NEWS=N&AN=23216835.